3GPP TSG-RAN WG2 #116e Tdoc R2-16xxxx

Electronic meeting, November 1st – 12th 2021

Agenda Item: x.x.x.x

Source: OPPO

Title: Summary of [POST115-e][714][V2X/SL] (OPPO)

Document for: Discussion, Decision

# Introduction

This document is to kick off the following email discussion:

* [POST115-e][714][V2X/SL] (OPPO)

Scope: For UC and GC, discuss the need of any mechanism to avoid SL DRX inactivity timer (possibly also including HARQ RTT/retransmission timer) mismatch between network and the TX UE for mode1 operation. If companies consider solution is needed, discuss the possible options to solve the issue.

Intended outcome: Discussion summary

Deadline: Long email discussion. 1st phase: check companies’ views for the simple/general question, collect candidate options from the companies for the question including multiple options before checking all companies’ views for each option. 2nd phase: check companies’ views for all questions (no restriction) Checking the rapporteur summary is done from the end of 2nd phase to tdoc submission.

# Phase-1 Discussion

The related issue(s) is discussed in the following contributions

|  |  |  |
| --- | --- | --- |
| Tdoc Number | P-number | Justification |
| R2-2107156 | P10 | …it is possible that a SL grant is not in SL active time of any destination that has data to be sent.. |
| R2-2107191 | P1-P4 | …when network receives a BSR (which shows intention by a Tx-UE to send out data) for multiple destinations, how for network to know which destinations are during DRX-active-time, and which are during DRX-inactive-time…  …E.g., in a resource pool configured with PSFCH, if Tx-UE decides to disable the FB, it is a question whether the RTT timer should start since the end of PSSCH. If it is adopted (considering it helps to save unnecessary RTT in case of FB-disabled case), it would be a problem for mode-1 scheduling since the network has no information on FB-enable/disable,… |
| R2-2108016 | P4-P5 | …if Tx UE reports a certain amount of data available for transmission for a specific destination, the gNB needs to know when the peer receiving UE(s) associated with this destination is in ActiveTime in order to allocate SL resources correspondingly….  …Nevertheless, the Tx UE behaviour would need to be specified for cases when it receives a SL allocation which doesn’t fall within its DRX ActiveTime.… |
| R2-2108469 | P1-P4 | …gNB cannot derive accurately the active time of SL Rx UE’s DRX in either SL unicast or groupcast even in case of mode 1 resource allocation scheduled from gNB and SL DRX configuration parameters are available in gNB… |
| R2-2106988 | P1-P2 | …Both Tx UE and Rx UE shall keep in SL active time during the period from sending the SL SR/BSR on Uu to SL PSCCH/PSSCH communication. Tx UE needs to indicate Rx UE to keep in SL active time when SL SR/BSR is sent… |
| R2-2106988 | P1-P2 | …Both Tx UE and Rx UE shall keep in SL active time during the period from sending the SL SR/BSR on Uu to SL PSCCH/PSSCH communication. Tx UE needs to indicate Rx UE to keep in SL active time when SL SR/BSR is sent… |
| R2-2108016 | P4-P5 | Proposal 4: Tx UE provides assistance information to gNB on DRX configuration/ActiveTime information per SL destination/service. In order to allow gNB to efficiently schedule SL resources (mode 1) to the Tx UE, the gNB should be aware of the time slots the Tx UE is in ActiveTime for a specific destination, e.g. SL service.  Proposal 5： RAN2 should discuss UE behavior when Tx UE receives SL resource allocation from gNB which are not within the ActiveTime of the Tx/Rx UE, e.g. UE may skip the allocated SL resources. |

## Inactivity timer

For inactivity timer, the problem can be summarized as:

* On the one hand, when SL DRX is configured, network has to estimate the DRX active time for each Rx-UE in order to provide SL grant to Tx UE during the active time (which is per-Rx-UE) to avoid resource waste.
* On the other hand, however, when Tx-UE is configured as mode-1, the decision of destination selection, are all up to Tx-UE and thus network has no information on them.

Since the destination selection above as input for DRX timer behaviour is unknown to network, from the contributions above perspective, it would lead to troubles for network to decide when to provide SL grant.

The phase-1 discussion is to collect view from companies on the validity of the issue, and to check solution candidates on the table.

Firstly, the problem is at gNB side, I.e., if mode-1 Tx UE reports SL-BSR for specific destinations, the gNB needs to know when the peer receiving UEs associated with these reported destinations (with data in the Tx buffer) are in active-time in order to allocate SL resources correspondingly. However, considering the destination selection is done at UE side, it is hard for gNB to derive the active time for each destination accurately.

**Q2.1-1a: For inactivity timer, for gNB, do you agree that if mode-1 Tx UE reports SL-BSR for specific destinations, considering the destination selection is done at UE side, it is hard for gNB to derive the active time for each destination accurately and to provide SL grant accordingly?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| OPPO | Yes | W/o information on destination selection, gNB implementation cannot figure out the inactivity timer status for each specific destination. |
| Xiaomi | Yes, with further clarification. | We understand the problem is caused by priority based destination selection in LCP. If there is no new data arrival at destination with higher LCH priority after SL-BSR report and before SL grant, UE would select the destination whose BS is included in previously transmitted BSR. gNB is able to know the destination selected by UE, since gNB is aware of the essential LCP parameters, such as LCH priority, PBR. However, if there is new data arrival at a destination with higher LCH priority after SL-BSR and before SL grant, UE may select this destination. But this destination was not included in transmitted SL-BSR. In this case, gNB may not be aware of the destination selected by UE and not be able to derive inactivity timer running. |
| CATT | Yes, but with comment | Firstly, we are puzzled that why we discuss this issue based on each DRX timer, since the active time is decided by the combinations of inactivity timer, retransmission timer and etc. **It is a common problem, and there is no need to discuss this issue timer by timer.**  **The common problem should be that: for gNB, do you agree that if mode-1 Tx UE reports SL-BSR for specific destinations, considering the destination selection is done at UE side, it is hard for gNB to derive the active time for each destination accurately and to provide SL grant accordingly?**  Since the LCP procedure is based on the highest priority of the logical channel with data available or sidelink MAC CE, hence, the gNB cannot know which destination will use the sidelink grant actually. Based on this, the gNB cannot derive the active time for each destination accurately. |
| Ericsson | No | In typical cases, the UE selects the destination with MAC CE or LCH with highest LCH priority. At least for the destination with LCH with highest LCH priority, the gNB is aware of it, since the BSR contains BS for each LCG of each destination. In most cases, each LCG contains only one LCH. The gNB is able to know BS of each LCH of each destination. In this case, the gNB will know which destination that the TX UE is mostly likely to select. In addition, for Mode 1 scheduling, the gNB is also aware when the selected destination will be in ON-duration, such the gNB can assign the grant to TX UE for the assumed Destination when the Destination is in ON-duration. Therefore, we don’t think the issue is valid. |
| InterDigital | Yes – with comments. | We would like to clarify that this problem is not due to the fact that the gNB does not know the DRX configuration of the RX UE(s) but rather that it does not know the active time because the inactivity timer (or retransmission timer) may be running at an RX UE without knowledge of the gNB being aware of this. This is because the TX UE does destination selection and knows whether the corresponding timers at the RX UE are running (e.g. inactivity timer and retransmission timer).  We also note that this is not an issue for groupcast transmission since inactivity timer and retransmission timer are not supported. So it is only an issue for mode 1 transmissions associated with unicast/groupcast. |
| vivo | Yes | Since the LCP procedure including destination selection is done by TX UE itself, the gNB cannot know which destination uses the sidelink grant finally. Hence, the gNB cannot deduce the inactivity timer status for each specific destination.  Furthermore, agree with CATT that there is a similar issue for the retransmission timer. |
| Nokia | Yes | We admit the existence of the problem for two reasons: gNB is not aware about the prolonged active time (caused by running inactivity timer or retransmission timer) at the RX-UE since the gNB does not know whether Inactivitiy timer (or Retransmission timer) at a specific destination (i.e. at a particular RX-UE) is running. Secondly the gNB is not aware about the final destination selection at the TX-UE (caused by LCH priority based destination selection) after gNB has provided SL grant. |
| Qualcomm | Comment | No, gNB knows all the LCGs associated different Destinations included in SL-BSRs, as well as the corresponding SL DRX configurations.  Yes, one rare corner case, if Tx UE uses a resource, allocated for a first SL data associated with a first destination, for a second SL data associated with a second destination which hasn’t been included in any SL-BSR yet, gNB won’t know the sidelink status for the second destination. However, the SL DRX active state for the second destination should be same as the first destination otherwise the Tx UE cannot use the resource, scheduled for the first destination, for the second destination. In this case, gNB may not know the destination accurately but may know that Tx UE and Rx UE are active (e.g., Inactivity timer) with the sidelink grant. |
| LG | Comment | That might be the case, but we don’t think that this is a critical issue that needs to be optimized by consuming a lot of time considering the current situation where there are still many other fundamental features that shall be finalized to support the SL DRX operation. Note that the similar problem (that the understanding of the active time of destination UE derived from the inactivity timer is not aligned between Mode-1 Tx UE and gNB) could occur even in the following example cases. Also the gNB could set the SL DRX configurations for Mode-1 Tx UE’s destination UEs so that such a problem does not occur as much as possible.  - E.g., when the MAC PDU transmission on the scheduled Mode-1 resource is dropped due to LTE/NR SL prioritization  - E.g., when the initial transmission of MAC PDU is performed through a resource other than the first one among the scheduled CG resources within a period  - E.g., when the skipping of MAC PDU occurs on the scheduled DG resources |
| ASUSTeK | Yes with comment | Agree with Xiaomi that this issue might occur when there’s new data arrival from higher priority LCH that is not reported in the latest SL-BSR, the UE may select a destination for a SL grant that is not expected or predicted by the network. The DRX timers’ status of a destination may be mismatched between Tx UE and NW. In most cases, however, the NW should be able to know which destination the Tx UE would select for a SL grant based on provided SL-BSR. |
| Apple | Yes with comment | The problem does exist because each SL grant is destination-agnostic. However, we are not sure this is a problem worth solving. The aggregated SL DRX active time of each RX UE (considering all the potential senders and all active SL-DRX configurations for this RX UE) is in general unknown to the sender (TX UE) and its serving gNB. No matter how we solve it, the solution is always sub-optimal, because gNB (or the mode-1 TX UE) will not be able to utilize all the ACTIVE time of a particular destination RX UE and can only constrain its scheduling based on its limited knowledge. |
| ZTE | Yes | We agree that caused by LCP procedure will always multiplex data with highest LCH priority, gNB does not know which destination is selected after data multiplexing. Therefore, gNB does not know the detailed active time of all RX UEs. |
| Huawei, HiSilicon | Yes | Since gNB is not aware of the destination selected by UE for a SL grant when UE has more than one destination, gNB cannot know which destination starts inactivity timer and possible retransmission timer. Thus gNB may assign a SL grant that is not in SL active time of any destination that has data to be sent.  In addition, we do not think gNB can know the selected destination by SL-BSR. Firstly, SL-BSR is based on LCG and a LCG can include more than one LCHs with different priorities. So gNB is not aware of the LCH priority from SL-BSR and cannot derive the destination selected by UE. Secondly, UE may select a destination having data with higher LCH/MAC CE priority that is not reported by SL-BSR. gNB cannot be aware of this case either. |
| Lenovo | Yes with comments | It should be noted that a SL grant (DCI) is not destination specific but UE specific, i.e. UE only considers those destinations which are in ActiveTime for allocated SL resources. For SL in general the gNB has not a very precise knowledge of Tx UEs buffer and ActiveTime situation. For SL mode 1, gNB assigns SL resources to the Tx UE and Tx UE selects autonomously the MCS/TB size within the allocated SL Time/Frequency resources. Since MCS and TB size selection is done autonomously by Tx UE, e.g. based on channel condition, gNB cannot predict the results of the LCP procedure for SL transmissions. Therefore gNB has no accurate knowledge of Tx UEs buffer status even though SL BS information is reported to the gNB. This is different from the situation on the Uu interface, where gNB has some knowledge of the channel conditions and is capable to predict the result of LCP procedure performed by the UE for UL transmissions. However, even though there could be a mismatch between Tx UE and gNB, the question is whether there is an essential problem to be solved. |

In phase-1 discussion, the guidance is to start from solution candidate collection.

**Q2.1-1b: If one answer Yes to Q2.1-1a, please briefly describe the solution candidate(s).**

|  |  |
| --- | --- |
| Company | Comments |
| OPPO | We believe   1. The specification effort on this issue has to be restricted carefully, e.g., R2 should not pursue a solution that move destination selection to gNB 2. Some assistance information from UE to gNB is needed to solve this. However, a RRC-based solution is too slow and will cause high signaling overhead considering the information on destination selection (and thus inactivity timer status) is triggered per-grant.   Combining the two, R2 should working on a MAC CE based solution to solve this.  In light of that, OPPO proposal is to enhance the legacy SL-BSR, in a way that   1. We do not need to change the format of SL-BSR at all 2. But restrict the UE behavior in a way that, only report the BS-entries for a destination if the concerned destination is in active-time. |
| Xiaomi | As we clarified in first question, the mismatch between UE and NW could only happen when there is new data arrival at a destination, which was not included in previously BSR, with higher LCH priority after SL-BSR and before SL grant. This is caused by LCH priority based destination selection. If we don’t change the LCH priority based destination selection, which we shouldn’t, the problem would always exist. The solution proposed by OPPO couldn’t resolve this problem. Anyway, we understand this should not happen frequently as the condition is rather harsh. Therefore, we don’t see a feasible solution with acceptable spec impact. |
| CATT | We have the same view as xiaomi, the solution proposed by OPPO cannot resolve this problem, since the destination which is in active time when SL-BSR reporting may be switched to inactive when receiving the sidelink grant.  In our understanding, there is no need to perform any enhancement on gNB, we only need to let both the destination(s) UE and the Tx UE which SL-BSR is reported keep in active time to wait the sidelink grant from network, which is similar as the current Uu behaviour that the UE should be kept in active time once it send SR. |
| Ericsson | First, we don’t believe the issue is relevant as we commented in Q2.1-a. Second, the solution which OPPO has proposed would bring additional design efforts for RAN2. Considering limited left in Rel-17, RAN2 shall focus on other more critical issues. |
| InterDigital | We think destination selection should remain at the UE. However, using the BSR to report only the destinations in the active time will not completely resolve the issue, because the gNB is still not aware of WHEN the inactivity timer will expire or was reset, and will still not know when to schedule the transmission.  In our opinion, the only solution which can resolve this issue is to inform the gNB when a timer gets reset or started (e.g. inactivity timer), so that the gNB can accurately predict how to schedule resources for each UE. |
| Vivo | In our understanding, only if the gNB can actually know the mapping between SL grant and destination, SL grant allocation by gNB can be really efficient and avoid wasting. But the overhead and specification impacts may be not acceptable.  Therefore, there seems no preferred solution (with limited spec impact) on this issue. |
| Nokia | Given the limited time in Rel-17 and the specification impact we do not favour to change destination selection mechanism and/or LCH priority handling. Obviously to resolve the problem, the gNB needs to be informed about the status of the inactivity timer (running or not running) at the RX-UE by an indication or assistance data provided by the TX-UE. |
| Qualcomm | Share the same view with Xiaomi. This is a rare corner case and not worth the impact to spec to get fixed. |
| LG | As commented by other companies, we also think that the solution proposed by OPPO is difficult to fundamentally resolve the problem. In case of a solution in which Mode-1 Tx UE informs gNB whether the timer of its destination UE has started (or reset), it would be meaningless unless additional information on the exact start (or reset) timing of the timer is reported together. Here, as the relevant information should be reported in units of L2 SRC/DST ID pair for UC and combination of QoS profile/L2 DST ID for GC/BC, it seems hard to justify the reporting overhead. As replied to Q2.1-1a, considering other example cases in which the similar problem occurs, we think that it would be sufficient for RAN2 to only discuss “how to handle the MAC PDU (re-)transmission/Mode-1 SL grant” and “what information (e.g., ACK or NACK) should be reported via PUCCH if configured”, when some or all of the scheduled Mode-1 (re-)resources do not overlap with the active time of Mode-1 Tx UE's destination UEs. |
| ASUSTeK | We think no spec-changing solution is needed for this issue since it’s a rare case. |
| Apple | OPPO solution will force a TX UE to postpone its SL BSR reporting if the destination RX UE is deemed “inactive” from the TX UE perspective based on its tracking of inactivity timer (and other timers) defined on this SL unicast link. However, as we explained above, whether RX UE is really inactive or not is still uncertain because RX UE may still monitor PSCCH for other potential senders. Thus, it seems illogical to force UE to postpone its SL BSR reporting based on those unsure conjectures. We think there is no ideal way to address this unless we switch the link-centric DRX design to node-centric DRX. For Rel-17, we can accept to left this to UE implementation even when gNB allocated a SL grant based on incomplete information about SL DRX status. The TX UE can decide itself how to deal with this SL grant. |
| ZTE | We do not think this is a critical issue since UE can drop the invalid SL grant, nothing is broken. And the OPPO‘s BSR solution actually does not solve the issue, since gNB still does not know which destination reported in the BSR is selected after data multiplexing. And due to the limited time in R17, we think this issue should be postponed. |
| Huawei, HiSilicon | As we replied in Q2.1-1a, the main issue would be that gNB may assign SL grant that is not in SL active time of any destination that has data to be sent. Note that if gNB assigns SL grants that cannot be used by UE, UE may keep reporting SL-BSR and gNB keeps assigning SL grants out of active time, the problem is not negligible. As there is no SL applications related statistics available, we think it is not very convincing to say that the case of “there is new data arrival at a destination with higher LCH priority after SL-BSR and before SL grant” is a corner case.  One way to solve the issue completely is that UE reports to gNB the selected destination for the SL grant, so that gNB can track the active time of each destination timely.  Considering other companies’ concern of limited time for specification, we could spend minimum effort in order to avoid the worst case that gNB keeps assigning SL grants out of active time. One way is that UE reports to gNB when that active time ends, i.e., all destinations having data to be sent are out of active time. Since gNB knows the start of on-durations, gNB can assign SL grants till start ~~end~~ of on-duration after receiving the report. We think in this way signaling overhead and specification impact can be acceptable. |
| Lenovo | Firstly, we agree with most companies who indicate that OPPO’s solution cannot resolve the problem thoroughly, because report SL-BSR only in active time may not be in time. Secondly, we think to optimize the problem, either change the basic structure of destination selection, or to report dynamic active time to gNB which is estimated by Tx UE. Former solution will have big impact on specification and latter solution will cause large signaling overhead. So we think both are not feasible solution in this stage. |

Secondly, the problem is at UE side, i.e., if mode-1 Tx UE obtains a SL grant, which is however not in SL active time of any destination that has data to be sent, so how should the UE to behave.

**Q2.1-2a: For inactivity timer, for UE, do you agree that a mode-1 SL grant may be provided by network to Tx-UE yet it is not in SL active time of any destination that has data to be sent?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| OPPO | Yes | As replied to Q2.1-1a, considering gNB anyway cannot derive the active time accurately, this may happen |
| Xiaomi | Yes |  |
| CATT | No | Firstly, as commented in Q2.1-1a, we are puzzled why we discuss this issue timer by timer, in our understanding, since the destination is selected by UE, it is hard for the gNB to know the actual active time for sidelink.    Secondly, we think the case mentioned by rapporteur should be avoided since it will cause sidelink resource waste.  In order to avoid this, the simplest method is to let the destinations which have reported SL-BSR to network to keep in active time until sidelink grant is received. |
| Ericsson | No | As we commented, we don’t believe the issue is valid. |
| InterDigital | Yes – but | While this is a problem now, the solution we indicated in the previous question would result in the gNB being able to derive the active time accurately, and so we would no longer need to handle this case. |
| Vivo | Yes but | Since gNB cannot deduce the active time of each destination accurately, this may not be avoided. But this issue usually occurs when a higher priority data of other destination arrives suddenly or the buffer status situation known by gNB and TX UE about highest priority data has obvious gap, which are not normal cases. Hence, there is no need to make a big effort to solve it. |
| Nokia | Yes |  |
| Qualcomm | Comment | If the grant is not in SL active time of a destination that has data to be sent, the Tx UE cannot use the grant for this destination. |
| LG | Comment | As replied to Q2.1-1b, further discussion is also necessary on how to handle a problematic case when some of the scheduled Mode-1 (re-)resources do not overlap with the active time of Mode-1 Tx UE's destination UEs. |
| ASUSTeK | Yes |  |
| Apple | Yes with comment | Yes, but “not in SL active time of any destination” is just TX UE’s own hypothesis, which may not reflect the true status of a destination SL UE. An opportunist TX UE can still choose to use this SL grant. |
| ZTE | Yes |  |
| Huawei, HiSilicon | Yes | As replied to Q2.1-1a, gNB may assign a SL grant that is not in SL active time of any destination that has data to be sent. |
| Lenovo | Yes | We think problem may happens, because of misalignment between gNB and UE that discussed in Q2.1-1a. UE behaviour needs to be specified in this case. |

In phase-1 discussion, the guidance is to start from solution candidate collection.

**Q2.1-2b: If one answer Yes to Q2.1-2a, please briefly describe the solution candidate(s).**

|  |  |
| --- | --- |
| Company | Comments |
| OPPO | We believe the legacy spec as follows already allows the UE to skip the grant  The MAC entity shall not generate a MAC PDU for the HARQ entity if the following conditions are satisfied:  - there is no Sidelink CSI Reporting MAC CE generated for this PSSCH transmission as specified in clause 5.22.1.7; and  - the MAC PDU includes zero MAC SDUs. |
| Xiaomi | We already agreed the active time should be consider during LCP. In this case, the grant should be dropped. |
| InterDigital | Same solution as 2.1-1b. |
| vivo | Agree with the Xiaomi that the grant can be dropped. |
| LG | If this problematic case occurs, Mode-1 Tx UE drops the MAC PDU (re-)transmission (and/or ignores the Mode-1 SL grant) and reports ACK information via PUCCH if configured. |
| ASUSTeK | The grant can be dropped. |
| Apple | This can be left to UE implementation. It is up to TX UE to drop it or use it. |
| ZTE | Same as 2.1-1b. |
| Huawei, HiSilicon | The solution replied to Q2.1-1b can avoid this case.  If no solution is applied to avoid a SL grant assigned out of active time, then UE has to drop it. Moreover, considering SL grants dropped can be for initial transmission and retransmission respectively, there are three cases as below.  1) Both initial transmission grant and retransmission grant(s) are not in active time. Under the assumption that no destination is selected for initial grant due to LCP procedure, MAC PDU is not obtained for initial grant. According to existing spec, all grants are skipped and no additional spec impact is seen.  2) Initial transmission grant is in active time while retransmission grant(s) are not in active time (e.g. a SL transmission is not sent due to UL transmission collision). Under the assumption that a destination is selected for initial grant via LCP procedure, MAC PDU is obtained for the grants. According to existing spec, retransmission grant(s) are not dropped. Thus, spec change is needed to ensure retransmission grant(s) that are not in active time are dropped.  3) Initial transmission grant is not in active time while retransmission grant (s) are in active time (e.g. on-duration). Under the assumption no destination is selected for initial grant due to LCP procedure, MAC PDU is not obtained for initial grant. According to existing spec, all grants are skipped. However, we think in this case, retransmission grant(s) are in active time can still be used to increase resource utilization efficiency. Thus spec change is needed to ensure grants that are not in active time are dropped and grants that in active time can be used. |
| Lenovo | In this case UE will skip or drop the SL grant. But this should be specified and not left to UE implementation. |

## RTT/Re-transmission timer

Compared with inactivity timer, the difference is

* For RTT/Re-transmission, it is mainly for the retransmission of an transmitted TB. I.e., for each provided SL grant, the task of gNB is to decide on whether to provide subsequent SL retransmission grant, based on PUCCH if configured, regardless of destination selection for the provided SL grant
* For inactivity timer, it is mainly for initial transmission of a new TB. I.e., gNB has to associate it with the destination specific BSR info, to decide whether to provide subsequent SL initial-transmission grant, where destination selection of the provided SL grant matters.

So there seems no problem for network to unknow destination selection by Tx-UE.

However, based on the agreement from R2#115

9: HARQ RTT is supported for both HARQ enabled and HARQ disabled cases by allowing HARQ RTT timer to be set to different values. FFS on the specific values that can be used for HARQ disabled case.

I.e., UE may be configured with **different** RTT timer value setting for FB enable/disabled case.

And based on the discussion in R2#113bis

Proposal 23 [12/13] If SL HARQ RTT timer is supported for HARQ disabled transmissions, the RX UE starts the SL HARQ RTT timer in the symbol/slot following SCI (SCI1+SCI2) reception. FFS whether this applies to all SCI transmissions.

* Skipped because it has dependency with the previous FFS.

Proposal 24 [19/21] For transmissions with HARQ feedback, the RX UE starts the SL HARQ RTT timer in the symbol/slot following the end of PSFCH transmission.

* Agreed.

Proposal 25 [21/21] If the RX UE does not transmit PSFCH for a HARQ enabled transmission (e.g. due to UL/SL prioritization) the RX UE still starts the HARQ RTT timer in the symbol/slot following the end of PSFCH resource.

* Agreed.

So, if P23 is adopted finally (not concluded yet), UE may adopt **mode-1 Tx UE,** RTT timer restart position for FB enabled/disabled case will be different.

Combining the two together, the problem can be summarized as uncertainty due to different RTT timer length/starting-position (and thus different re-tx timer starting position) for FB-enable/disabled case, which is essentially because network has no information on LCH selection decision by Tx-UE, and thus does not know the FB-enable/disable decision, in a resource pool configured with PSFCH.

**Q2.2-1a: For RTT/Re-tx timer, for gNB, do you agree that for a mode-1 resource pool configured with PSFCH, considering the LCH selection and thus FB enable/disable decision is done at UE side, it is hard for gNB to derive the RTT/Re-tx timer accurately and to provide SL grant accordingly?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| OPPO | See comment | For the two issues on timer length difference and timer starting position difference   * For the former, it is not an issue since network configuration can configure a same value for both case * Yet the latter one cannot be solved yet.   So the problem mainly comes from the ambiguity of RTT timer starting position in case P23 is adopted as stated above. |
| Xiaomi | Yes | Similar as Q1. If there is new data arrival at a LCH with higher priority after SL-BSR and before SL grant, gNB may not be able to derive th RTT/RTX timer. |
| CATT | Yes, but with comment | As commented in Q2.1-1a, we are puzzled why we discuss this issue timer by timer, in our understanding, since the destination is selected by UE, it is hard for the gNB to know the actual active time for sidelink. |
| Ericsson | No | From the BSR, the gNB knows which destination the UE is likely to select, and what LCHs are likely to select, since the gNB knows LCH mapping restrictions for each LCH. Based on which, the gNB also knows whether SL HARQ feedback is enabled or disabled (based on info associated with the LCH with highest priority). Therefore, at least for SL FB enabled case, we don’t see the issue. For FB disabled, it is likely that the RTT timer will be set to zero. Therefore, there is no issue either. |
| InterDigital | No | We agree with Ericsson that the gNB should know which logical channel the UE will select for a specific grant. Otherwise, the whole scheduling framework would breakdown to begin with, and there would be no use for BSR (regardless if this is Uu or SL). |
| Vivo | Yes | The reason is also that the gNB cannot know which destination and what type of data, e.g. HARQ feedback disabled/enabled, use the SL grant. |
| Nokia | Yes | According to our understanding the problem arises due to the fact that the gNB does not know whether TX-UE has FB enabled/disabled and different RTT timer lengths can be configured dependent on the HARQ feedback enabled/disabled (as agreed by #9 in RAN2#115) |
| Qualcomm | No | If gNB grants SL resources with PSFCH and corresponding PUCCH, then Tx UE may respond ACK for no more retransmissions or respond NACK for retransmissions regardless if HARQ enabled or not and gNB may operate the RTT/Re-tx timer referenced from the PUCCH. |
| LG | Comment | As commented by several companies, considering that LCH-related parameter setting (e.g., HARQ FB enabled/disabled) and Mode-1 CG grant specific LCH restriction are performed by gNB, we don't think that this is an critical issue that should be optimized by introducing the complicated solution. Note that the similar problem (that the understanding of the active time of destination UE derived from the RTT/Re-Tx timer is not aligned between Mode-1 Tx UE and gNB) could occur even in at least the first example case described in our answer to Q2.1-1a. From our perspective, it would be sufficient for RAN2 to only discuss “how to handle the MAC PDU (re-)transmission/Mode-1 SL grant” and “what information (e.g., ACK or NACK) should be reported via PUCCH if configured”, when some or all of the scheduled Mode-1 (re-)transmission resources do not overlap with the active time of Mode-1 Tx UE's destination UEs. |
| ASUSTeK | Yes | The problem can occur as new data arrival not reported to NW before receiving a SL grant, and DRX timers’ status for a Rx UE can be mismatch between Tx UE and NW since DST selection is done at Tx UE. |
| Apple | Yes | Similar to Q1, this problem can happen as gNB cannot know all the SL activities among the SL UEs. |
| ZTE | Yes | Same as Q2.1-1a, we agree that due to LCP rules, gNB does not know the selected destination after data multiplexing. |
| Huawei, HiSilicon | Yes | Firstly, As replied to Q2.1-1a, due to destination selection is done at UE side, gNB cannot know which destination starts inactivity timer, RTT timer and possible retransmission timer.  Secondly, gNB does not know whether retransmission timer starts or not without the knowledge of ACK/NACK from Rx UE for FB enabled case.  Thirdly, as rapporteur points out, gNB does not know when RTT timer/retransmission timer starts without the knowledge of FB enabled or disabled.  Therefore, gNB is not aware of active time of each destination due to the uncertainty of retransmission timer. Thus gNB may assign a SL grant that is not in SL active time of any destination that has data to be sent, which is the same result due to uncertainty of inactivity timer as replied to Q2.1-1a. |
| Lenovo | Yes with comments | Similar to Q1, gNB cannot know accurately about the selected LCHs by UE, sometimes misalignment may happen. If this case happens, gNB does not know whether HARQ FB is enabled or disabled for the transmission and will not know the exactly RTT/retransmission timer. |

In phase-1 discussion, the guidance is to start from solution candidate collection.

**Q2.2-1b: If one answer Yes to Q2.2-1a, please briefly describe the solution candidate(s).**

|  |  |
| --- | --- |
| Company | Comments |
| OPPO | We need to allow, **for resource pool configured with PSFCH**, that RTT timer starting position is PSFCH, i.e., the same as for the case of FB-enabled.  The solution can be   1. Either to adopt it for both mode-1/2, so P23 above is not adopted; 2. Or use it for mode-1 only, which means the RTT timer starts from either SCI or PSFCH is configurable per pool, and thus P23 is adopted for mode-2 only (implemented by network configuration); |
| Xiaomi | The mismatch between UE and NW could only happen when there is new data arrival at LCH with higher priority after SL-BSR and before SL grant. This is caused by priority based LCH selection. If we don’t change the priority based LCH selection, which we shouldn’t, the problem would always exist. Anyway, we understand this should not happen frequently as the condition is rather harsh. Therefore, we don’t see a feasible solution with acceptable spec impact. |
| CATT | As answered in Q2.1-1b, in our understanding, there is no need to perform any enhancement on gNB, we only need to let both the destination(s) UE and the Tx UE which SL-BSR is reported keep in active time to wait the sidelink grant from network, which is similar as the current Uu behaviour that the UE should be kept in active time once it send SR. |
| vivo | Similar with reply in Q2.1-1b, the overhead and specification impacts may be not acceptable if the gNB is timely informed with the selected destination and RTT/Retx timer triggering. So no solution seems acceptable. |
| Nokia | Given the limited time in Rel-17 and existing overload situation we do not favour to tackle this issue in Rel-17 by introducing new signalling to inform the gNB by the TX-UE about its selected RX-UE feedback mode and RTT setting. |
| ASUSTeK | We think no spec-changing solution is needed for this issue since it’s a rare case. |
| Apple | As similar to Q1, there will be some glitches for mode 1 TX UE, but it is fine for us to left this to UE implementation to handle the imperfect gNB scheduling. |
| ZTE | Same as Q2, we think this is not a critical issue and can be postponed due to limited time budget in R17. |
| Huawei, HiSilicon | The uncertainty of retransmission timer and inactivity timer brings the same issue that gNB may assign a SL grant that is not in SL active time of any destination that has data to be sent. So the solution replied to Q2.1-1b is common for this issue as well. |
| Lenovo | Similar to the response in Q1, we reluctantly to have optimization for this case. |

Secondly, similar to inactivity timer above, for completion, maybe good to check if any problem at UE side, i.e., if mode-1 Tx UE obtains a SL grant, which is however not in SL active time of any destination that has data to be sent, so how should the UE to behave.

**Q2.2-2a: For RTT/Re-tx timer, for UE, do you agree a mode-1 SL grant may be provided by network to Tx-UE yet it is not in SL active time of any destination that has data to be sent?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| OPPO | Yes | As replied to Q2.1-2a.  The difference is that here for Q2.2-2a, the problem is for re-transmission grant, yet the former one for Q2.1-2a is more for initial transmission grant. |
| Xiaomi | Yes |  |
| CATT | No | As replied to Q2.1-2a.  We think the case mentioned by rapporteur should be should be avoided since it will cause sidelink resource waste.  In order to avoid this, the simplest method is to let the destinations which have reported SL-BSR to network to keep in active time until sidelink grant is received. |
| Ericsson | No | We don’t believe the issue is relevant see our comments for Q2.2-1a |
| InterDigital | No | Same view as Ericsson |
| vivo | Yes with comments | For retransmission, the SL grant may not be wasted since the RX UE with NACK feedback will be in active time triggered by retx timer.  For SL grant of new data, the situation is similar with Q2.1-2a. |
| Nokia | Yes |  |
| Qualcomm | Comment | If the grant is not in SL active time of a destination that has data to be sent, the Tx UE cannot use the grant for this destination’s HARQ retransmission. |
| LG | Comment | As replied to Q2.2-1a, further discussion is also necessary on how to handle a problematic case when some of the scheduled Mode-1 (re-)transmission resources do not overlap with the active time of Mode-1 Tx UE's destination UEs. |
| ASUSTeK | Yes |  |
| Apple | Yes with comment | Yes, but “not in SL active time of any destination” is just TX UE’s own hypothesis, which may not reflect the true status of a destination SL UE. An opportunist TX UE can still choose to use this SL grant. |
| ZTE | Yes |  |
| Huawei, HiSilicon | Yes | As replied to Q2.2-1a, gNB may assign a SL grant that is not in SL active time of any destination that has data to be sent. |
| Lenovo | Yes | As long as gNB cannot accurately knows the RTT/retransmission timer of Rx UE, such issue may occur. |

In phase-1 discussion, the guidance is to start from solution candidate collection.

**Q2.2-2b: If one answer Yes to Q2.1-2a, please briefly describe the solution candidate(s).**

|  |  |
| --- | --- |
| Company | Comments |
| OPPO | Different from Q2.1-2b, here for re-transmission, current spec has not considered the case where SL re-transmission grant has to be discarded even if the buffer is not empty, so a solution is needed, to   * Discard the retransmission grant if the concerned Rx UE is not in DRX active-time * And report NACK to network if PUCCH is configured |
| Xiaomi | The same principle should be applied for retransmission, i.e. the grant should be dropped. |
| vivo | Agree with Xiaomi that the grant can be dropped. |
| LG | If this problematic case occurs, Mode-1 Tx UE drops the MAC PDU (re-)transmission (and/or ignores the Mode-1 SL grant) and reports ACK information via PUCCH if configured. |
| ASUSTeK | The grant can be dropped. |
| Apple | This can be left to UE implementation. It is up to TX UE to drop it or use it. |
| ZTE | Agree with xiaomi. |
| Huawei, HiSilicon | Same as replied to Q2.1-2b. |
| Lenovo | In this case UE will skip or drop the SL grant. This should be specified and not left to UE implementation. |

# Phase-2 discussion

## Inactivity timer

Based on the reply to Q2.1-1a/b, rapp summarize the solution preference into the following options.

**Q3.1-1: For inactivity timer, for gNB, for the issue that “mode-1 Tx UE reports SL-BSR for specific destinations, considering the destination selection is done at UE side, it is hard for gNB to derive the active time for each destination accurately and to provide SL grant accordingly”, what is your preference on the solution?**

**Option-1: no solution needed (either due to it is not a valid problem or due to no feasible solution with acceptable spec impact in Rel-17)**

**Option-2: enhanced SL-BSR based solution, i.e., only report the BS-entries for a destination if the concerned destination is in active-time.**

**Option-3: SL-BSR triggered SL active time extension, i.e., both Tx UE and Rx UE shall keep in SL active time during the period from sending the SL SR/BSR + Tx UE needs to indicate Rx UE to keep in SL active time when SL SR/BSR is sent**

**Option-4: new report to gNB, i.e., Tx-UE inform gNB about the status of the inactivity timer, FFS on the signalling form and signalling content.**

**Option-5: Other (if this is selected, please clarify the solution in details)**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| OPPO | Option-1 or Option-2 | Proponent for option-2  And we are also fine to go for option-1 if that is the majority view. |
| Xiaomi | Option 1 | We understand this issue should not happen frequently as the condition is rather harsh. Therefore, we don’t see a feasible solution with acceptable spec impact. |
| InterDigital | Option 4 (or option 1 otherwise) | We think option 4 is the only reliable way to solve the issue (for the reasons we commented in phase 1). |
| Ericsson | Option 1 or Option 4 | Generally, we think no solutions needed in this release. Since there may be misalignment between UEs, however, if the gNB schedules a grant to the TX UE only when RX UEs are in on-duration time, the issue can be minimized.  However, we are also fine with option 4 if there are majority companies supporting to define some solutions. Option 4 would not require too much efforts for RAN2 to design. |
| Apple | Option 1 | We think there is no perfect solution for this problem. The gain of such a solution is not significant. The TX UE will not be able to track all the “ACTIVE TIME” of a RX UE anyway if the RX UE has engaged with other peer UEs or listening to broadcast/groupcast. |
| Huawei, HiSilicon | Option 2 or Option 5 | One way to solve the issue completely is that UE reports to gNB the selected destination for the SL grant, so that gNB can track the active time of each destination timely.  However, considering other companies’ concern of limited time for spec implementation, we can spend minimum effort to avoid the worst case that UE may keep reporting SL-BSR since gNB assigns SL grants that cannot be used by UE and gNB keeps assigning SL grants out of active time. One way is that UE reports to gNB when active time ends, i.e., all destinations having data to be sent are out of active time. Since gNB knows the start of on-durations, gNB can assign SL grants till start ~~end~~ of on-duration after receiving the report. We think in this way signalling overhead and specification effort would be acceptable. |
| CATT | Option 3 (or option 1 otherwise) | Proponent for option-3  In our understanding, if this problem is not solved, it may cause sidelink resource waste. Option-3 can solve this problem without much specification effort since it is similar as legacy behavior when UE sends SR in Uu, it should keep in active time in Uu.  And we are also fine to go for option-1 if this is the majority view. |
| Spreadtrum | Option 1 | Only Option 4 is a feasible solution. However, Option 4 also brings large spec impact. We prefer no solution in this release. |
| ZTE | Option1 | We think this is not a critical issue since this issue only happens when on-duration timer is not running and we do not see a perfect solution. |
| Lenovo | Option 4 | A transmitter UE informs its serving gNB when a SL DRX Inactivity timer is (re)started. This can be implicitly done by reporting one of the following new information to the serving gNB:   * Total BO that must be transmitted in the current DRX Cycle * BO for each destination reported in their corresponding LCGs for which SL DRX Inactivity timer(s) is started |
| ITL | Option 1 or Option 4 | We think there is no solution to precisely solve the problem. Only Option 4, a method in which the gNB allocates an SL grant based on DRX information, seems to be a possible solution. |
| ASUSTeK | Option 1 |  |
| Qualcomm | Option 1 | Considering spec impact and signaling overhead, not worth fixing a rare corner case. |
| Nokia | Option 1 |  |
| Intel | Option 1 | We agree with Apple that due to how mode 1 inherently works, there may not be a perfect solution here and the proposed solutions incur increased specification impact. |
| vivo | Option 1 |  |
| LG | Option 1 with comment | That might be the case, but we don’t think that this is a critical issue that needs to be optimized by consuming a lot of time considering the current situation where there are still many other fundamental features that shall be finalized to support the SL DRX operation.  If necessary to solve the issue, it would be sufficient for RAN2 to only discuss “how to handle the MAC PDU (re-)transmission/Mode-1 SL grant” and “what information (e.g., ACK or NACK) should be reported via PUCCH if configured”, when some or all of the scheduled Mode-1 (re-)transmission resources do not overlap with the active time of Mode-1 Tx UE's destination UEs. |

Based on the reply to Q2.1-2a/b, rapp summarize the solution preference into the following options

**Q3.1-2: For inactivity timer, for UE, for the issue that “a mode-1 SL grant may be provided by network to Tx-UE yet it is not in SL active time of any destination that has data to be sent”, what is your preference on the solution?**

**Option-1: No solution needed due to it is not a valid problem**

**Option-2: Grant dropping is needed to solve this, and there is no spec impact**

**Option-3: Grant dropping is needed to solve this, and there is spec impact (if this option is selected, please clarify what is the spec impact)**

**Option-4: Left to UE implementation, and there is no spec impact.**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| OPPO | Option-2 and option-3 for different cases | For initial transmission, the current spec already allows UE to drop the grant, so it is option-2.  For re-transmission, the current spec does not allow the UE to drop the grant when the buffer is not empty, even if the Rx-UE is not in DRX active time, so it is option-3. |
| Xiaomi | Option 2 |  |
| InterDigital | Option 1 | With option 4 from the previous question, this is no longer an issue. |
| Ericsson | Option 1 | Agree with InterDigital. |
| Apple | Option 4 | We do not think UE shall be forced to drop a mode 1 grant. If a UE still want to try to use the grant, it shall not be forbidden. This can be up to UE implementation. |
| Huawei, HiSilicon | Option 3 | Considering SL grants dropped can be for initial transmission and retransmission respectively, there are three cases as below.  1) Both initial transmission grant and retransmission grant(s) are not in active time. Under the assumption that no destination is selected for initial grant due to LCP procedure, MAC PDU is not obtained for initial grant. According to existing spec, all grants are skipped and no additional spec impact is seen.  2) Initial transmission grant is in active time while retransmission grant(s) are not in active time (e.g. a SL transmission is not sent due to UL transmission collision). Under the assumption that a destination is selected for initial grant via LCP procedure, MAC PDU is obtained for the grants. According to existing spec, retransmission grant(s) are not dropped. Thus, spec change is needed to ensure retransmission grant(s) that are not in active time are dropped.  3) Initial transmission grant is not in active time while retransmission grant (s) are in active time (e.g. on-duration). Under the assumption no destination is selected for initial grant due to LCP procedure, MAC PDU is not obtained for initial grant. According to existing spec, all grants are skipped. However, we think in this case, retransmission grant(s) which are in active time can still be used to increase resource utilization efficiency. Thus spec change is needed to ensure grants that are not in active time are dropped and grants that in active time can be used. |
| CATT | Option 1 | With option 3 from the previous question, this is not an issue any more. |
| Spreadtrum | Option 2 |  |
| ZTE | Option2 |  |
| Lenovo | Option 3 | For both initial transmission and retransmission, we think define UE behaviour for SL grant that not in active time is clearer. We agree wth the different cases which can occur mentioned by Huawei. . |
| ITL | Option 2 |  |
| ASUSTeK | Option 2 | For initial transmission, the UE should skip a SL grant if no destination is selected in LCP. For retransmission of a SL HARQ process of which HARQ buffer is not empty, the Rx UE should expect a retransmission at the time a retransmission could take place and be in active time based on SL drx retransmission timer, so we think no special handling is needed for this case. |
| Qualcomm | Option 1 or 2 |  |
| Nokia | Option 1 |  |
| Intel | Option 2 | We think that as an unwanted consequence of destination selection and SL grant allocation being handled by different nodes in mode-1, the potential issue of SL grant being allocated during the RX UE’s inactive time is but inevitable. In this case, we think the SL grant can just be dropped and no other spec impact is needed. |
| vivo | Option 2 or 4 |  |
| LG | Option 2 or Option 3 |  |

## RTT/Re-transmission timer

Based on the reply to Q2.2-1a/b, rapp summarize the solution preference into the following options.

**Q3.2-1: For RTT/Re-tx timer, for gNB, for the issue that “for a mode-1 resource pool configured with PSFCH, considering the LCH selection and thus FB enable/disable decision is done at UE side, it is hard for gNB to derive the RTT/Re-tx timer accurately and to provide SL grant accordingly”, what is your preference on the solution?**

**Option-1: no solution needed (either due to it is not a valid problem or due to no feasible solution with acceptable spec impact in Rel-17)**

**Option-2: For resource pool configured with PSFCH, for FB-disabled case, RTT timer starting position can be also PSFCH (either fixed to be PSFCH, or configurable to be either PSFCH or SCI)**

**Option-3: For resource pool configured with PSFCH, for FB-disabled case, RTT timer starting position is fixed to be SCI.**

**Option-4: SL-BSR triggered SL active time extension, i.e., both Tx UE and Rx UE shall keep in SL active time during the period from sending the SL SR/BSR + Tx UE needs to indicate Rx UE to keep in SL active time when SL SR/BSR is sent**

**Option-5: Other (if this is selected, please clarify the solution in details)**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| OPPO | Option-2 or Option-3 | Proponent for option-2  And we are also fine to go for option-3 if majority see no problem for gNB in mode-1 to estimate the FB enable/disable decision by Tx-UE and thus estimate the starting position of RTT timer (PSFCH for FB-enabled and SCI for FB-disabled) before providing SL grant. |
| Xiaomi | Option 1 | We understand this issue should not happen frequently as the condition is rather harsh. Therefore, we don’t see a feasible solution with acceptable spec impact. |
| InterDigital | Option 1 |  |
| Ericsson | Option 1 |  |
| Apple | Option 1 | We think there is no perfect solution for this problem. The gain of such a solution is not significant. The TX UE will not be able to track all the “ACTIVE TIME” of a RX UE anyway if the RX UE has engaged with other peer UEs or listening to broadcast/groupcast. |
| Huawei, HiSilicon | Option 5 | Same as replied to Q3.1-1 |
| CATT | Option 1 | In our understanding, there is no perfect solution for this problem. It does not need to be solved since the similar issue also exists in Uu DRX when HARQ ACK sent by UE is misunderstood as HARQ NACK.  For option.4, it may be from our comment. But in our view, it is not necessary to make any enhancement to this issue, so the option.4 is not needed. |
| Spreadtrum | Option 1 |  |
| Lenovo | Option 1 | The timer value configuration for these two timers can solve this. |
| ITL | Option 1 | In our understanding, when the Tx UE considers LCH selection and FB Enable/Disable decision, a situation arises in which misalignment occurs between the gNB and the UE. In this case, we think that there is no fundamental way to solve the problem unless UE does not transmit unreported data through SL BSR. |
| ASUSTeK | Option 1 |  |
| Qualcomm | Option 1 |  |
| Nokia | Option 1 |  |
| Intel | Option 1 | We share the view from other companies in that this issue may not occur frequently enough and the proposed solutions are not needed. We also agree with CATT that option 4 seems overly restrictive and can probably be removed (if spec impact is a valid concern) |
| vivo | Option 1 |  |
| LG | Option 1 | Same as replied to Q3.1-1. |

Based on the reply to Q2.2-2a/b, rapp summarize the solution preference into the following options

**Q3.2-2a: For RTT/Re-tx timer, for UE, for the issue that “a mode-1 SL grant may be provided by network to Tx-UE yet it is not in SL active time of any destination that has data to be sent” , what is your preference on the solution?**

**Option-1: No solution needed due to it is not a valid problem**

**Option-2: Grant dropping is needed to solve this, and there is no spec impact**

**Option-3: Grant dropping is needed to solve this, and there is spec impact (if this option is selected, please clarify what is the spec impact)**

**Option-4: Left to UE implementation, and there is no spec impact.**

|  |  |  |
| --- | --- | --- |
| Company | Option | Comments |
| OPPO | Option-2 and option-3 for different cases | For initial transmission, the current spec already allows UE to drop the grant, so it is option-2.  For re-transmission, the current spec does not allow the UE to drop the grant when the buffer is not empty, even if the Rx-UE is not in DRX active time, so it is option-3. |
| Xiaomi | Option 3 | We understand retransmission grant should be dropped. |
| InterDigital | Option 1 |  |
| Ericsson | Option 1 |  |
| Apple | Option 4 | We do not think UE shal be forced to drop a mode 1 grant. It can be up to UE implementation. |
| Huawei, HiSilicon | Option 3 | Same as replied to Q3.1-2. |
| CATT | Option 4 |  |
| Spreadtrum | Option 4 |  |
| Lenovo | Option 3 | Same as replied to Q3.1-2 |
| ITL | Option 2 |  |
| ASUSTeK | Option 2 |  |
| Qualcomm | Option 1 or 2 |  |
| Nokia | Option 1 |  |
| Intel | Option 4 |  |
| vivo | Option 2 or 4 |  |
| LG | Option 2 or Option 3 |  |

1. xxx.
2. xxx.

# Conclusion

# References

1. xxx