**3GPP TSG-RAN2 Meeting #116bis Electronic  R2-220xxxx**

**17th January – 25th January 2022**

**Source: Samsung**

**Title: Summary of [AT116bis-e][057][ePowSav] PDCCH Skip (Samsung)**

**Document for: Report and Decision**

**Agenda Item: 8.9.2.4**

# Introduction

This document summarizes the following email discussion.

* [AT116bis-e][057][ePowSav] PDCCH Skip (Samsung)

 Scope: Treat R2-220200, R2-2200187, R2-2201222. Collect comments

Intended outcome: Report, with potential agreements for online CB (and-or Open Issues, can be captured offline).

 Deadline: Tue W2, for online CB

 Deadline for comments: 22:00 UTC, 24th January

# Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
| Company | Name | Email Address |
| Samsung (Rapporteur) | Anil Agiwal | anilag@samsung.com |
| Qualcomm | Linhai He | linhaihe@qti.qualcomm.com |
| LG | Jonggil Nam | jonggil.nam@lge.com |
| Ericsson | Mattias Bergström | Mattias.a.bergstrom@ericsson.com |
| vivo | Chenli | Chenli5g@vivo.com |
| DENSO | Hideaki Takahashi | hideaki.takahashi.j6e@jp.denso.com |
| Intel | Seau Sian Lim | seau.s.lim@intel.com |
| MediaTek | Li-Chuan TSENG | li-chuan.tseng@mediatek.com |
| Xiaomi | Liyanhua | Liyanhua1@xiaomi.com |
| CATT | Pierre Bertrand | pierrebertrand@catt.cn |
| Nokia | Chunli Wu | Chunli.wu@nokia-sbell.com |
| ZTE | Fei Dong | Dong.fei@zte.com.cn |
| Sequans | Noam.cayron | noam.cayron@sequans.com |
| Apple | Sethuraman Gurumoorthy | sethu@apple.com |

# Discussion

RAN1 has discussed PDCCH monitoring adaptation in RRC\_CONNECTED. According to RAN1, PDCCH monitoring adaptation by SSSG switching and PDCCH skipping for a duration is supported.

# PDCCH skipping and SR

According to [1], if the UE has received PDCCH skipping indication and scheduling request (SR) is triggered for BSR (Buffer status report) or BFR (beam failure recovery) or consistent LBT failure and SR is transmitted over PUCCH, UL grant (scheduled by PDCCH) is delayed due to skipping duration. To overcome the issue, it is proposed that PDCCH skipping is cancelled if the PDCCH skipping duration overlaps with SR pending duration.

According to [2], in legacy, UE can perform UL transmission regardless of its DRX state. At end of that UL transmission, UE enters DRX active time because it needs to monitor PDCCH for network’s response. For example, UE may transmit scheduling request (SR) in the middle of DRX off time. As long as that SR is pending, UE monitors PDCCH in anticipation of UL grant from network. It is proposed that UE should ignore PDCCH skipping as long as the SR is still pending.

**Q1. Do companies agree that UE ignores PDCCH skipping (i.e. PDCCH skipping is cancelled) while the SR is pending?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes |  |
| LG | Yes but | PDCCH skipping is for a short term power saving within the DRX mechanism and should be transparanet to MAC. In other words, we think PDCCH skipping would not have any impact to MAC DRX timers or Active Time event. Technically we agree that the MAC shall monitor PDCCH for pending SR regardless of PDCCH skipping, i.e., ignore PDCCH skipping. But we are not sure if that has any impact to MAC given that the PDCCH skipping procedure is to be specified in RAN1 specification. We think whether to ignore or cancel the PDCCH skipping by considering MAC DRX timers or Active Time event is up to RAN1 decision.  |
| Ericsson | Yes |  |
| Samsung | Yes |  |
| vivo | Yes, but | From RAN2 perspective, we see no issue that UE ignores PDCCH skipping while SR is pending. Besides we also agree with LG that it is up to RAN1 decision. |
| DENSO | Yes | Whilst we tend to agree that PDCCH skipping is in the L1 scope, it is also true that RAN1 spec (e.g. 38.213) does not specify the UE behavour while SR is pending. So, it could also be considered to specify this behavior in MAC. |
| Intel | Maybe Yes | We thought that there is a slight difference between ‘ignores’ and ‘is cancelled’. If PDCCH skipping is cancelled, it means that even after SR is not pending, there is still no PDCCH skipping even if it is supposed to be still ongoing. Our understanding is that PDCCH skipping should continue in this case.Current MAC spec has the following:When DRX is configured, the Active Time for Serving Cells in a DRX group includes the time while:- *drx-onDurationTimer* or *drx-InactivityTimer* configured for the DRX group is running; or- *drx-RetransmissionTimerDL* or *drx-RetransmissionTimerUL* is running on any Serving Cell in the DRX group; or- *ra-ContentionResolutionTimer* (as described in clause 5.1.5) or *msgB-ResponseWindow* (as described in clause 5.1.4a) is running; or- a Scheduling Request is sent on PUCCH and is pending (as described in clause 5.4.4); or- a PDCCH indicating a new transmission addressed to the C-RNTI of the MAC entity has not been received after successful reception of a Random Access Response for the Random Access Preamble not selected by the MAC entity among the contention-based Random Access Preamble (as described in clauses 5.1.4 and 5.1.4a).Maybe we just need a general statement regarding how to handle skipping duration and above Active Time definition. For examaple, UE should always monitor PDCCH for the last 3 bullets (FFS which bullets?) irrespective of whether there is skipping duration. |
| MediaTek | Yes, but | We think the UE behavior to “ignore PDCCH skipping while the SR is pending” is reasonable. However, to avoid parallel discussions in two WGs, we think this should be discussed in RAN1. Also we share Intel’s conceren about “ignore” vs. “cancel”; we need to dscribe the UE behavior accurately in the spec. |
| Xiaomi | - | According to RAN1:* At most 2 bit indication in self-scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) can be specified for triggering the PDCCH monitoring adaptation in a single cell
	+ FFS: the bit size of the indication is configurable
	+ FFS: bit mapping to the PDCCH monitoring behaviour
	+ FFS: details of indication of multiple cells case
	+ A new indication field in scheduling DCI is used for indicating PDCCH monitoring adaptation

If the skipping is carried on the scheduling DCI, then I guess the UE can use the grant right? Then the UE will not need to ignore the skiping indication.If the skipping is only carried in a DCI for only skipping without grant, we agree that UE can take the same way as in DRX.So it is a little bit early for RAN2 to discuss this. We would rather to wait for more RAN1 input on UE ‘s behaviour of receiving the skipping. |
| CATT | Yes | Agree with LG’s point that it may remain transparent to MAC. |
| Nokia | Yes | RAN2 should decide. |
| ZTE | Yes, but | Agree with LG’s analysis, we think RAN2 can confirm UE must cancel the PDCCH skipping when SR is pending, but the ultimate conclusion shall be decided in RAN1. |
| Sequans | Yes, but | Agree with LG. Agree that PDCCH should be ignored, not cancelled. |
| Apple | Yes |  |

3.2 PDCCH skipping and Random access

According to [1], Skipping duration can also overlap with a) RAR/MsgB reception window or b) duration when contention resolution timer is running which may result in missing PDCCH for RAR/MsgB or Msg3 retransmission or Msg4. To overcome the issue, it is proposed that PDCCH skipping is cancelled if the PDCCH skipping duration overlaps with RAR/MsgB window. PDCCH skipping is cancelled if the PDCCH skipping duration overlaps with duration while contention resolution timer is running. Similarly, [2] proposes that UE should ignore PDCCH skipping as long as it is within a RAR window or a MsgB response window or as long as contention resolution timer is running.

**Q2. Do companies agree that UE ignores PDCCH skipping (i.e. PDCCH skipping is cancelled) during the RAR/MsgB window?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes |  |
| LG | Yes | See Q1 comment  |
| Ericsson | Yes |  |
| Samsung | Yes |  |
| vivo | Yes  |  |
| DENSO | Yes |  |
| Intel | Maybe Yes | See comments to Q1 |
| MediaTek | Yes | See comments to Q1 |
| Xiaomi | - | See Q1 comment |
| CATT | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes | See Q1 comments |
| Sequans | Yes | See Q1 comments |
| Apple | Yes |  |

**Q3. Do companies agree that UE ignores PDCCH skipping (i.e. PDCCH skipping is cancelled) while contention resolution timer is running?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes |  |
| LG | Yes but | See Q1 comment  |
| Ericsson | Yes |  |
| Samsung | Yes |  |
| vivo | Yes  |  |
| DENSO | Yes |  |
| Intel | Maybe Yes | See comments to Q1 |
| MediaTek | Yes | See comments to Q1 |
| Xiaomi | - | See Q1 comment |
| CATT | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes | See Q1 comment |
| Sequans | Yes | See Q1 comments |
| Apple | Yes |  |

* 1. PDCCH skipping and HARQ

In [2] it is proposed UE should ignore PDCCH skipping as long as UL HARQ reTx timer is running

**Q4. Do companies agree that UE ignores PDCCH skipping (i.e. PDCCH skipping is cancelled) while UL HARQ reTx timer is running?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes |  |
| LG | Yes but | See Q1 comment  |
| Ericsson | Yes |  |
| Samsung | Yes |  |
| vivo | No | As we have learned from RAN1, RAN1 is discussing the issue related to Q4. Whether this question is valid depends on the outcome of RAN1 discussion. For example, if RAN1 agreed to apply PDCCH spkipping after HARQ-ACK, this case doesn’t exist, so there is no need to discuss this issue. Thus, we think this issue is somehow premature. We could wait for RAN1 discussion first. Otherwise inconsistency may occur.  |
| DENSO | Yes |  |
| Intel | Maybe Yes | See comments to Q1 |
| MediaTek | Yes | See comments to Q1 |
| Xiaomi | - | See Q1 comment |
| CATT | Yes |  |
| Nokia | Yes |  |
| ZTE | Yes | See Q1 comment |
| Sequans | Yes | See Q1 comments |
| Apple | Maybe Yes | Should we wait for RAN1 discussion on this one ? |

* 1. PDCCH skipping and CSI/SRS transmissions

According to [2],

* If network tells UE to skip PDCCH monitor for a period of time, UE will not expect to be scheduled with DL assignment or UL grant during the skipped duration. However, periodic or semi-persistent CSI (P/SP-CSI) or periodic or semi-persistent SRS transmission would continue. If the skipped duration is not too long (e.g. comparable with the periodicity of CSI or SRS), CSI and SRS transmissions are still useful, because they can give network the latest channel measurements and help network make scheduling decisions once PDCCH skipping ends. However, if the skipped duration is long (e.g. longer than several transmission occasions of CSI or SRS), it is wasteful for UE to continue transmitting CSI or SRS during the skipped duration. It is more efficient if network can configure a threshold on PDCCH skipping duration over which UE is allowed to either skip or relax its periodic or semi-persistent CSI or SRS transmissions.

**Q5. Do companies agree that Network can configure a threshold on PDCCH skipping duration over which UE may skip and relax its periodic or semi-persistent CSI or SRS transmissions?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes | Proponent |
| LG | No | We think PDCCH skipping is mainly for a short time scale power saving, which was also RAN2 understanding according to RAN2#106 agreement

|  |
| --- |
| RAN2#106 Agreement (R2-1908601)* DCI-based PDCCH monitoring skipping is aimed to operate on a short time scale (i.e. shorter time scale then the L2 DRX). Under this condition, it has not been identified that DCI-based PDCCH monitoring skipping duplicates the DRX functionality.
 |

Therefore, we don’t see a need for further optimizing CSI/SRS transmission based on PDCCH skipping duration.[QC] RAN1 have agreed that the maximum skipping duration can be up to 100ms, which is about the same length as typical DRX cycles. In current DRX procedure, CSI and SRS are not transmitted during DRX off time, because they are not needed for scheduling and that helps save UE power. We think the same prinicple should be applied to PDCCH skipping – if network is not going to schedule UE for a long period of time, then there is no need for UE to transmit CSI and SRS during that period. The following is the RAN1 agreement on the range of PDCCH skipping duration.Agreement* For value X in Beh 1A, candidate skipping values are
	+ Up to [100ms] length is supported,
		- The X is configured and indicated in the unit of slot.
			* Working assumption for candidate values for X
				+ {1,2,3,…,20,30, 40, 50, 60, 80, 100} for 15 kHz SCS,
				+ {1,2,3,…,40, 60, 80, 100, 120,160,200} for 30 kHz SCS,
				+ {1,2,3,…,80, 120, 160, 200, 240, 320,400} for 60kHz SCS,
				+ {1,2,3,…,160, 240, 320,400, 480, 640,800} for 120kHz SCS
	+ FFS: Equal to or longer than the applicable minimum scheduling offset
	+ FFS: additional symbol level / PDCCH monitoring period level skipping duration
 |
| Ericsson | No | Optimization -> We don’t do optimizations.[QC] In our understanding, optimization is an enhancement that requires complicated implementation but has marginal benefits. Our proposal reuses the principle of a legacy procedure. So its benefits can be expected. Implementation wise, it requires only a new threshold, which hardly is any complicated, unless that is Ericsson’s guideline for “complicated implementation”.  |
| Samsung | No | Agree with Ericsson |
| vivo | No | We can leave this issue to RAN1, since RAN2 has no idea on how long the time of PDCCH skipping duration will last. If we can’t determine whether the issue will occur, how can we agree whether the enhancement will be needed. |
| DENSO | No | Agree with LG. |
| Intel | No | We do not see this as essential |
| MediaTek | No | This is not a must |
| Xiaomi | NO | In RAN2 #106, we have agreed:DCI-based PDCCH monitoring skipping is aimed to operate on a short time scale (i.e. shorter time scale then the L2 DRX). Under this condition, it has not been identified that DCI-based PDCCH monitoring skipping duplicates the DRX functionality.We need to clarify whether the case is valid first. |
| CATT | No | Agree with LG + this is no time for optimizations. |
| Nokia | No |  |
| ZTE | No |  |
| Sequans | Yes | Agree with QC. Since from previous questions it seems we are anyway going to send an LS to RAN1, and since CSI-RS/SRS are anyway in their purview, we think it would be good to add this concern. We can continue from there once we have their response. |
| Apple | No |  |

* 1. PDCCH skipping and DCP

According to [2],

* In legacy, UE is not required to monitor a DCP occasion during DRX active time. But since UE does not monitor PDCCH during PDCCH skipping, it is worth discussing whether UE should monitor DCP occasions during skipping. If a skipping duration is short, it is not power efficient for UE to have extra wakeup during skipping and monitor DCP, because UE soon will resume PDCCH monitoring anyway. On the other hand, if a skipping duration is long (e.g. comparable with a DRX cycle or even longer), then it makes sense for UE to monitor a DCP occasion, in case of there are new data arrival. Therefore, DCP monitoring during PDCCH skipping should also be made conditional on the length of the skipping duration.

**Q6. Do companies agree that Network can configure a threshold on PDCCH skipping duration over which UE monitors DCP occasions during PDCCH skipping?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes | Proponent |
| LG | - | It is RAN1 issue. Even from RAN2 perspective, we don’t see a need for furthe optimization of PDCCH skipping given that PDCCH skipping is mainly for a short term power saving.  |
| Ericsson | - | Agree with LG |
| Samsung | No |  |
| vivo | No | We think introducing a threshold is over-engineered, easier method can be considered, e.g., allowing the UE to monitor DCP in PDCCH skipping or introduing indications to control whether monitoring DCP in PDCCH skipping duration.  |
| DENSO | - | Agree with LG |
| Intel | No | We do not see this as essential |
| MediaTek | No | This is not a must |
| Xiaomi | - | We need to first clariy whether skipping duration is long enough. We think it maybe valid for skipping duration to overlap with the DCP associated with the next DRX cycle. But overlapping with following several DRX cylces is the rare case.So the current spec can resolve this as described in Q7. |
| CATT | No | Agree with LG. Both DCP and PDCCH skipping are under NW control, which should operate both consistently. |
| Nokia | No |  |
| ZTE | No |  |
| Sequans | No, but | Agree with CATT. Monitoring DCP seems to contradict the purpose of PDCCH skipping. We assume that for the cases discussed above where PDCCH skipping should be ignored, DCP is monitored as well. |
| Apple | No |  |

According to [3], in Rel-17, the DCP can be skipped by the DCI based power saving, that is, the DCP for the corresponding DRX period cannot be received from lower layer in the skipping period. It is proposed to reuse the *ps-Wakeup* to indicate whether the UE should start the *drx-onDurationTimer* when the corresponding DCP is skipped due to PDCCH skipping or SSSG switch. No specification change is needed.

**Q7. Do companies agree to reuse the *ps-Wakeup* to indicate whether the UE should start the *drx-onDurationTimer* when the corresponding DCP is skipped due to PDCCH skipping or SSSG switch. No specification change is needed?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | No | In our view, whether to monitor DCP within a PDCCH skipping period is better to be conditioned on the duration of the skipping. Since the duration is dynamically signaled instead of RRC configured, relying on a flag (ps-wakeup) to control monitor or not is not efficient. |
| LG | Yes but | PDCCH skipping should be transparent to MAC, which means the MAC entity does not care whether the UE is currently in PDCCH skipping duration or not. In this regards, the MAC behaviour regarding *ps-Wakeup* can be maintained.  |
| Ericsson | Yes | Agree with LG. |
| Samsung | Yes |  |
| vivo | - | In our understanding, whether/how to configure the skipping is up to network. If network wants UE to monitor DCP, then, PDCCH skipping will not be configured or the timer duration will be shorter. In this way, there is no need to discuss this issue.Besides, as mentioned by other companies, we are fine to not change anything in the spec. In this way, this could be naturally covered by the existing specification, as the description of “ps-wakeup” is as follow:*Indicates the UE to wake-up if DCI format 2-6 is not detected outside active time (see TS 38.321 [3], clause 5.7)* *If the field is absent, the UE does not wake-up if DCI format 2-6 is not detected outside active time.* |
| DENSO | Yes | Agree to reuse the existing behaviour. |
| Intel | Yes | As long as there is no spec change |
| MediaTek | Yes |  |
| Xiaomi | Yes | If the DCP is skipped by PDCCH skipping, then no DCP will be detected by PHY according to 213:If a UE is provided search space sets to monitor PDCCH for detection of DCI format 2\_6 in the active DL BWP of the PCell or of the SpCell and the UE does not detect DCI format 2\_6, the physical layer of the UE does not report a value of the Wake-up indication bit to higher layers for the next long DRX cycle.And according to *300, we have captured:*In addition, the UE may be indicated, when configured accordingly, whether it is required to monitor or not the PDCCH during the next occurrence of the on-duration by a DCP monitored on the active BWP. If the UE does not detect a DCP on the active BWP, it does not monitor the PDCCH during the next occurrence of the on-duration, unless it is explicitly configured to do so in that case.Then, UE will not start the next conduration. That is also the NW wants since skiping means it is likey there is no data coming.If people want to follow ***ps-Wakeup,*** we are OK as long as there is no specification change is needed. |
| CATT | Yes | Agree with LG. Anyways, no specification change is needed. |
| Nokia | - | Should discuss the desired behavior first. Whether the skipping periodic overlap with DCP is under NW control anyway. If it overlaps and the UE does not monitor DCP, the UE can skip the following onduration.OTOH, PHY can also indicate DCP as 1 to MAC when it is missed as per current specification, and MAC starts the OnDuration Timer. If it is still within the skipping period, the UE will not monitor PDCCH anyway, but it would not impact other activities during the Onduration like CSI measurement/report. |
| ZTE | Proponent  | Yes with LG’s comments, it shall be the same as Rel-16. |
| Sequans | Yes | R16 reuse is better |
| Apple | Yes |  |

* 1. SSSG Switching

In [2], it is proposed that network can configure which SSSG UE shall use when it starts DRX on duration or activates a new BWP (including the first active DL BWP of a newly activated SCell). If the configuration is absent, UE uses the default SSSG. Network can always use DCI to switch UE to the best SSSG upon state transition, but it certainly comes with extra signaling cost and longer scheduling delay (e.g. in case the default SSSG is in use before a state transition, it takes longer to UE to get the switching DCI).

**Q8. Do companies agree that network can configure which SSSG UE shall use when it starts DRX on duration or activates a new BWP (including the first active DL BWP of a newly activated SCell). If the configuration is absent, UE uses the default SSSG?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes | Proponent |
| LG | No | It is RAN1 issue. |
| Ericsson | - | It is RAN1 issue. |
| Samsung | No | It is RAN1 issue. |
| vivo | No | It is RAN1 issue |
| DENSO | - | It is RAN1 issue. |
| Intel | No | Again this is not an essential change. It can just use the default SSSG |
| MediaTek | No | It is RAN1 issue. |
| Xiaomi | - | It is a optimization. Whether the NW can configure the first SSSG should depends on the gain. We prefer to discuss this in RAN1. |
| CATT | - | RAN1 issue. |
| Nokia | See comment | Ok for OnDuration. Not needed for new BWP. |
| ZTE | - | This is RAN1 issue |
| Sequans | - | Generally is fine, but it is a RAN1 issue |
| Apple | - | It is for RAN1 to discuss and decide |

* 1. Assistance Information

According to [2], UE should be allowed to indicate its preferred configurations/parameters for adaptive PDCCH monitoring. More specifically, UE should be allowed to request its preferred set of PDCCH skipping duration(s) and SSSG switch timer via UE Assistance Information. It is proposed that, UE can request its preferred skipping duration(s) and SSSG switch timer via UE Assistance Information.

**Q9. Do companies agree that UE can request its preferred skipping duration(s) and SSSG switch timer via UE Assistance Information?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No ?** | **Comments** |
| Qualcomm | Yes | Proponent |
| LG | No | PDCCH skipping is to make the UE not to monitor the PDCCH when the network has not more DL data. Only network knows DL scheduling and there is nothing that UE can assist DL scheduling.  |
| Ericsson | No | Optimization -> We don’t do optimziations. |
| Samsung | No |  |
| vivo | No | Postpone. |
| DENSO | No | Not sure the gain to optimise such a short time scale action |
| Intel | No | We do not see this as essential at this late stage. |
| MediaTek | No |  |
| Xiaomi | No |  |
| CATT | No | Agree with LG and Ericsson. |
| Nokia | No | NW can decide based on traffic characteristics. |
| ZTE | No |  |
| Sequans | No | Agree with LG and DENSO, this seems too complicated for a short skip, where most of the information is on NW side anyway |
| Apple | No |  |

# Conclusion

**TBD**

# Reference

[1] R2-2200200, PDCCH Skipping in RRC\_CONNECTED Samsung Electronics Co., Ltd discussion

[2] R2-2200187, Enhancements for adaptive PDCCH monitoring Qualcomm Incorporated discussion

[3] R2-2201222, Initial Discussion on DCI based Power Saving ZTE Corporation,Sanechips