3GPP TSG RAN WG1#106bis-e R1-2110406

e-Meeting, October 11th – 19th, 2021

Source: Moderator (vivo)

Title: FL summary#1 of DCI-based power saving adaptation

Agenda Item: 8.7.2

Document for: Discussion and Decision

# Introduction

This contribution is a summary of the AI 8.7.2.

* Section 2 is a list of the issues to be discussed/decided.
* Section 3 is void.
* Section 4 is a summary of previous meeting agreements.
* Section 5 is a summary of proposals from companies’ contributions submitted.
* Section 6 is void.
* Section 7 is the decription of WI.
* Section 8 is the reference documents.
* Section 9 is the history of the FL summary.

# Issue list

## Issues#1: UE Behaviours

### Initial proposals

Yes: CMCC, InterDigital, MediaTek, vivo, ZTE, Sanechips, Spreadtrum

No: Panasonic

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| **[High] Proposal 1-1 (v1)**  Confirm the working assumption:   * Beh 1: PDCCH skipping is not activated |

Yes: ASUS, vivo, Apple, APT, CMCC, DoCoMo, InterDigital, MediaTek, NEC, Nokia, NSB, Nordic, Samsung

No: CATT, ETRI

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| **[High] Proposal 1-2 (v1)**  Confirm the working assumptions:   * At most 3 SSSGs is supported to be configured for PDCCH monitoring adaptation. |

Yes: CMCC, InterDigital, MediaTek, vivo, Samsung

No: ETRI

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| **[High] Proposal 1-3 (v1)**  Confirm the working assumptions:   * Beh 2B: stop monitoring SS sets associated with SSSG#0 and SSSG#1 and monitoring of SS sets associated to SSSG#2. |

Yes: APT, ETRI(with revisions), InterDigital, MediaTek, vivo, Panasonic

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| **[High] Proposal 1-4 (v1)**  Confirm the working assumption:   * Indication of Beh 1A for current SSSG when two SSSG(s) are configured is supported |

Only one company [Panasonic] indicate to support indication of Beh 1A when three SSSG(s) (if supported) are configured.

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| **[Medium] Proposal 1-5 (v1)**  Indication of Beh 1A when three SSSG(s) (if supported) are configured is supported. |

CMCC, Huawei, HiSilicon, vivo propose to define typical combinations for PDCCH monitoring adaptation, among which gNB configures one of the combinations of UE behaviors.

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| **[High] Proposal 1-6 (v1)**  For scheduling DCI indication based PDCCH monitoring adaptation, UE can be configured by RRC signaling to support one of the following PDCCH monitoring adaptation configurations,   * Configuration 1 (i.e., PDCCH skipping)   + Indicated UE Behaviors are Beh 1 and 1A * Configuration 2 (i.e., 2 SSSG switching)   + Indicated UE Behaviors are Beh 2 and 2A * Configuration 3 (i.e., 3 SSSG switching)   + Indicated UE Behaviors are Beh 2, 2A and 2B * Configuration 4 (i.e., 2 SSSG switching with PDCCH skipping)   + Indicated UE Behaviors are Beh 1, 1A, 2 and 2A |

Further discussion on the details of bit mapping (mainly pure RAN1 impact) is needed.

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| **[High] Proposal 1-7 (v1)**   * For configuration 1 (i.e., PDCCH skipping)   + 1-bit in scheduling DCI is supported to indicate PDCCH monitoring adaptation UE behaviors     - ‘0’ is Beh 1 and ‘1’ is Beh 1A * For configuration 2 (i.e., 2 SSSG switching)   + 1-bit in scheduling DCI is supported to indicate PDCCH monitoring adaptation UE behaviors     - ‘0’ is Beh 2 and ‘1’ is Beh 2A * For configuration 3 (i.e., 3 SSSG switching)   + 2-bit in scheduling DCI is supported to indicate PDCCH monitoring adaptation UE behaviors     - ‘00’ is Beh 2     - ‘01’ is Beh 2A     - ‘10’ is Beh 2B     - ‘11’ is reserved * For configuration 4 (i.e., 2 SSSG switching with PDCCH skipping)   + 2-bit in scheduling DCI is supported to indicate PDCCH monitoring adaptation UE behaviors     - ‘00’ is Beh 1     - ‘01’ is Beh 1A     - ‘10’ is Beh 2     - ‘11’ is Beh 2A |

Other proposals from individual company

LGE

***Proposal 4: Bit mapping to the monitoring behavior and/or bit size of indication of monitoring adaptation can be differently configured for each DCI format.***

***Proposal 5: 0, 1, and 2 bit indication of monitoring adaptation can be flexibly configured for DCI format x\_2.***

Panasonic

**Proposal: When a search space is not configured with any SSSG ID, UE continues monitoring PDCCH in this search space without being impact by the DCI-based PDCCH monitoring adaptation.**

### Companies views (1st round)

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| **Company** | **Comment** |
| Nordic | We are fine to confirm 1-1 1-2 1-3 and 1-4 as package and move forward. But if no concesus to do so, fall-back to 1A standalone, and 2/2A standalone.  Moreover, it should be clarified, e.g. by a note, that configuring SS-group or SS-set with zero monitoring candidates is not explicitelly precluded. Since, specification supports it nowadays.  In general it is fine to go with P 1-6, given that we confirm 1-1 1-2 1-3 and 1-4  Regarding P 1-7 we cannot support signalling of Configuration 4, we believe that default SSG timer should be reset every time DCI with indication is received. Then there will not be interaction between PDCCH skipping duration and SSG switching, which simplifies the feature.   * For configuration 4 (i.e., 2 SSSG switching with PDCCH skipping)   + 2-bit in scheduling DCI is supported to indicate PDCCH monitoring adaptation UE behaviors     - ‘00’ is Beh 2 + Beh 1     - ‘01’ is Beh 2 + Beh 1A     - ‘10’ is Beh 2A + Beh 1     - ‘11’ is Beh 2A + Beh 1A |
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## Issues#2: Monitoring Type 0/1/1A/2 CSS

### Initial proposals

Yes to monitor Type0/0A/1/2-PDCCH: Nokia, NSB, vivo, Panasonic

No: Huawei, HiSilicon, LGE, MediaTek

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| **[High] Proposal 2-1 (v1)**  PDCCH monitoring adaptation should not be applied to Type0/0A/1 or 2 PDCCH CSS. |

### Companies views (1st round)

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| **Company** | **Comment** |
| Nordic | PDCCH based monitoring adaptation is ~~limited~~applied to USS and type-3 CSS.  We have above agreement, no need to rediscuss. Monitoring adaptation does not apply during Paging widnwo, RACH window, …. i.e. UE monotirs all the RNTI in these windows. |
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## Issues#3: SSSG switching

### Initial proposals

**Timer from non-default ro default SSSG**

For a transition from SSSG1 to SSSG0 and SSSG2 to SSSG0, a similar mechanism with Rel. 16 SSSG-switching feature is adopted.

Apples thinks the timer can be optionally configured for non-default SSSG. If not configured, the UE continues monitoring current SSSG until explicit switching command is sent.

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| **[High] Proposal 3-1 (v1)**   * UE fallbacks to default SSSG (i.e., SSSG#0) after timer expiration is supported.   + Timer can be optionally configured. |

**Values for SSSG switching timers**

Rel-16 configuration of timer has maximum 20ms length and doesn’t support 120kHz.

Ericsson thinks existing Rel-16 value ranges of SSSG switching timer (e.g. max 20 ms) can be insufficient for some use cases e.g. for timer-based switching from sparse SSSG to dense SSSG when DRX IAT is running. Hence for Rel. 17 PDCCH monitoring adaptation, extended value range of SSSG switching timer (compared to Rel-16) is supported. FFS : detailed values.

Apple thinks to support configured a large value until next DRX cycle to allow UE to stay.

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| **[High] Proposal 3-2 (v1)**   * The value of the timer in slots for monitoring PDCCH in the active DL BWP of the serving cell before moving to the default search space group is   + {1…20} for 15 kHz SCS,   + {1...40} for 30 kHz SCS,   + {1…80} for 60kHz SCS,   + {1…160} for 120kHz SCS,   + Note: For 15 kHz, 30kHz, 60kHz SCS, the value range is as the same as Rel-16 *searchSpaceSwitchingTimer-r16* |

**Configuration of SSSG switching timers**

Per SSSG timer: Apple, CMCC, Ercisson, Qualcomm, vivo

Per BWP/cell timer: Huawei, HiSilicon (per cell), Lenovo, Nokia, NSB(per BWP)

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| **[High] Proposal 3-3 (v1)**   * Separate RRC configuration for timer value(s) is supported for switching from SSSG#2 to SSSG#0 and from SSSG#1 to SSSG#0 respectively. |

**DCI dynamically indicates a timer duration from multiple RRC configured values**

Yes: ASUS, vivo, Nordic

No: MediaTek

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| **[High] Proposal 3-4 (v1)**   * Scheduling DCIs indicating PDCCH schedules data can be configured to dynamically indicate a timer duration among at most *N* RRC configured values for the switched SSSG, UE switches back to default SSSG after timer expired.   + Alt 1: Z bits is configured for scheduling DCIs for indicating timer duration   + Alt 2: the bits for indicating PDCCH monitoring adaptation also indicating timer duration. Details FFS   + FFS: *N* |

**Timer for non-default SSSG to non-default SSSG switching**

Apple wants to enable non-default SSSG to non-default SSSG switching.

**Timer for default SSSG to non-default SSSG switching**

**Others**

Apple proposed that PDCCH skipping can be triggered from either default SSSG, or non-default SSSG. When triggered from non-default SSSG, the non-default SSSG timer freeze during skipping duration.

Companies are encouraged to provide answer to the following questions

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| **[Medium] Questions 3-5 (v1)**   * + Q1: whether and how to support t**imer for non-default SSSG to non-default SSSG switching**   + Q2: whether and how to support t**imer for default SSSG to non-default SSSG switching**   + Q3: other issues? |

### Companies views (1st round)

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| **Company** | **Comment** |
| Nordic | 3-1 someone wants to remove this feature from specification? We are puzzled  3-2 we believe that lower bound could be reduced to 10ms or even 5ms  3-3 Support  3-4 Depends on outcome of P 1-7 |
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## Issues#4: PDCCH skipping duration

### Initial proposals

**Possible values for skipping durations**

DoCoMo: applicable minimum scheduling offset

MediaTek: skipping duration X in the range of [2ms, 200ms]. FFS granularity

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| **[High] Proposal 4-1 (v1)**   * For value X in Beh 1A, candidate skipping values are   + in the range of [2ms, 200ms]   + including possibility to skip current DRX if DRX is configured.   + FFS: Equal to or longer than the applicable minimum scheduling offset |

**DCI dynamically indicates a value of the skipping duration from multiple RRC configured values**

Yes: Ericsson, Huawei, HiSilicon, Intel, Nordic, vivo, ZTE, Sanechips, OPPO, Panasonic, Spreadtrum

No: MediaTek

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| **[High] Proposal 4-2 (v1)**   * For Beh 1A,   + The UE can be configured to be indicated by DCI a value of X slots (i.e., skipping duration) among at most *M* RRC configured values by scheduling DCIs indicating PDCCH schedules data     - the bits for indicating PDCCH monitoring adaptation also indicating skipping duration. Details FFS     - FFS: *M* = 2 or 3 |

**Skipping duration configuration**

* Per SSSG
  + Apple, Huawei, HiSilicon (SSSG is configured), InterDigital
* Per BWP
  + CMCC, Ericsson, Huawei, HiSilicon (SSSG is not configured), Nokia, NSB, Samsung

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| **[High] Proposal 4-3 (v1)**   * For Beh 1A,   + Different skipping duration can be configured per SSSG. |

### Companies views (1st round)

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| **Company** | **Comment** |
| Nordic | 4-1 upper bound should be reduced to 20ms or even 10 ms , and to skip DRX MAC-CE can be used already.  4-2 depends on P 1-7, and also could be considered as package with P 3-4  4-3 should be considered together with P3-4 and 4-2 when discussing unified signlaling framework. |
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## Issues#5: Interaction with HARQ

### Initial proposals

Nordic, Samsung, Qualcomm, Huawei/Hisilicon, LGE, ZTE/Sanechips, DOCOMO, MTK, IDCC, Nokia, CMCC, Fraunhofer, Lenovo/Motorola Mobility, vivo thinks monitoring adaptation interaction with retransmission/HARQ-ACK and etc is needed.

Intel thinks PDCCH monitoring adaptation should not be dependent on HARQ outcome or PUSCH transmission.

* ***Recommendations*** : continue working on the specification impact. Companies are encouraged to further revise the proposal.

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| **[High] proposal 5-1 (v1):**   * + After being indicated to skipping PDCCH monitoring adaptation (e.g., by PDCCH skipping or dormant/empty SSSG), the UE still performs PDCCH monitoring for HARQ retransmission at least during a ‘retransmission period’.     - FFS: start and end of ‘retransmission period’       * Alt 1: When triggered by DL DCI, the start and end of ‘retransmission period’ is defined as HARQ-ACK condition is satisfied         + FFS HARQ-ACK condition, e.g., the start of ‘retransmission period’ is when the UE transmit NACK       * Alt 2: the start and end of ‘retransmission period’ is defined as         + Alt 2a: the start of *drx-RetransmissionTimerDL(UL)* and expiration of *drx-RetransmissionTimerDL(UL)* respectively if DRX is configured.         + Alt 2b: the start of *drx-HARQ-RTT-TimerDL(UL)* and expiration of *drx-RetransmissionTimerDL(UL)* respectively if DRX is configured.     - FFS How to perform PDCCH monitoring during the retransmission period, e.g.,       * UE switch to another SSSG, e.g., default SSSG or a SSSG specially configured only for retransmission period .       * UE suspends or stops PDCCH skipping.       * UE performs discontinuously PDCCH monitoring according to the roundtrip and retransmission timers to receive any HARQ retransmissions       * Others not precluded |

### Companies views (1st round)

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| **Company** | **Comment** |
| Nordic | Deprioritize discussion after basic functionality is finalized |
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## Issues#6: Application delay

### Initial proposals

**Scheduling DCI**

Companies are encouraged to provide answers to the following questions.

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| **[High] Questions 6-1 (v1)**  Whether sperate application delay definition is needed for   * Q1: PDCCH skipping (i.e., Switching between Beh 1/1A) and SSSG switching (i.e., Switching between Beh 1/1A/2/2A/2B) * Q2: Downlink grant and uplink grant * Q3: Scheduling DCI and non-scheduling DCI (if supported) |

**Non-scheduling DCI**

For non-scheduling DCI, Apple and LGE provides proposals as follows,

Apple

* *Proposal 12: When PDCCH monitoring adaptation is triggered by non-scheduling DCI, application delay for SSSG switching is 25 OFDM symbols for , and 39 OFDM symbols for .*
* *Proposal 13: When PDCCH monitoring adaptation is triggered by non-scheduling DCI, application delay for PDCCH skipping is 11 OFDM symbols for , and 25 OFDM symbols for .*

LGE proposes to time-based application delay if monitoring adaptation is indicated by a DCI without scheduling information.

**Summary of the proposals for different cases**

* Scheduling DCI
  + PDCCH skipping
    - Downlink grant
      * Option a: Nokia, NSB, ZTE, Sanechips
      * Option b: Lenovo, MotM, Samsung
      * Option d: Apple, ETRI, LGE, OPPO, Samsung
      * Option f: Ericsson, Qualcomm, CATT, vivo, Spreadtrum
      * Option g: Samsung
    - Uplink grant
      * Option a: Nokia, NSB, ZTE, Sanechips
      * Option b: Lenovo, MotM, Samsung
      * Option c: Apple(no DRX), LGE
      * Option h: Apple(DRX)
      * Option f: Ericsson, Qualcomm, CATT, vivo, Spreadtrum
      * Option g: Samsung
  + SSSG Switching
    - Downlink grant
      * Option a: Nokia, NSB, Qualcomm(with revision), vivo, ZTE, Sanechips
      * Option b: Samsung
      * Option d: Apple, Ercisson, ETRI, Huawei, HiSilicon, LGE, Samsung
      * Option g: Samsung
    - Uplink grant
      * Option a: Nokia, NSB, Qualcomm(with revision), vivo, ZTE, Sanechips
      * Option b: Samsung
      * Option c: Apple(no DRX), Huawei, HiSilicon, LGE
      * Option h: Apple(DRX)
      * Option g: Samsung
* Non-scheduling DCI
  + Option a with different value for SSSG switching and skipping: Apple
  + Time-based application delay: LGE

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| **[High] proposal 6-2 (v1):**   * Further consider the following application delay for PDCCH adaptation,   + Option a: the application timelines provided in Table 10.4-1 in TS38.213 for search-space group switching for unlicensed band form is reused.     - for SCS configuration , FFS X = 25 or 39     - FFS:   + Option b: the application delay needed for PDCCH processing for Rel-16 minimum application delay for K0min/K2min indication is reused/extended.   + Option c: PDCCH monitoring adaptation command applies after PUSCH transmission if triggered by UL DCI   + Option d: PDCCH monitoring adaptation command applies after HARQ-ACK transmission (or plus some margin for HARQ-ACK decoding).   + Option e: after successfully decoding TB.   + Option f: Application delay should be “ZERO” for PDCCH monitoring adaptation. PDCCH monitoring adaptation would be applied after UE receive the additional PDCCH monitoring adaptation control signaling bit(s) in DCI   + Option g: Application delay(s) are configured via RRC signaling   + Option h: Application delay applies after drx-RetransmissionTimerUL expires * FFS reference points for the application time * FFS whether the same or different and howapplication delay(s) should be used for SSSG switching and PDCCH skipping functions * FFS whether the same or different and how application delay for PDCCH monitoring adaptation indicated by DCI and timer expiration |

Samsung pointed out that to avoid scheduling delay, UE should be able to continue receiving scheduling DCI before applying any PDCCH monitoring adaptation. However, the UE doesn’t expect receive a different or a new trigger for PDCCH monitoring adaptation during the application delay period.

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| **[Medium] proposal 6-3 (v1):**  UE doest not exepct to receive different PDCCH monitoring adaptation indications during the application time. |

### Companies views (1st round)

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| **Company** | **Comment** |
| Nordic | We believe that for PDCCH skipping and SSG without PDCCH candidates application delay can be left up to implementation.  Option i: Leave up to implementation. |
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## Issues#7: non-scheduling DCI based PDCCH monitoring adaptation

### Initial proposals

Support of proposal 7-1: Spreadtrum, Qualcomm, CMCC, ETRI, Intel, Apple, Nokia, NSB, CATT

Object of proposal 7-1: MediaTek

* ***Recommendations*** : continue working on the specification impact. Companies are encouraged to provide further proposals w.r.t specification impact.

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| **[Medium] proposal 7-1 (v1):**   * PDCCH does not schedules data and indicates SSSG switching or PDCCH skipping for an active BWP in active time is supported by   + DCI Format 1\_1 (SCell dormancy case 2 like) |

For proposal 7-2:

* Outside active time:
  + Support: Lenovo/MotM, Qualcomm, LGE, ETRI
  + Object: MediaTek
* Inside active time:
  + Support: Huawei/HiSilicon, LGE, Intel, Apple
  + Object: MediaTek

And some companies think we should deprioritize proposal 7-2 at this moment.

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| **[Medium] proposal 7-2 (v1):**   * DCI format 2\_6 outside active time is supported to indicate SSSG switching or PDCCH skipping for an active BWP in active time when DRX is configured. * DCI format 2\_6 being received in active time is supported to indicate SSSG switching or PDCCH skipping for an active BWP in active time when DRX is configured. |

### Companies views (1st round)

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| **Company** | **Comment** |
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## Issues#8: details of indication of multiple cells case

Agreement

* 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

### Initial proposals

Apple

***Proposal 8: When DCI format 0-1, 0-2, 1-1 and 1-2 is used to trigger PDCCH monitoring adaptation, the adaptation is applied to all CCs within a CC group.***

APT:

**Proposal 2: A single PDCCH monitoring adaptation indication for multiple cells should be supported.**

CMCC

**Proposal 6. The scheduling DCI is used to only indicate the PDCCH monitoring behaviour of the same serving cell as the scheduled PDSCH/PUSCH.**

Ericsson

**Proposal 7 Support intercell indication for PDCCH monitoring adaptation.**

Huawei, HiSilicon

***Proposal 6: Reuse/extend dormancy indication field in scheduling DCI to indicate PDCCH monitoring adaptation, at least indicate PDCCH skipping for a duration.***

MediaTek

***Proposal 8: To reduce the signaling overhead, the indication of multi-cell is not supported.***

Qualcomm

***Proposal 6: In the CA scenario, for the joint adaptation across CCs, carrier-group-based PDCCH monitoring adaptation is considered.***

* ***Recommendations*** : continue working on the specification impact. Companies are encouraged to provide further proposals w.r.t specification impact.

### Companies views (1st round)

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| **Company** | **Comment** |
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## Issues#9: Others

### Initial proposals

**SR/RACH**

Support of proposal 9-1/9-2 Huawei/HiSilicon, Qualcomm, LGE, Nokia/NSB(SR only), CMCC ZTE/Sanechips, APT

* ***Recommendations***: FL recommend companies continue discussion on the aspects from this and previous discussions:
  + BSR status needs to be considered
  + Power saving gain being shown on these proposal.
  + the system does work without these function and we see them as optimization.
  + implicit switching by SR/RACH should be limited during PDCCH skipping/empty SSSG

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| **[Medium] Proposal 9-1 (v1):**  PDCCH monitoring adaptation triggered by SR is supported.  **[Medium] Proposal 9-2 (v1):**  PDCCH monitoring adaptation by RACH is supported. |

**Default SSSG for DRX On**

Support: Ericsson, DoCoMo, ETRI, Nokia, NSB

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| **[Medium] Proposal 9-3 (v1)**  For UE configured with DRX, higher layer signaling can configure SSSG that a UE monitors when coming out of DRX to monitor an ON duration. |

**Others**

* Ercisson

***Proposal 12 The SSSG that a UE monitors after skipping duration ends is explicitly configured by RRC or is indicated by the PDCCH monitoring adaptation bitfield in the DCI.***

* Huawei, HiSilicon

***Proposal 11: To simplify UE’s implementation,*** ***UE ignores the PDCCH adaptation field in the DCI received during a skipped duration.***

***Proposal 14: When bwp-InactivityTimer is configured, it needs further discussion on how to minimize the impact on bwp-InactivityTimer triggered BWP switching due to PDCCH skipping.***

***Proposal 15: If PDCCH skipping/SSSG switching and BWP switching are indicated simultaneously by the same scheduling DCI, the behavior indicated by the DCI is one of the behaviors configured on the target BWP***

* ***For PDCCH skipping, the indicated value of the skipped duration is one of the values configured on the target BWP;***
* ***For SSSG switching, the indicated SSSG is one of the SSSG on the target BWP.***

***Proposal 16: In case of a scheduling DCI indicating PDCCH skipping and BWP switching simultaneously, it should be discussed on the application time when the UE starts PDCCH skipping.***

* Nordic

***Proposal-4:*** *When a UE receives a first PDCCH indication to switch to a non-default SSG containing zero SS-sets, UE does not expect to receive second PDCCH in USS or TYPE-3 after the first PDCCH and before the end of SSG switching application delay (defined in R16).*

***Proposal-8:*** *UE expects that in indicated row, a timer initial value is always greater than skipping duration.*

* Samsung

**Proposal 1: Support a default PDCCH monitoring behaviour when the PDCCH skipping duration X expires, based on the following alternatives:**

* **Alt1: UE monitors all configured search space sets,**
* **Alt2: UE monitors default SSSG.**

### Companies views (1st round)

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| **Company** | **Comment** |
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# Void

# Summary of the previous agreements

*RAN1#102-e*

Agreements:

* Reusing power model in TR38.840 for evaluation of DCI-based power saving adaptation schemes.
  + Note: company reporting additional power model for missing state or update is not precluded.

Agreements:

* Company should report assumptions used for periodic measurement activities for the Rel-17 DCI-based power saving adaptation evaluation.
  + The periodic activities defined in TR38.840 can be reused.
  + Measurement for RLM/BFD every C-DRX cycle can be optionally modelled

Agreements:

* The performance metrics described in TR38.840 section 8.2 is reused for power saving evaluation of Rel-17 DCI-based power saving adaptation during ActiveTime.
* The following Rel-15 / 16 features is recommended of the power consumption as reference for baseline. Company can report the feature(s) being used in the baseline.
  + DRX
    - C-DRX cycle 40msec for VoIP
      * 10ms IAT, 8ms On-duration
      * Assume max two packets bundled
    - C-DRX cycle 160msec for FTP
      * Alt 1: 20 msec IAT, 8ms On-duration
      * Alt 2: short DRX
        + 20 ms [or 40ms as optional] IAT, 8ms On-duration
        + 20 ms for short DRX cycle, 4 cycles
      * Note: 100 msec IAT, 8ms On-duration can also be used with sufficient justifications that available Rel-15/16 Techniques being used to reduce UE power saving
  + DCP for DRX adaptation,
    - DCP offset  to DRX ON = 2 ms, other values are not precluded
  + Cross-slot scheduling adaptation
    - Minimum K0 can be adapted from 0 to 1 for FR1, 0 to [4] for FR2
  + BWP switching, including
    - MIMO layer adaptation,
      * Max # of MIMO layer can be adapted from 4 layer to 2 layer for FR1, 2 layer to 1 layer for FR2
    - PDCCH monitoring period adaptation
      * PDCCH monitoring period can be adapted from per slot monitoring to X slot monitoring
        + X = [2] for FR1 and [8] for FR2
    - Bandwidth adaptation
      * Bandwidth can be adapted from 100MHz to 20MHz for FR1,FFS for FR2
    - Note:
      * BWP transition time type 2 is assumed, BWP transition duration is
        + 5 slot @ 30kHz SCS for FR1,
        + 18 slot@120kHz SCS for FR2
        + the slot-average power level for BWP transition duration is according to TR38.840
        + BWP transition time type 1 can be optional modelled
      * BWP switching is Y (ms) after last packet/data burst.
        + Y = [8], other values are not precluded
      * Whether BWP switching is modeled depends on the assumed UE capability and evaluated schemes.
  + Scell dormancy assumption for CA capable UEs
    - FR1 & FR2: SCell dormancy with [160 ms] periodic CSI measurement and reporting
* Other settings
  + CA assumption if configured for CA capable UEs
    - For FR1, FFS
    - For FR2, 4\*100MHz can be considered.
  + Assumptions for scheduler
    - For FR1, no restriction on the beam assumptions being used in each slot
    - For FR2, up to each company, e.g., gNB equally schedule the slots for UEs targeting to different beams.
    - Note: the assumptions does not necessary mean to restrict or precluded any implementation. Other assumptions are not precluded and can be reported by companies.
  + Company to report the used assumption for the interruption and also power savings impact due to presence/absence of interruptions .

Agreements:

Legacy traffic models in TR38.840 can be considered for Rel-17 DCI-based power saving adaptation evaluation, other traffic models can be optionally modelled and company report which traffic model(s) is used.

Draft LS is approved (with generic RAN2 action), with final LS in [R1-2007419](file:///C:/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_102/Docs/R1-2007419.zip).

*RAN1#103-e*

Agreements:

Observation:

* Each of the following schemes is individually shown to be beneficial for UE power saving compared to the baseline.
  + Dynamically switching search space set
  + Dynamically skipping PDCCH monitoring for a certain duration or until next DRX ON
* At least the following Rel-15 and/or Rel-16 power saving solutions have been utilized for baseline,
  + For eMBB traffic,
    - DRX setting(including using short DRX or long DRX with a short IAT or long IAT), Wake-up signal, Cross-slot scheduling, CA/Scell dormancy, MAC-CE skipping, BWP switching
  + For VoIP traffic,
    - DRX setting(only long DRX cycle with a short IAT), Wake-up signal,  Cross-slot scheduling, MAC-CE skipping
  + For IM traffic,
    - DRX setting(long DRX cycle [with a short IAT]), Wake-up signal
  + For intensive eMBB traffic,
    - DRX setting(including using short DRX or long DRX with a short IAT), Wake-up signal, Cross-slot scheduling, [CA/Scell dormancy], MAC-CE skipping, BWP switching
    - Note: intensive eMBB traffic is optional and companies may use FTP model 3 with different packet size and mean data arrival time, e.g., 15ms, 30ms, 50ms or 100ms.
* Note 1: For Search space switching, switching from 1slot monitoring to 2, 4, 8, 10, 16 or 32 slot with 30kHz SCS (FR1) and 120kHz (FR2) is utilized.
* Note 2: For PDCCH skipping , skipping 2ms, 4ms, 5ms, 8ms, 15ms, 16ms, 32ms,  64ms or to next DRX cycle is utilized
* Note 3: the baseline assumed may vary across companies

Agreements:

* **Specify at least one of the following options for Rel-17 dynamic PDCCH adaptation ~~in time-domain~~ for active time,**
  + **Option 1: Search space set group switching,e.g., ~~potential adjustments/enhancements for~~including explicit and implicit search spaceset group switching ~~specified in R16 for NR-U~~**
  + **Option 2: PDCCH skipping for a certain duration / DRX cycle**
* **FFS: which option(s)~~(e.g. taking into account additional gain of option 1 over option 2, or vice-versa)~~**
* **Candidate DCI formats for dynamic PDCCH adaptation include DCI formats 1\_1(including scheduling and non-scheduling DCI), 0\_1, 1\_2, 0\_2, 2\_0, 2\_6.**
* **Note:**
  + **Companies are encouraged to provide analysis on specification impact, power saving benefit and system impact (e.g., packet latency, system overhead)**
* **FFS: other schemes are not precluded for further study**

*RAN1#104-e*

Agreements:

* Strive for a common design for DCI based PDCCH monitoring adaptation in active time for an active BWP to support functionalities inclusive of both SSSG switching and PDCCH skipping for a duration.
  + Details FFS

Agreements:

* Further study whether and how to minimize the impact to data scheduling for new transmissions and retransmissions.
  + FFS details
* Further study the application delay for PDCCH adaptation indication

Agreements:

For DCI based PDCCH skipping in active time for an active BWP (if supported), the following can be further considered,

* Explicit indication of PDCCH adaptation
  + Scheduling DCI
    - Format 1\_1
    - Format 0\_1
    - Format 0\_2/1\_2
  + Non-scheduling DCI
    - Format 2\_6 in active time
    - Format 2\_0
    - Format 1\_1 (SCell dormancy case 2)
  + additional indication mechanism
    - By reusing Rel-16 SCell dormancy indication when CA is configured, FFS details
    - By reusing Rel-16 cross-slot scheduling indication when R16 cross-slot scheduling is configured, FFS detailds
* DCI dynamically indicates a duration/periodic interval for skipping
  + FFS: how to indicate the duration/period interval, e.g., number of slots or skipping current DRX
* PDCCH skipping for a duration indicated by minimum scheduling offset
* Others are not precluded

Agreements

* For DCI based SSSG switching in active time for an active BWP (if supported), the following can be further considered,
  + Explicit indication of PDCCH adaptation
    - Scheduling DCI based
      * Format 1\_1,
      * Format 0\_1,
      * Format 0\_2/1\_2
      * ~~Format 1\_0~~
    - Non-scheduling DCI ~~supported by vivo, Samsung~~
      * Format 2\_6 in active time
      * Format 2\_0
      * ~~Format 1\_0~~
      * Format 1\_1 (SCell dormancy case 2)
    - additional indication mechanism
      * By reusing Rel-16 SCell dormancy indication when CA is configured, FFS details
      * By associating Rel-16 cross-slot scheduling indication when R16 cross-slot scheduling is configured, FFS detailds
    - DCI dynamically indicates a duration ~~period~~ for the switched SSSG, UE switch back to previous/default SSSG after duration ends~~timer expried~~
  + Timer-based SSSG switching, including RRC configured a timer, UE switch back after timer expired.
  + SSSG activation/deactivation
  + FFS: Implicit SSSG switching
    - SSSG switching triggered by SR
    - SSSG switching triggered by RACH
    - Default SSSG that a UE monitors when coming out of DRX to monitor an ON duration.
* FFS: whether/how to support SSSG switching for multiple groups of cell(s).
* FFS: whether/how to support SSSG switching in active time with DCP outside active time
* FFS: whether / how to support more than 2 SSSGs,
  + FFS: number of SSSGs
* FFS: a search space set group to emulate PDCCH skipping
* Others are not precluded

Agreements:

* The following alternatives can be considered for DCI based PDCCH monitoring adaptation in active time for an active BWP for power saving
  + Alt 1: Enhancement of Rel-16 SSSG switching to support PDCCH monitoring adaptation including skipping for a duration
  + Alt 2a: Enhancement of DCI(s) utilized for Rel-16 power saving adaptation for supporting both skipping PDCCH monitoring for a duration and SSSG switching
  + ~~Alt 2b: Enhancement of DCI(s) utilized for Rel-16 power saving adaptation for supporting both skipping PDCCH monitoring for a duration and PDCCH monitoring periodicity adaptation~~
  + Others not precluded

*RAN1#105-e*

Agreement:

* PDCCH schedules data and also indicates PDCCH monitoring adaptation by SSSG switching and PDCCH skipping for a duration is supported.
  + At least DCI format(s) 1-1, 0-1, 1-2 and 0-2 can be used for the indication(s)

Agreement:

* ~~At least~~ one of  Alt 1 and Alt 2 is supported, to be decided in RAN1#106,
* Alt 1: Supporting SSSG  switching to emulate PDCCH skipping functionality,
  + Alt 1-1: by an ‘empty’ SSSG which no SS set(s) is configured for the ‘empty’ SSSG, UE does not monitoring PDCCH on the ‘empty’  SSSG,
  + Alt1-2: by a ‘dormant SSSG’ which may have associated SS sets, and monitored conditionally (e.g., depending on HARQ NACK or RTT/ReTx timers)
* Alt 2: PDCCH schedules data and also indicates PDCCH monitoring adaptation by PDCCH skipping for a duration is supported.
  + FFS details, including
    - e.g., joint / separate indication of SSSG switching and PDCCH skipping
    - Determination of the duration(s) for PDCCH skipping, e.g.,
      * by RRC signaling,
      * by DCI indication
      * Implicitly, to the end of C-DRX active time

Agreement:

At least SSSG#0 and SSSG#1 switching is supported for Rel-17 SSSG switching indicated by PDCCH scheduling data and/or timer.

* FFS: support of more than 2 SSSGs

*RAN1#106-e*

Agreement

* 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

Agreement

Select either package 1 or package 2

Package 1

·       UE behavior after receiving PDCCH indication of monitoring adaptation can be one of the followings,

* + - Working Assumption: Beh 1: PDCCH skipping is not activated
    - Beh 1A: PDCCH skipping means stopping PDCCH monitoring for a duration X
      * FFS the possible values for X
      * FFS: Whether and how to support more than one skipping duration(s)
      * FFS: whether to continue monitoring PDCCH scrambled by C-RNTI for Type 0/1/1A/2 CSS or not
    - Beh 2: stop monitoring SS sets associated with SSSG#1 and SSSG#2 (if confirmed and configured) and monitoring  of SS sets associated to SSSG#0 (legacy behaviour)
    - Beh 2A: stop monitoring SS sets associated with SSSG#0 and SSSG#2 (if confirmed)  and monitoring  of SS sets associated to SSSG#1 (legacy behaviour)
    - Working Assumption: Beh 2B(if confirmed): stop monitoring SS sets associated with SSSG#0 and SSSG#1 and monitoring  of SS sets associated to SSSG#2 (if confirmed)

·       Note: The number of supported SSSG is left to UE feature discussion.

·       FFS: UE capability of supported UE behaviors

·       Indication of Beh 1A when SSSG(s) are not configured is supported.

·       Working assumption: Indication of Beh 1A for current SSSG when two SSSG(s) are configured is supported

·       FFS: Indication of Beh 1A when three SSSG(s) (if supported) are configured

·       Y bits is configured for scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) indicating PDCCH schedules data and also PDCCH monitoring adaptation

* + - FFS how the UE behavior(s) defined above mapping to Y bits

§  Note: at most Y = 2

·       Working Assumption at most 3 SSSGs is supported to be configured.

* + - FFS: whether or how SSSG can be configured to be monitored conditionally (e.g., depending on HARQ NACK or RTT/ReTx timers)
    - FFS: whether or how non-default SSSG to another non-default SSSG

·       FFS details of timer(s) for switching between SSSG(s)

* + - UE fallbacks to default SSSG (i.e., SSSG#0) after timer expiration.
    - R16 timer for SSSG switching and the corresponding behavior is as baseline

·       FFS whether the timer(s) is configured per SSSG, ~~or~~per BWP or other approaches.

·       FFS whether the skipping duration(s) is configured per SSSG, per BWP, or other approaches.

·       FFS PDCCH monitoring adaptation indicated by non-scheduling DCI

·       PDCCH based monitoring adaptation is ~~limited~~applied to USS and type-3 CSS.

Package 2 (Alt 1 and Alt 2)

* If alt 1 is supported,
  + supporting SSSG  switching to emulate PDCCH skipping functionality by an ‘empty’ SSSG (i.e. Alt 1-1)or ‘dormant’ SSSG(i.e. Alt 1-2)
    - Y bits is configured for scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) indicating SSSG index.
      * FFS dynamic indication of ~~initial~~ timer value(s)
      * FFS details
    - At most [3] SSSGs is supported to be configured.
      * Note: including‘empty’ SSSG or ‘dormant’ SSSG
    - ~~FFS support of single timer to switch to default SSSG#0  or support of multiple timers between SSSGs~~
    - FFS whether one or more of the following timer(s) is supported for switching between
      * Option 1: Non-default SSSG to default SSSG (i.e., SSSG#0)
      * Option 2: Non-default SSSG to another non-default SSSG
      * Option 3: Default SSSG (i.e., SSSG#0) to non-default SSSG(s)
    - FFS: down selection between ‘empty’ SSSG (i.e. Alt 1-1)or ‘dormant’ SSSG(i.e. Alt 1-2)
    - ~~FFS: whether ‘empty’ SSSG and ‘dormant’ SSSG, can be looked as a skipping duration and whether to introduce a SSSG state.~~
    - FFS: whether the timer is configured per SSSG, per BWP, or other approaches.
    - ~~FFS: whether multiple timer duration(s) can be configured by RRC, and DCI dynamically indicates a timer duration~~
    - ~~FFS: do we need to define default SSSGs and for what purpose?~~
    - Note: description of ‘empty’ SSSG and ‘dormant’ SSSG has been provided in RAN1#105-E
* If alt 2 is supported,
  + PDCCH schedules data and also indicates PDCCH monitoring adaptation by PDCCH skipping for a duration is supported.
    - Y bits is configured for scheduling DCIs (i.e., DCI format 1-1/0-1/1-2/0-2) indicating PDCCH monitoring adaptation ~~(including  SSSG index, and/or PDCCH skipping duration(s))~~
      * ~~Alt 2-1:~~
        + FFS: Determination of the duration for PDCCH skipping, e.g.,

One skipping duration configured by RRC signaling,

Multiple candidate values of skipping duration configured by RRC signaling and use DCI to dynamically indicate one of the configured skipping duration

by specification

* + - * + FFS: possible value(s) of the duration
        + FFS: joint or separate indication with SSSG switching
      * ~~Alt 2-3:~~
        + FFS: whether introduce SSS/SSSG specific skipping indication via e.g. bitmap, codepoint, joint indication with a minimum scheduling offset value
    - FFS: whether the skipping duration is configured per SSSG, per BWP, or other approaches.
    - FFS: PDCCH skipping indicated by non-scheduling DCI
    - FFS: interaction with SSSG switching (when configured), e.g. impact to skipping when SSSG timer expires, which SSSG after PDCCH skipping is monitored, etc.

Agreement

Package 1 in above agreement is selected.

# Proposals from companies’ submitted contributions

## Huawei, HiSilicon

1. **R1-2108746Extensions to Rel-16 DCI-based power saving adaptation for an active BWP Huawei,** **HiSilicon**

***Observation 1: Do not support empty/dormant SSSG in Rel-17, considering Behavior 1A is already supported in the agreed package 1 and the combination of behaviors 1A/2/2A can be configured if it is intended to use PDCCH skipping and SSSG switching together.***

***Observation 2:*** ***The value of skipping duration(s) should be configured per BWP to make it work without SSSG configuration.***

***Observation 3:*** ***For the combination of behaviors 1/1A, up to 3 durations can be configured per BWP to give gNB more flexibility.***

***Observation 4: For the combination of Beh 1A/Beh 2/Beh 2A where two SSSGs are enabled, different skipping granularities can be configured/defined for different SSSGs to indicate PDCCH skipping which is more efficiently and gives gNB more flexibility.***

***Observation 5：PDCCH monitoring adaptation indicated by group common DCI format is beneficial，e.g., DCI format 2\_6 inside DRX active time, if there is no data transmission.***

According to the discussions, we have the following proposals.

***Proposal 1: Specify the typical combinations of UE behaviors, i.e., combination of behaviors 1/1A, behaviors 1A/2/2A, behaviors 2/2A and behaviors 2/2A/2B (if Beh 2B is confirmed), among which gNB configures one of the combinations of UE behaviors.***

***Proposal 2: Support reporting the supported combinations in combination of behaviors 1/1A, behaviors 1A/2/2A, behaviors 2/2A and behaviors 2/2A/2B (if Beh 2B is confirmed) by UE capability.***

***Proposal 3: The PDCCH skipping duration is N\* “skipping granularity”, where***

* ***N is indicated by a codepoint in DCI, which is one of per BWP configured values.***
  + ***For the combination of Beh1A/Beh 2/Beh 2A, the number of N can be up to 2;***
  + ***For the combination of Beh 1/Beh 1A, the number of N can be up to 3.***
* ***If SSSG is configured in a BWP, “skipping granularity” is configured/defined per SSSG in the BWP;***
* ***If no SSSG is configured, “skipping granularity” is defined as 1 slot in the BWP.***

***Proposal 4: UE skips PDCCH monitoring for DCI with CRC scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI in Type 0/1/1A/2 CSS during the skipped duration.***

***Proposal 5: the legacy timer-based SSS switching is reused:***

* ***In case 2 SSSGs are configured, if UE receives a DCI indicating SSSG1, the UE starts PDCCH monitoring according to SS set associated to SSSG 1 and the UE sets the timer;***
* ***In case 3 SSSGs are configured, if UE receives a DCI indicating SSSG1 or SSSG2, the UE starts PDCCH monitoring according to SS sets with group index 1 or 2 and the UE sets the timer;***
* ***Regardless current SSSG for UE is SSSG1 or SSSG2, when the timer expires, the UE fallbacks to SSSG0;***
* ***The timer for SSSG switching is configured per cell.***

***Proposal 6: Reuse/extend dormancy indication field in scheduling DCI to indicate PDCCH monitoring adaptation, at least indicate PDCCH skipping for a duration.***

***Proposal 7: Extend MCS/NDI/RV/HARQ process number/antenna port/DMRS sequence initialization field used for SCell dormancy case 2 to indicate PDCCH monitoring adaptation.***

***Proposal 8: Support group common DCI, e.g. DCI format 2\_6 inside DRX active time, to indicate PDCCH skipping and SSSG switching.***

***Proposal 9: Support different application delay for SSSG switching and PDCCH skipping：***

* ***If DCI indicates the UE switching to another SSSG, UE applies the DCI after HARQ-ACK feedback for DCI with DL grant or PUSCH transmitting for DCI with UL grant;***
* ***If DCI indicates the UE to skip PDCCH monitoring, the application delay is max(applicable K0min, Z), after which the UE stops monitoring PDCCH in a duration.***

***Proposal 10: After being indicated to skipping PDCCH monitoring, if the HARQ feedback for PDSCH is NACK, the UE still performs PDCCH monitoring for HARQ retransmission when drx-RetransmissionTimerDL is running.***

***Proposal 11: To simplify UE’s implementation,*** ***UE ignores the PDCCH adaptation field in the DCI received during a skipped duration.***

***Proposal 12: UE monitors PDCCH for retransmission scheduling if the HARQ retransmission timer of any HARQ process is running during an indicated skipping duration.***

***Proposal 13: Support SSSG switching or terminate PDCCH skipping triggered by SR and RACH.***

***Proposal 14: When bwp-InactivityTimer is configured, it needs further discussion on how to minimize the impact on bwp-InactivityTimer triggered BWP switching due to PDCCH skipping.***

***Proposal 15: If PDCCH skipping/SSSG switching and BWP switching are indicated simultaneously by the same scheduling DCI, the behavior indicated by the DCI is one of the behaviors configured on the target BWP***

* ***For PDCCH skipping, the indicated value of the skipped duration is one of the values configured on the target BWP;***
* ***For SSSG switching, the indicated SSSG is one of the SSSG on the target BWP.***

***Proposal 16: In case of a scheduling DCI indicating PDCCH skipping and BWP switching simultaneously, it should be discussed on the application time when the UE starts PDCCH skipping.***

## ZTE, Sanechips

1. **R1-2108867 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTE, Sanechips**

[**Observation 1: For PDCCH adaptation, the processing time for responding DL SPS PDSCH release needs to be considered.**](#_Toc24323)

[**Observation 2: When cross-slot scheduling is applied for the UE, the delay for applying the PDCCH adaptation does not need to consider the minimum scheduling offset.**](#_Toc6913)

[**Proposal 1: Whether UE supports PDCCH skipping function and/or SSSG switching function should be determined by UE capability.**](#_Toc1267)

[**Proposal 2: The working assumptions about Beh 1 should be confirmed.**](#_Toc21430)

[**Proposal 3: If the working assumption about Beh 2B is confirmed, whether more than 2 SSSGs is supported should be determined by UE capability.**](#_Toc32667)

[**Proposal 4: Support multiple PDCCH skipping durations. The multiple durations can be configured by RRC signaling and indicated by DCI dynamically.**](#_Toc4110)

[**Proposal 5: Support the mapping method for PDCCH skipping in Table 1.**](#_Toc19519)

[**Proposal 6: For SSSG switching, timer-based triggering mechanism for SSSG switching can be reused to simplify the specification work.**](#_Toc4413)

[**Proposal 7: A skipping timer used for PDCCH adaptation from SSSG monitoring to PDCCH skipping should be considered in the cases of PDCCH monitoring adaptation without DCI indication.**](#_Toc20228)

[**Proposal 8: UE should switch to a default SSSG after the end of PDCCH skipping duration, wherein the default SSSG should be configured by RRC signaling to adapt to various traffic models.**](#_Toc17179)

[**Proposal 9: A flag field used to enable one of the indication information of SSSG switching and PDCCH skipping can be introduced.**](#_Toc9088)

[**Proposal 10: The UE should monitor PDCCH for retransmission data, but it does not monitor PDCCH for an initial transmission data during the PDCCH skipping period.**](#_Toc15746)

[**Proposal 11: The UE should monitor PDCCH according to all of search space sets configured in the DL active BWP or search space sets in a default SSSG when the following events occur during a skipping duration.**](#_Toc10844)

[**• SR indicated by the UE,**](#_Toc11744)

[**• beam failure detection, or**](#_Toc5387)

[**• random access procedure in RRC connected mode due to out-of sync, etc.**](#_Toc23189)

[**Proposal 12: The application delay for PDCCH adaptation for μ=0/1/2 can reuse that of SSSG switching in Rel-16. The minimum value of application delay for PDCCH adaptation for μ=3 can be 25 symbols.**](#_Toc26689)

## Spreadtrum Communications

1. R1-2108918 Discussion on power saving techniques for connected-mode UEs Spreadtrum Communications

Rel-17 SSSG switching technique

***Proposal 1: The wakeup indication for Rel-17 SSSG switching technique should be down prioritized.***

***Proposal 2: The state machine for Rel-17 SSSG switching technique should be down prioritized, or simplified as much as possible.***

***Proposal 3: The application delay for Rel-17 SSSG switching technique can be defined.***

Rel-17 PDCCH skipping technique

***Proposal 4: The wakeup indication for Rel-17 PDCCH skipping technique is not supported.***

***Proposal 5: The state machine for Rel-17 PDCCH skipping technique is not supported.***

***Proposal 6: The application delay for Rel-17 PDCCH skipping technique is zero.***

Scheduling DCI

***Proposal 7: The bits size for indication in self-scheduling DCI is configurable.***

***Proposal 8: PDCCH skipping and Rel-17 SSSG switching should be separately triggered by DCI.***

***Proposal 9: The indication of PDCCH skipping and Rel-17 SSSG switching in cross-cell scheduling DCI means that PDCCH skipping or Rel-17 SSSG switching occurs in the source cell.***

***Proposal 10: Confirm the working assumption that Behaviour 1 is supported.***

***Proposal 11: Up to 4 codepoints, including Behaviour 1 and up to 3 skipping durations for Behaviour 1A, are supported for PDCCH skipping.***

DCI fields

***Proposal 12: Consider also the following DCI fields for PDCCH that schedules data and also indicates PDCCH monitoring adaptation by SSSG switching and PDCCH skipping.***

* ***Reusing the Rel-16 indication of cross-slot scheduling***
* ***Reusing the Rel-16 Indication of SCell dormancy***

Non-scheduling DCI with C-RNTI scrambling

***Proposal 12: Support the non-scheduling DCI with C-RNTI scrambling that indicates PDCCH monitoring adaptation by SSSG switching and PDCCH skipping.***

## vivo

1. R1-2108988 Discussion on DCI-based power saving adaptation in connected mode vivo

**Proposal 1:**Confirm the working assumption:

* Beh 1: PDCCH skipping is not activated

**Proposal 2:** Confirm the working assumptions:

* At most 3 SSSGs is supported to be configured.
  + Note: the configuration of Rel-17 SSSGs is per BWP.
* Beh 2B: stop monitoring SS sets associated with SSSG#0 and SSSG#1 and monitoring of SS sets associated to SSSG#2.

**Proposal 3:** Confirm the working assumption:

* Indication of Beh 1A for current SSSG when two SSSG(s) are configured is supported

**Proposal 4:** Indication of Beh 1A when three SSSG(s) (if supported) are configured is not supported.

**Proposal 5:** UE can be configured by RRC signaling to support one of the following PDCCH monitoring adaptation mode and agree the following table of the PDCCH monitoring adaptation mode, UE Behaviors, bits for indicating UE behaviors in DCI and codepoint mapping for each mode.

|  |  |  |  |
| --- | --- | --- | --- |
| **PDCCH monitoring adaptation mode** | **Indicated UE Behaviors** | **Bits for indicating UE behaviors in DCI** | **Codepoint mapping** |
|
| **Mode 1**  Note: PDCCH skipping | 1, 1A | 1-bit | 0: Beh 1  1: Beh 1A |
| **Mode 2**  Note: 2 SSSGs switching | 2, 2A | 1-bit | 0: Beh 2  1: Beh 2A |
| **Mode 3**  Note: 3 SSSGs switching | 2,2A,2B | 2-bit | 00: Beh 2  01: Beh 2A  10: Beh 2B  11: reserved |
| **Mode 4**  Note: 2 SSSGs switching with PDCCH skipping | Alt 1: 1, 1A, 2, 2A; | 2-bit | Alt 1  00: Beh 1  01: Beh 1A  10: Beh 2  11: Beh 2A |
| Alt 2: 1A, 2, 2A; | Alt 2  00: Beh 1A  01: Beh 2  10: Beh 2A  11: reserved |

**Proposal 6:** Type0/0A/1/2-PDCCH CSS monitoring is not impacted by Rel-17 PDCCH monitoring adaptation

**Proposal 7**

* Scheduling DCIs indicating PDCCH schedules data can be configured to dynamically indicate a timer duration among *N* RRC configured values for the switched SSSG, UE switches back to default SSSG after timer expired.
  + Alt 1: Z bits is configured for scheduling DCIs for indicating timer duration
  + Alt 2: the bits for indicating PDCCH monitoring adaptation also indicating timer duration. Details FFS
  + FFS: *N*

**Proposal 8**

* The value of the timer in slots for monitoring PDCCH in the active DL BWP of the serving cell before moving to the default search space group is
  + For 15 kHz SCS, {1…20}
  + For 30 kHz SCS, {1...40}
  + For 60kHz SCS, {1…80}
  + For 120kHz SCS, {1…160}
  + Note: For 15 kHz, 30kHz, 60kHz SCS, the value range is as the same as Rel-16 *searchSpaceSwitchingTimer-r16*
* Separate RRC configuration for timer value(s) is supported for switching from SSSG#2 to SSSG#0 and from SSSG#1 to SSSG#0 respectively.

**Proposal 9**

* For Beh 1A,
  + The UE can be configured to be indicated by DCI a value of X slots (i.e., skipping duration) among *M* RRC configured values by scheduling DCIs indicating PDCCH schedules data
    - FFS: *M* = 2 or 3
    - Candidate skipping values:
      * For 15 kHz SCS, {1...20}
      * For 30 kHz SCS, {1…40}
      * For 60kHz SCS, {1…80}
      * For 120kHz SCS, {1…160}
      * skipping current DRX
    - Alt 1: W bits is configured for scheduling DCIs for indicating skipping duration
    - Alt 2: the bits for indicating PDCCH monitoring adaptation also indicating skipping duration. Details FFS, e.g., Beh 1A-1 for skipping duration 1 and Beh 1A-2 for skipping duration 2.

**Proposal 10:** the following additional mechanisms is supported for SSSG switching when interaction with HARQ in case UE receives the PDCCH in SSSG 0 indicating SSSG switching from 0 to 1,

* UE switches to SSSG#1 after decoding the PDCCH,
* UE switches to SSSG#0 (from SSSG1), if
  + Alt 1-1: UE Tx NACK,
  + Alt 1-2: *k* slot after UE Tx NACK
  + Alt 2: after *drx-RetransmissionTimer* starts

And after UE successfully complete retransmission,

* UE switches to SSSG#1 (from SSSG0),
  + Alt 1: UE Tx an ACK which corresponds to the PDCCH indicating SSSG switching from 0 to 1
  + Alt 2: after *drx-RetransmissionTimer* expires

Proposal 11:

* For PDCCH monitoring adaptation mode 1(i.e., Switching between Beh 1/1A),
  + PDCCH monitoring adaptation would be applied after UE receive the additional PDCCH monitoring adaptation control signaling bit(s) in DCI.
* For PDCCH monitoring adaptation mode 2, 3 and 4(i.e., Switching between Beh 1/1A/2/2A/2B),
  + the application timelines provided in Table 10.4-1 in TS38.213 is reused.
    - FFS: for SCS configuration , FFS X = 25 or 39
    - FFS:

**Proposal 12:** Update the RRC parameter list for 8.7.2 according to the table in section 3 in R1-2108988

## OPPO

1. R1-2109087 DCI-based power saving adaptation solutions OPPO

***Proposal 1: Indication field for triggering PDCCH monitoring adaptation is unified.***

***The number of indication bits could be 1 or 2, depending on the number of adaptation behaviors configured.***

***Proposal 2: Indicating skipping of PDCCH monitoring occasions by number of slots should be supported as PDCCH monitoring adaptation.***

***More than one PDCCH skipping period should be configurable.***

***Proposal 3: In case of indicating PDCCH search space sets groups by the DCI bits, a default SSSG is always configured.***

***If 3 SSSGs is configured simultaneously, restricted state transition should be applied in the adaptation.***

***Proposal 4: When multiple PDCCH search space groups are switchable, autonomous PDCCH monitoring adaptation to the default SSSG is triggered by timer.***

***Proposal 5: The search space group switching indication in the DCI can also trigger cross-slot scheduling states.***

***In that case, the application delay of cross-slot is also applicable.***

***Proposal 6: Introduce a delay window in the PDCCH skipping indication, which is based on PDCCH-PDSCH-HARQ-ACK timing and re-scheduling timing.***

***Proposal 7: In the delay window for retransmission, PDCCH monitoring can be only after PDCCH-PDSCH-HARQ-ACK timing and in few consecutive monitoring occasions.***

***Proposal 8: Application time is to be introduced in SSSG switching.***

***Proposal 9: No further DCI format other than 1\_1, 0\_1, 1\_2 and 0\_2 is used for triggering PDCCH monitoring adaptation.***

## CATT

1. R1-2109238PDCCH monitoring adaptation CATT

***Proposal 1: PDCCH skipping indicated by scheduling DCI is not impacted by the PDSCH/PUSCH transmission and the associated HARQ processing when the bit value of PDCCH skipping interval indication changes.***

***Proposal 2: When SSSG is not configured, the 1 or 2 bits indication should be both supported for PDCCH skipping indication and the bit size of the adaptation indication would be configured by RRC signal.***

***Proposal 3: The 2 bits indication would work well for UE to perform one of the PDCCH monitoring adaptation, i.e. PDCCH skipping or SSSG switching between SSSG0 and SSSG1, when the legacy SSSG(s) are configured.***

***Proposal 4: More than two SSSGs should not be supported for PDCCH monitoring adaptation.***

***Proposal 5: The non-scheduling DCI should also be supported for PDCCH monitoring adaptation to dynamically indicate UE to reduce the PDCCH monitoring without any changes of Search Space configuration.***

## CMCC

1. R1-2109294Discussion on PDCCH monitoring reduction during DRX active time CMCC

**Proposal 1. Confirm the working assumption of Beh 1 and Beh 2B.**

* **SSSG#2 can be a dormant SSSG which the SS sets associated to SSSG#2 are conditionally monitored (e.g., depending on HARQ NACK or RTT/ReTx timers).**

**Proposal 2. The flowing configuration combinations can be configured by gNB which using maximum 2bits to indicate the UE PDCCH monitoring behaviour.**

* **Configuration#1: One skipping duration, 1 bit used to indicate Beh 1 or Beh 1A.**
* **Configuration#2: More than one skipping durations, 2 bits used to indicate Beh 1 or a skipping duration of Beh 1A.**
* **Configuration#3: Two SSSGs, 1 bit used to indicate Beh 2 or Beh 2A.**
* **Configuration#4: Three SSSGs, 2 bits used to indicate one of Beh 2, Beh 2A and Beh 2B.**
* **Configuration#5: One skipping duration and two SSSGs, 1 bit used to indicate Beh 1 or Beh 1A and another 1 bit used to indicate Beh 2 or Beh 2A.**

**Proposal 3. The skipping duration(s) is configured per BWP.**

**Proposal 4. The timer(s) is configured per SSSG.**

**Proposal 5. UE should switch to the last non-dormant SSSG used before current dormant SSSG (SSSG#2) when the timer expires.**

**Proposal 6. The scheduling DCI is used to only indicate the PDCCH monitoring behaviour of the same serving cell as the scheduled PDSCH/PUSCH.**

**Proposal 7. A default SSSG can be configured and applied for the following cases:**

* **SSSG switching triggered by SR**
* **SSSG switching triggered by RACH**

**Proposal 8. Format 1\_1 (SCell dormancy case 2) is supported as non-scheduling DCI indication for PDCCH monitoring adaptation in active time for an active BWP.**

## NEC

1. R1-2109361 Discussion on DCI-based power saving adaptation NEC

**Proposal 1: Support up to 3 SSSGs for PDCCH monitoring adaptation by SSSG switching.**

**Proposal 2: PDCCH skipping should be implemented separately from SSSG switching.**

**Proposal 3: The number of bits for triggering the PDCCH monitoring adaptation in a cell may be configurable.**

**Proposal 4: The index of the monitored SSSG can be dynamically indicated for SSSG switching.**

## Samsung

1. R1-2109503 Discussion on DCI-based power saving techniques Samsung

**Observation 1:** Beh 1 is not needed when SSSG switching is configured.

**Proposal 1: Support a default PDCCH monitoring behaviour when the PDCCH skipping duration X expires, based on the following alternatives:**

* **Alt1: UE monitors all configured search space sets,**
* **Alt2: UE monitors default SSSG.**

**Proposal 2: Support one PDCCH skipping duration configured per DL BWP.**

**Proposal 3: Confirm the WA for Beh 2B: stop monitoring SS sets associated with SSSG#0 and SSSG#1 and monitoring of SS sets associated to SSSG#2 (if confirmed).**

**Proposal 4: Support a timer for SSSG switching, where UE falls back to the default SSSG when the timer expires.**

**Proposal 5: Support code-point mapping for Beh 1/1A/2/2A/2B based on the configuration of SSSGs and PDCCH skipping duration.**

**Proposal 6: Support application delay for PDCCH monitoring adaptation triggered by scheduling DCI format, based on one of the following alternatives:**

* **Alt1: same as application delay for minimum scheduling offset in Rel-16,**
* **Alt2: configured by higher layer,**
* **Alt3: after HARQ-ACK feedback.**

**Proposal 7: UE can continue receiving new PDCCH during the application delay of an PDCCH monitoring adaptation, but the UE doesn’t expect to receive new PDCCH indicates different PDCCH monitoring adaptation during the application delay.**

**Propose 8: Support UE assistance information for PDCCH monitoring adaptation, including**

* **preferred search space set group,**
* **PDCCH skipping duration.**

## MediaTek Inc.

1. R1-2109584On enhancements to DCI-based UE power saving during DRX active time MediaTek Inc.

**Proposal 1: Given UE capability of supported UE behaviors, confirm all working assumptions in package 1.**

**Observation 1: At most 3 PDCCH monitoring behaviors are needed for Rel-17 power saving adaptation.**

* **Per-slot monitoring: The default monitoring behavior during scheduling of data packets**
* **PDCCH skipping for a duration: Switch to this behavior after the last TB scheduling**
* **Periodical PDCCH monitoring: Switch to this behavior when there is potential timing critical data scheduling (e.g., for AR/VR UL traffic)**

**Proposal 2: Monitoring PDCCH scrambled by C-RNTI for Type 0/1/1A/2 CSS in Beh 1A is not supported.**

**Proposal 3: Support skipping duration X in the range of [2ms, 200ms]. FFS granularity.**

**Proposal 4: Only one skipping duration is supported in Beh 1A.**

**Proposal 5: If SSSG switching, i.e., Beh 2/2A/2B, is configured, the UE fallbacks to default SSSG, i.e., SSSG #0 after timer expiration or after skipping duration (if Beh 1A is configured).**

**Proposal 6: Only one SSSG timer is supported when three SSSG are configured.**

**Proposal 7: The bit size of the indication is not configurable because it can be derived based on the number of configured behaviors.**

**Proposal 8: To reduce the signaling overhead, the indication of multi-cell is not supported.**

**Proposal 9: Deprioritize the non-scheduling DCI indication.**

**Proposal 10: Introduce retransmission duration where the UE should keep PDCCH monitoring for possible PDSCH/PUSCH retransmission. The UE starts the retransmission duration if PDSCH is not decoded successfully or PUSCH is transmitted.**



**Figure 3. Retransmission handling depending on HARQ process**

**Proposal 11: Introduce the check duration where the UE determines whether to start retransmission duration.**

* + **The check duration can be set as the time length of k0 + k1 in downlink.**
  + **The check duration can be set as the time length of k2 in uplink.**

**Proposal 12: The retransmission duration for DL/UL can be set to the sum of RTT and retransmission timer of DRX configuration.**

* ***drx-HARQ-RTT-TimerDL* + *drx-RetransmissionTimerDL* for downlink scheduling.**
* ***drx-HARQ-RTT-TimerUL* + *drx-RetransmissionTimerUL* for uplink scheduling.**
* **Note: whether UE can skip monitoring in RTT timer is left for UE implementation.**
* **FFS: UE behavior when receive DL and UL indications of different retransmission time durations**

## Intel Corporation

1. R1-2109623 Discussion on DCI-based UE Power Saving Schemes during active time Intel Corporation

**Observation 1: Use of DCI format 2\_6 for PDCCH monitoring adaptation during active time doesn’t create any ambiguity regarding the expected UE behavior, since monitoring occasions are mutually exclusive when format 2\_6 is used as wake up signal before DRX ON.**

**Observation 2:**

* **PDCCH monitoring adaptation can be potentially triggered by both scheduling and non-scheduling DCI formats and it is expected that unified approach is taken regarding start of the adaptation**
* **Impact to HARQ retransmission due to PDCCH monitoring adaptation can be avoided by gNB implementation**

**Proposal 1: Support configurable bit field size in scheduling DCI for PDCCH monitoring adaptation the with following behaviors supported for each size:**

* **Behaviors 1, 1A when only 1 bit is configured**
* **Behaviors 1, 1A, 2, 2A when 2 bits are configured**

**Proposal 2: Multiple PDCCH skipping durations are supported and RRC signaling provides a value of skipping duration per BWP.**

* **Possible values for skipping duration include 4ms, 8ms, 16ms, 32ms, 64ms etc.**

**Proposal 3: Support indication of PDCCH monitoring adaptation by following ways.**

* **DCI Format 1\_1 (SCell dormancy case 2) when not scheduling data.**
* **DCI Format 2\_6 during active time.**

**Proposal 4: PDCCH monitoring adaptation should not be dependent on HARQ outcome or PUSCH transmission**

* **Monitoring adaptation does not start before Z slots from the slot where DCI is received, and Z is given by (1, 1, 2, 2) for DL SCS of (15, 30, 60, 120) KHz, respectively.**

## NTT DOCOMO, INC.

1. R1-2109691 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.

**Proposal 1: For PDCCH skipping functionality, SSSG switching should be used.**

**Proposal 2: Confirm the Working Assumption that at most 3 SSSGs is supported to be configured.**

**Proposal 3: The default SSSG when UE is indicated to monitor PDCCH within on-duration should be supported.**

**Observation 1: PDCCH skipping along with cross-slot scheduling can maximize the benefit of cross-slot scheduling.**

**Proposal 4: It should be considered that the duration of PDCCH skipping is equal to or longer than the applicable minimum scheduling offset.**

## ETRI

1. R1-2109813 DCI-based power saving adaptation during DRX active time ETRI

**Proposal 1: Do not support Beh 2B (revert the working assumption).**

**Observation 1: Noting that Alt. 2 needs a new DCI field to indicate PDCCH skipping and it may have an issue addressed in Table 1, Alt. 1 may result in less specification change.**

**Proposal 2: For Beh 1A, the PDCCH skipping behaviour is implemented based on SSSG switching by using the empty SSSG (e.g., SSSG#2).**

**Proposal 3: When the timer expires at a SSSG (e.g., SSSG#1 or empty SSSG), UE switches back to the default SSSG (e.g., SSSG#0).**

**Proposal 4: Confirm the following working assumption with a revision: “Indication of Beh 1A ~~for current SSSG~~ when two SSSG(s) are configured is supported”.**

**Proposal 5: PDCCH which does not schedule data and indicate SSSG switching or PDCCH skipping for an active BWP in active time is supported by DCI Format 1\_1 (SCell dormancy case 2 like)**

**Proposal 6: DCI format 2\_6 outside active time is supported to indicate SSSG switching or PDCCH skipping for an active BWP in active time when DRX is configured.**

**Proposal 7: For UE configured with DRX, higher layer signaling can configure SSSG that a UE monitors when coming out of DRX to monitor an ON duration.**

**Proposal 8: At least for the case where ACK/NACK for the DCI is present, application time of SSSG switching or PDCCH skipping is configured to be after the HARQ-ACK transmission timing + some margin for gNB’s HARQ-ACK decoding processing time.**

**Proposal 9: Application time of SSSG switching or PDCCH skipping is configured to be after the potential retransmission period, i.e., time period while DRX retransmission timer for PDSCH/PUSCH is running.**

## FGI, Asia Pacific Telecom

1. R1-2109831 Discussion on extension(s) to Rel-16 DCI-based power saving adaptation FGI, Asia Pacific Telecom

**Observation 1: Indicating PDCCH skipping and SSSG switching UE behaviours jointly can save information bits for the PDCCH monitoring adaptation DCI comparing to indicating PDCCH skipping and SSSG switching UE behaviours separately.**

**Proposal 1: Joint indication for PDCCH skipping and SSSG switching over an PDCCH monitoring adaptation DCI bit field should be considered.**

**Observation 2: A single PDCCH monitoring adaptation indication for multiple cells can reduce the signalling overhead of DCI.**

**Proposal 2: A single PDCCH monitoring adaptation indication for multiple cells should be supported.**

**Ovservation 3: Retransmission period defined by HARQ-ACK condition can only handle DL retransmission case well, but fail to deal with the UL retransmission case.**

**Proposal 3: After receiving a DCI indicating PDCCH skipping and/or switching to an empty SSSG, the UE**

* **does not perform PDCCH skipping when *drx-RetransmissionTimerDL(UL)* is running.**
* **switches out of the empty SSSG when *drx-RetransmissionTimerDL(UL)* is running.**

**Observation 4: For SR, the UE should monitor the PDCCH to receive the scheduling for UL grant. For RACH, the UE should monitor the PDCCH to receive the Msg2/Msg4/MsgB.**

**Observation 5: Since NW cannot predict the UE will trigger SR and CBRA, the explicit PDCCH monitoring adaptation indication by NW to switch out of the empty SSSG or to stop PDCCH skipping does not work.**

**Proposal 4: Implicit PDCCH monitoring adaptation for SR and RACH should be considered.**

## Panasonic

1. R1-2109857 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime Panasonic

**Proposal 1: In the condition that when 3 SSSGs are configured, Beh 1A on PDCCH skipping is also supported and configurable, confirm the working assumption on support at most 3 SSSGs.**

**Proposal 2: PDCCH scrambled by C-RNTI is monitored in Type 0/1/1A/2 CSS.**

**Proposal 3: When a search space is not configured with any SSSG ID, UE continues monitoring PDCCH in this search space without being impact by the DCI-based PDCCH monitoring adaptation.**

**Proposal 4:** **The explicit state of "the working assumption of Beh 1: PDCCH skipping is not activated" is not required.**

**Proposal 5: Confirm the working assumption that Indication of Beh 1A for current SSSG when two SSSG(s) are configured is supported.**

**Proposal 6: More than one PDCCH skipping duration can be supported depending on the RRC configuration.**

**Proposal 7: By RRC configuration, either individual or joint support for PDCCH skipping and SSSG switching can be flexibly supported.**

Proposal 8: The timer for SSSG switching and the duration for PDCCH skipping should be configured by RRC for each state for DCI indication.

## Lenovo, Motorola Mobility

1. R1-2109946 Enhanced DCI based power saving adaptation Lenovo, Motorola Mobility

**Proposal 1: As for scheduling DCI based PDCCH monitoring adaptation, one codepoint indicates PDCCH skipping for a semi-statically configured skipping duration. The remaining 1 (for 1-bit field) or 3 (for 2-bit field) codepoints indicate SSSG switching (from SSSG 0 to SSSG 1, from SSSG 0 to SSSG 2, between SSSG 1 and SSSG 2).**

**Proposal 2: When 3 SSSGs configured, one search space switch timer value is configured for a serving cell, as in Rel-16 NR.**

**Proposal 3: Reuse the Rel-16 application delay for K0,min/K2,min indication as an application delay for PDCCH skipping.**

**Proposal 4: Upon detecting a DCI format indicating PDCCH skipping, UE stops monitoring PDCCH in UE-specific search spaces and Type-3 common search spaces,**

* **not earlier than the application delay after the end of PDCCH including the indication, and**
* **for DL DCI format(s), upon expiration of *drx-RetransmissionTimerDL* if *drx-HARQ-RTT-TimerDL* or *drx-RetransmissionTimerDL* is running, and**
* **for UL DCI format(s), upon expiration of *drx-RetransmissionTimerUL* if *drx-HARQ-RTT-TimerUL* or *drx-RetransmissionTimerUL* is running.**

**Proposal 5: Rel-17 NR supports search space set switching when starting an ON duration timer in every DRX cycle based on DCI format 2\_6.**

## InterDigital, INC.

1. R1-2109955 PDCCH monitoring reduction in Active Time InterDigital, Inc.

**Proposal 1: Confirm the following working assumptions:**

* **Working assumption: Indication of Beh 1A for current SSSG when two SSSG(s) are configured is supported.**
* **Working Assumption: Beh 1: PDCCH skipping is not activated.**

**Proposal 2: Codepoints in the DCI can be configured per SSSG to indicate SSSG switching, PDCCH skipping.**

**Proposal 3: PDCCH skipping duration(s) indicated by the codepoint(s) can be configured per SSSG.**

**Proposal 4: Confirm the following working assumptions:**

**Working Assumption: Beh 2B (if confirmed): stop monitoring SS sets associated with SSSG#0 and SSSG#1 and monitoring of SS sets associated to SSSG#2 (if confirmed)**

**Working Assumption: At most 3 SSSGs is supported to be configured.**

**Proposal 5: The timer(s) is configured per SSSG.**

**Proposal 6: PDCCH skipping indication (including monitoring the PDCCH according to a null SSSG) is not applied in an interval when the DL retransmission timer is running.**

**Proposal 7: PDCCH skipping indication (including monitoring the PDCCH according to a null SSSG) is not applied in an interval when the UL retransmission timer is running.**

## LG Electronics

1. R1-2109982 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG Electronics

***Observation 1: Based on TS38.213 and TS38.321, legacy UE monitors PDCCH candidates for a DCI with CRC scrambled by C-RNTI in a Type0/0A/1/2-PDCCH CSS set for a duration.***

***Observation 2: If monitoring behavior of Observation 1 is applied without modification to a UE indicated to skip for a duration, it will decrease power saving efficiency of monitoring adaptation.***

***Observation 3: Supporting SSSG switching to emulate PDCCH skipping functionality, i.e. Beh 2B, cannot be possible if PDCCH skipping shut down UE’s monitoring PDCCH candidates for a DCI with CRC scrambled by RNTIs controlled by a DRX functionality.***

***Proposal 1: After receiving indication of PDCCH skipping, a UE should not monitors PDCCH candidates for a DCI with CRC scrambled by C-RNTI in a Type0/0A/1/2-PDCCH CSS set for a duration.***

***Proposal 2: Support joint indication of PDCCH skipping and SSSG switching for bit mapping to the PDCCH monitoring behavior of at most 2 bit indication in self-scheduling DCIs.***

***Proposal 3: Support the following design for DCI-based PDCCH monitoring adaptation for the 2-bit joint indication:***

* + - ***1-bit flag distinguishing between PDCCH skipping and SSSG switching***
    - ***UE behavior corresponding to each state configured by RRC signaling***

***Proposal 4: Bit mapping to the monitoring behavior and/or bit size of indication of monitoring adaptation can be differently configured for each DCI format.***

***Proposal 5: 0, 1, and 2 bit indication of monitoring adaptation can be flexibly configured for DCI format x\_2.***

***Proposal 6: Support PDCCH monitoring adaptation indicated by a DCI format 2\_6 inside/outside DRX Active Time.***

* + - ***Discuss whether and how to define the monitoring window for DCI format 2\_6 inside DRX Active Time.***

***Proposal 7: Application delay enabling the UE and network to handle missing case of DCI indicating SSSG switching should be supported.***

***Proposal 8: Consider different application delay for two cases:***

* + - ***Command applied after UE’s UL transmission (PUSCH or ACK) if monitoring adaptation is indicated by a DCI with scheduling information.***
    - ***Time-based application delay if monitoring adaptation is indicated by a DCI without scheduling information.***

***Proposal 9: Support implicit PDCCH monitoring adaptation triggered by SR and RACH***

* + - ***Discuss whether and how to define a monitoring window for a UL grant regarding SR***

## Apple

1. R1-2110045 Enhanced DCI-based power saving adaptation Apple

***Proposal 1: Different skipping duration can be configured per SSSG.***

***Proposal 2: Timer can be optionally configured for non-default SSSG. If not configured, the UE continues monitoring current SSSG until explicit switching command is sent.***

***Proposal 3: PDCCH skipping can be triggered from either default SSSG, or non-default SSSG. When triggered from non-default SSSG, the non-default SSSG timer freeze during skipping duration.***

***Proposal 4: When both SSSG switching and PDCCH skipping bit are triggered with one DCI, PDCCH skipping is applied first, after skipping, the UE continue monitoring with the SSSG.***

***Proposal 5: Enable non-default SSSG to non-default SSSG switching.***

***Proposal 6: Different timer can be configured per non-default SSSG when 3 SSSGs are enabled.***

***Proposal 7: When empty SSSG2 is triggered from non-default SSSG 1, freeze timer 1 of SSSG1 and start counting down of timer 2. When timer 2 expires, fall back to SSSG 1.***

***Proposal 8: When DCI format 0-1, 0-2, 1-1 and 1-2 is used to trigger PDCCH monitoring adaptation, the adaptation is applied to all CCs within a CC group.***

***Proposal 9: For PDCCH based adaptation using non-scheduling DCI, enable DCI format 1-1 with triggering bits per cell group.***

***Proposal 10: For PDCCH based adaptation using non-scheduling DCI, enable DCI format 2-6 monitoring in DRX-ON duration, with triggering bits per cell group indication.***

***Proposal 11: Allow more than 2 bits in non-scheduling DCI, with maximum skipping size can be configured to until next DRX cycle.***

***Proposal 12: When PDCCH monitoring adaptation is triggered by non-scheduling DCI, application delay for SSSG switching is 25 OFDM symbols for , and 39 OFDM symbols for .***

***Proposal 13: When PDCCH monitoring adaptation is triggered by non-scheduling DCI, application delay for PDCCH skipping is 11 OFDM symbols for , and 25 OFDM symbols for .***

***Proposal 14: When PDCCH monitoring adaptation is triggered by DCI format 1-1 and 1-2, application delay applies after the last OFDM symbol of ACK transmission. Application delay can be 1 slot considering gNB ACK decoding time and UE processing time to apply the new configuration.***

***Proposal 15: When PDCCH monitoring adaptation is triggered by DCI format 0-1 and 0-2, application delay applies after the last OFDM symbol of PUSCH transmission when drx-RetransmissionTimerUL is not configured or longer than a threshold.***

***Proposal 16: When PDCCH monitoring adaptation is triggered by DCI format 0-1 and 0-2, application delay applies after drx-RetransmissionTimerUL expires if drx-RetransmissionTimerUL is configured and less than a threshold.***

## ASUSTeK

1. R1-2110130 A common framework for SSSG switching and PDCCH skipping ASUSTeK

**Observation1: Rel-16 SSSG switch is well-specified in Rel-16 and could provide a good frame work for both Rel-17 SSSG switch as well as PDCCH skipping.**

**Proposal 1: RAN1 considers Rel-16 SSSG switch as a starting point for power saving adaptation during Active Time and makes further required adjustment which fits needs of Rel-17 power saving better.**

**Observation 2: time duration could be variant, e.g. indicating by DCI to fit the needs of power saving.**

**Observation 3: SSSG activation deactivation may not fit the case of PDCCH skipping.**

**Proposal 2: RAN1 considers the following adjustment to Rel-16 SSSG switch to support both Rel-17 SSSG switch and PDCCH skipping:**

* **Variant time duration indicated by DCI**
* **DCI format triggering the SSSG switch**
* **More than two SSSGs**

## Ericsson

1. R1-2110139 Design of active time power savings mechanisms Ericsson

[Observation 1 Existing Rel-16 value range of SSSG switching timer (e.g. max 20 ms) can be insufficient for some use cases e.g. for timer-based switching from sparse SSSG to dense SSSG when DRX IAT is running.](#_Toc84011133)

[Observation 2 UE PDCCH monitoring behavior during PDCCH monitoring adaptation application delay should be clear to avoid different understanding between NW and UE.](#_Toc84011134)

[Proposal 1 For a given serving cell, when UE is configured with only PDCCH-skipping, up to 3 skipping durations (>0) are supported.](#_Toc84011762)

[Proposal 2 For a given serving cell, when UE is configured with only SSSG-switching, 1 bit in the bitfield is used when 2 SSSGs are configured and up to 2 bits in the bitfield are used when 3 SSSGs are configured.](#_Toc84011763)

[Proposal 3 For a given serving cell, when UE is configured with both PDCCH-skipping and SSSG-switching, configuration of 2 SSSGs and up to 2 skipping durations is supported.](#_Toc84011764)

[Proposal 4 The skipping durations are configured per BWP.](#_Toc84011765)

[Proposal 5 For PDCCH-skipping, the skipping duration is defined in units of slots of the cell for which PDCCH monitoring behavior is being adapted.](#_Toc84011766)

[Proposal 6 For Rel. 17 PDCCH monitoring adaptation, extended value range of SSSG switching timer (compared to Rel-16) is supported. FFS : detailed values](#_Toc84011767)

[Proposal 7 Support intercell indication for PDCCH monitoring adaptation.](#_Toc84011768)

[Proposal 8 Indication for PDCCH monitoring adaptation (by SSSG switching and PDCCH skipping for a duration) is supported only via DCI formats 1-1/1-2/0-1/1-1.](#_Toc84011769)

[Proposal 9 For a cell for which PDCCH monitoring can be adapted, it should be possible to support different number of bits for same cell indication and intercell indication (e.g. 2-bits for indication on same cell and 1-bit for intercell indication from another cell).](#_Toc84011770)

[Proposal 10 For a cell for which PDCCH monitoring can be adapted, it should be possible to independently configure same cell indication and intercell indication.](#_Toc84011771)

[Proposal 11 For a transition between SSSG1 and SSSG0, a similar mechanism with Rel. 16 SSSG-switching feature is adopted.](#_Toc84011772)

[Proposal 12 The SSSG that a UE monitors after skipping duration ends is explicitly configured by RRC or is indicated by the PDCCH monitoring adaptation bitfield in the DCI.](#_Toc84011773)

[Proposal 13 UL scheduling request can be used as a trigger to switch between SS-set groups. The SS-set group that UE monitors after transmitting an UL scheduling request is configurable by NW.](#_Toc84011774)

[Proposal 14 For UE configured with DRX, higher layer signaling can configure SSSG that a UE monitors when coming out of DRX to monitor an ON duration.](#_Toc84011775)

[Proposal 15 Use the baseline application delay from Rel. 16 SSSG-switching feature.](#_Toc84011776)

[a. FFS: delay for 120 kHz SCS.](#_Toc84011777)

[Proposal 16 For SSSG-switching indicated via scheduling DCI format 1-1/1-2, UE applies switching command (i.e. to the indicated SSSG) after transmitting HARQ-ACK feedback. FFS: whether HARQ-ACK is used for both SSSG0 to SSSG1 and SSSG1 to SSSG0 transitions.](#_Toc84011778)

[Proposal 17 For PDCCH-skipping via scheduling DCI format 1-1/1-2, UE applies the skipping after the UE receives the indication. If the UE fails to decode the PDSCH (and transmits a NACK), the skipping is canceled in the slots after the NACK transmission (if any).](#_Toc84011779)

[Proposal 18 PDCCH monitoring adaptation for Rel. 17 should not entail an interruption to UE transmission/reception on any serving cell.](#_Toc84011780)

## Qualcomm Incorporated

1. R1-2110200 DCI-based power saving adaptation during DRX ActiveTime Qualcomm Incorporated

Proposal 1: If two SSSGs (i.e., default and non-default SSSGs) are configured, the default SSSG is associated with sparse PDCCH monitoring and the non-default SSSG is associated with dense PDCCH monitoring. The indication of Beh 1A is allowed only on the non-default SSSG.

Proposal 2: When PDCCH skipping is indicated, to enable HARQ retransmission during the indicated PDCCH skip duration, discontinuous PDCCH monitoring according to RTT and Retransmission timers is allowed, if configured.

Proposal 3: For explicit indication of PDCCH monitoring adaptation, in addition to scheduling DCI formats 0\_1/1\_1/0\_2/1\_2, non-scheduling DCI formats are also considered:

* DCI format 1\_1 (similar to Case 2 SCell dormancy indication),
* DCI format 2\_6 (outside active time).

Proposal 4: For implicit indication of PDCCH monitoring adaptation, the following candidates are considered:

* **Configured timer: per-non-default SSSG, if more than two SSSGs are supported,**
* **Transmission of SR and PRACH: terminate a PDCCH skip duration after transmitting a scheduling request or a PRACH preamble.**

Proposal 5: For the application delay of PDCCH monitoring adaptation, combination of the application delays of Rel-16 minimum scheduling offset restriction and Rel-16 SSSG switching is considered:

* **Different application delays are used for indication types (explicit or implicit) and power saving adaptation schemes (PDCCH skipping and SSSG switching).**
* **Different application delays are used depending on whether the PDCCH monitoring adaptation is jointly configured with Rel-16 minimum scheduling offset restriction or not.**

Proposal 6: In the CA scenario, for the joint adaptation across CCs, carrier-group-based PDCCH monitoring adaptation is considered.

Observation 1: One of the following combinations may be configured for PDCCH monitoring adaptation:

1. **Standalone PDCCH skipping**
2. **Standalone SSSG switching between two SSSGs**
3. **PDCCH skipping + SSSG switching between two SSSGs**
4. **SSSG switching among three SSSGs**

Observation 2: During the application delay, the UE does not expect to receive another indication of power saving adaptation different from the previous indication.

## Nordic Semiconductor ASA

1. R1-2110285 On PDCCH monitoring adaptation Nordic Semiconductor ASA

***Proposal-1:*** *When SSG switching is not configured:*

* *a gNB may configure up to four rows, each contains* 
  + *one from up to three skipping durations or “no skipping”*
* *DCI field indicates one of the rows*

***Proposal-2****: UE does not expect to receive PDCCH in USS or TYPE-3 after PDCCH indicating skipping duration and until the end of that indicated duration*

***Proposal-3:*** *When PDCCH skipping is not configured, support up to 3SSG*

* *one default SSG#0*
* *up to two non-default SSGs {#1,#2}*
  + *Note: a non-default SSG may contain zero SS-sets or be dormant*

***Proposal-4:*** *When a UE receives a first PDCCH indication to switch to a non-default SSG containing zero SS-sets, UE does not expect to receive second PDCCH in USS or TYPE-3 after the first PDCCH and before the end of SSG switching application delay (defined in R16).*

***Proposal-5:*** *Consider support for a dormancy SSG, the non-default SSG configured with sparse MOs, where monitoring of all or subset of group’s search-space sets is conditional on a pending re-transmission.*

***Proposal-6****: When PDCCH skipping is not configured*

* *a gNB may configure up to four rows, each contains* 
  + *one from up to three SSGs (field mandatory)*
  + *one from up to three timer initial value for non-default SSG (field optional)*
* *DCI field indicates one of the rows.*

***Proposal-7****: When PDCCH skipping and SSGs are both configured*

* *a gNB may configure up to four rows, each contains* 
  + *one from up to two SSGs (field is mandatory)*
  + *one from up to two timer initial value for non-default SSG (field is optional)*
  + *one from up to two skipping durations or no skipping (field is optional)*
* *DCI field indicates one of the rows.*

***Proposal-8:*** *UE expects that in indicated row, a timer initial value is always greater than skipping duration.*

***Proposal-9:*** *Focus on finalizing single-cell case before discussing CA*

## Fraunhofer HHI, Fraunhofer IIS

1. R1-2110310DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IIS

**Proposal 1: The codepoints of the indication in DCI shall be configurable from one of the behaviors sets (1/1A) or (1A/2/2A).**

**Proposal 2: The skipping durations shall be configurable per BWP.**

**Proposal 3: SSSG Fallback timers shall be configurable per SSSG.**

**Proposal 4: If cross-slot scheduling is configured, joint indication of SSG switching and minimum offset adaption shall be supported.**

**Proposal 5: The PDSCH processing time shall be adaptable based on certain parameters, e.g., the minimum scheduling offset or the currently active SS group.**

## Nokia, Nokia Shanghai Bell

1. R1-2110313 UE power saving enhancements for Active Time Nokia, Nokia Shanghai Bell

In Section 2.1 we discussed the aspects related to DCI format design (and related behaviour) for PDCCH monitoring adaptation and made following proposals and observations:

**Proposal:** For SSSG switching, the DCI field directly indicates the applied SSSG index, e.g. field values {00,01,10} map to {SSSG#0(default), SSSG#1, SSSG#2}.

**Proposal:** DCI field directly indicates the PDCCH monitoring skipping for a duration, e.g. via field value {11}. After the duration, UE shall resume the PDCCH monitoring based on the default SSSG, SSSG#0.

**Observation:** If no SSSGs are configured, default value (i.e. {00}) can indicate that no skipping is applied.

**Proposal:** Support Rel-17 SSSG switching, in addition to scheduling DCIs also based on non-scheduling DCI via DCI format 1\_1.

**Observation:** The need to support PDCCH skipping for a duration via non-scheduling DCI could be considered.

In Section 2.2 we looked the timer based adaptation and related configurations and concluded as follows:

**Proposal:** If SSSGs are configured, after the timer for skipping the PDCCH monitoring expires, UE should return to default SSSG, i.e. SSSG#0.

**Proposal:** For timer based SSSG switching, upon timer expiry UEs will switch to default SSSG, SSSG#0.

**Observation:** Assuming that, for both SSSG switching and stopping PDCCH monitoring, upon timer expiry UE shall return to default SSSG, streamlines, and simplifies the operation.

**Observation:** If UE receives scheduling or non-scheduling DCI indicating no SSSG switch (i.e. field value corresponds to the active SSSG), UE resets the SSSG switching timer.

**Observation:** Configuration for the duration for the skipping PDCCH monitoring is affected by the allowed traffic latency and other traffic KPIs, which are not dependent on the SSSG.

**Proposal**: One common timer value is assumed for SSSG switching. One common value is assumed for skipping duration the PDCCH monitoring for all SSSGs.

**Proposal**: Configurations for duration of PDCCH skipping and timer for SSSG switching can be done in BWP specific manner.

In Section 2.3 we considered other open aspects related to the PDCCH monitoring adaptation:

**Proposal**: Confirm the working assumption that 3 SSSGs are supported:

* Working Assumption at most 3 SSSGs is supported to be configured.

**Proposal:** PDCCH monitoring adaptation should not be applied to Type0/0A/1 or 2 PDCCH CSS.

**Proposal:** Procedures such as SR transmission, BSR or beam failure recovery should result UE to stop PDCCH monitoring adaptation and resume normal PDCCH monitoring (i.e. stop PDCCH skipping and/or change to default SSSG).

**Proposal:** Use the application delay timeline introduced in Rel-16 for SSSG switching.

**Proposal:** Consider support configuring of SSSG that is applied at the start of the On Duration.

**Observation:** For PDCCH monitoring adaptation case, where UE still continues to monitor PDCCH, albeit at reduced rate, there may not be any need to have special handling of HARQ re-transmissions scheduling, but scheduling can follow the applied SS set(s).

**Observation:** Special handling of HARQ re-transmissions is only needed when UE stops the PDCCH monitoring for extended time.

**Proposal:** For stopping PDCCH monitoring based on {empty} SSSG or PDCCH skipping, define timers similarly as in C-DRX operation to enable configuring time windows for handling the open re-transmissions.

**Observation:** Associating minimum cross-slot scheduling restriction to certain SSSGs could be considered.

# Void

# Work Item Description

*NR\_UE\_pow\_sav-Core; WID in* [*RP-200938*](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_88e/Docs/RP-200938.zip)*. The objectives are as follows*

|  |
| --- |
| 1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]    1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]  * NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting   1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1] * NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required  1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]    1. Study and specify, if agreed, extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time for an active BWP, including PDCCH monitoring reduction when C-DRX is configured [RAN1]  * NOTE: Rel-15 and Rel-16 available power saving solutions should be supported by the UE and included in the evaluation. RAN1 will ask the confirmation from RAN2 that Rel-15 and Rel-16 available power saving solutions are properly utilized.   1. Study the feasibility and performance impact of relaxing UE measurements for RLM and/or BFD, particularly for low mobility UE with short DRX periodicity/cycle, and specify, if agreed, relaxation in the corresponding requirements [RAN4] * NOTE: Supplementary RAN2 work, if needed, can be triggered by RAN4 LS |

# Reference

**The following contributions are submitted in RAN1#106-E in AI 8.7.2,**

1. R1-2108746 Extensions to Rel-16 DCI-based power saving adaptation for an active BWP Huawei, HiSilicon
2. R1-2108867 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTE, Sanechips
3. R1-2108918 Discussion on power saving techniques for connected-mode UEs Spreadtrum Communications
4. R1-2108988 Discussion on DCI-based power saving adaptation in connected mode vivo
5. R1-2109087 DCI-based power saving adaptation solutions OPPO
6. R1-2109238 PDCCH monitoring adaptation CATT
7. R1-2109294 Discussion on PDCCH monitoring reduction during DRX active time CMCC
8. R1-2109361 Discussion on DCI-based power saving adaptation NEC
9. R1-2109503 Discussion on DCI-based power saving techniques Samsung
10. R1-2109584 On enhancements to DCI-based UE power saving during DRX active time MediaTek Inc.
11. R1-2109623 On remaining issues of PDCCH monitoring adaptation in active time Intel Corporation
12. R1-2109691 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.
13. R1-2109813 DCI-based power saving adaptation during DRX active time ETRI
14. R1-2109831 Discussion on extension(s) to Rel-16 DCI-based power saving adaptation FGI, Asia Pacific Telecom
15. R1-2109857 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime Panasonic
16. R1-2109946 Enhanced DCI based power saving adaptation Lenovo, Motorola Mobility
17. R1-2109955 DCI-based power saving adaptation during DRX ActiveTime InterDigital, Inc.
18. R1-2109982 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG Electronics
19. R1-2110045 Enhanced DCI-based power saving adaptation Apple
20. R1-2110130 A common framework for SSSG switching and PDCCH skipping ASUSTeK
21. R1-2110139 Design of active time power savings mechanisms Ericsson
22. R1-2110200 DCI-based power saving adaptation during DRX ActiveTime Qualcomm Incorporated
23. R1-2110285 On PDCCH monitoring adaptation Nordic Semiconductor ASA
24. R1-2110310 DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IIS
25. R1-2110313 UE power saving enhancements for Active Time Nokia, Nokia Shanghai Bell

**Other references:**

1. RP-200938, “Revised WID: UE Power Saving Enhancements for NR”, MediaTek Inc., RAN#88-e

# History

1. R1-2007065 FL summary of potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime RAN1#102-E Moderator (vivo)
2. R1-2007117 FL summary#2 of potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime RAN1#102-E Moderator (vivo)
3. R1-2007225 FL summary#3 of potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime RAN1#102-E Moderator (vivo)
4. R1-2007400 FL summary#4 of potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime RAN1#102-E Moderator (vivo)
5. R1-2009501 FL summary#1 of power saving for Active Time RAN1#103-E Moderator (vivo)
6. R1-2009655 FL summary#2 of power saving for Active Time RAN1#103-E Moderator (vivo)
7. R1-2009656 FL summary#3 of power saving for Active Time RAN1#103-E Moderator (vivo)
8. R1-2009804 FL summary#4 of power saving for Active Time RAN1#103-E Moderator (vivo)
9. R1-2101893 FL summary#1 of power saving for Active Time RAN1#104-E Moderator (vivo)
10. R1-2101894 FL summary#2 of power saving for Active Time RAN1#104-E Moderator (vivo)
11. R1-2106040 FL summary#1 of power saving for Active Time RAN1#105-E Moderator (vivo)
12. R1-2106041 FL summary#2 of power saving for Active Time RAN1#105-E Moderator (vivo)
13. R1-2108224 FL summary#1 of power saving for Active Time RAN1#106-E Moderator (vivo)
14. R1-2108225 FL summary#2 of power saving for Active Time RAN1#106-E Moderator (vivo)
15. R1-2108386 FL summary#3 of power saving for Active Time RAN1#106-E Moderator (vivo)
16. R1-2108387 FL summary#4 of power saving for Active Time RAN1#106-E Moderator (vivo)
17. R1-2108620 FL summary#5 of power saving for Active Time RAN1#106-E Moderator (vivo)