
Agenda Item: 5.1.9.2
Source: Huawei, HiSilicon
Title: Discussion on PHR calculation
Document for: Discussion and decision

1 Introduction

Regarding UL power control, the following agreements have been achieved in previous meetings [1][2][3]:

Agreements:

- NR supports beam specific power control as baseline.
 - FFS details especially regarding handling layer/layer-group/panel specific/beam group specific/beam pair link specific power control
 - FFS whether to apply open loop only, closed loop only, or both
- Waveform (CP-OFDM vs. DFT-s-OFDM) specific power control for a UE, e.g., PHR, offset needs to be studied in WI.

Agreements:

- For beam specific power control, NR defines beam specific open & closed loop parameters.
 - FFS: details on beam common parameter(s)
 - Note: Agreed on RAN1 #88 FFS details on “beam specific”, especially regarding handling layer/layer-group/panel specific/beam group specific/beam pair link specific power control
- gNB is aware of the power headroom differences for different waveforms, if the UE can be configured for both waveforms.
 - FFS: offset configured/specified, reported,
 - FFS on the details of power control parameters for example, P_c, Max or other open/closed loop parameter

Agreements:

- The following DL RS can be used for PL calculation for UL PC
 - If the power offset between SSS and DM-RS for PBCH is known by the UE, both SSS and DM-RS for PBCH of SS block
 - If the power offset between SSS and DM-RS for PBCH is not known by the UE, SSS only of SS block
 - CSI-RS;
 - FFS: the applicable case for above DL RSs; if both are used, whether/how to combine/handle the measurement

In this paper, we discuss consideration on power headroom calculation and reporting mechanism in NR.

2 Power headroom calculation and reporting

In previous meetings, it was agreed that NR supports beam specific power control as baseline. Detailed parameters and other possible impacts (waveform, numerology, traffic, etc.) are under discussion. Accordingly, power headroom calculation need to be considered with these impacts.

2.1 PHR for multi-beam operation

Generally, beam-specific power headroom calculation should be supported, with open-loop and closed-loop parameters. In this case, each BPL (group) would lead to one PH value.

In LTE system, PH triggering condition is defined with a set of events. The UE will be configured with two timer: *prohibitPHR-Timer* and *periodicPHR-Timer* and a threshold parameter *dl-PathlossChange*. It was agreed pathloss can be derived from SS block/CSI-RS. In our contribution [4], we proposed that CSI-RS based L1 RSRP and/or SS block based L1/L3 RSRP can be configured for CONNECTED mode.

Multiple BPLs can be maintained and the beamforming gain would varied from one to another. The transmission BPLs can be dynamically scheduled. In power control, PL for each BPL would contribute to a stable interference level at gNB. Though, in perspective of PHR, the PL change would be too fast.

For example, if current beam is changed compared to the latest time, then the PL will possibly change. So, the PL change may exceed *dl-PathlossChange*. In this case, PL change condition for PHR triggering would be always occupied. One solution is that the UE could monitor PL change independently per beam. Once the timers satisfy PHR triggering condition, the UE could collect beams with large PL change and report the PHs of them. Then one or more PH are reported.

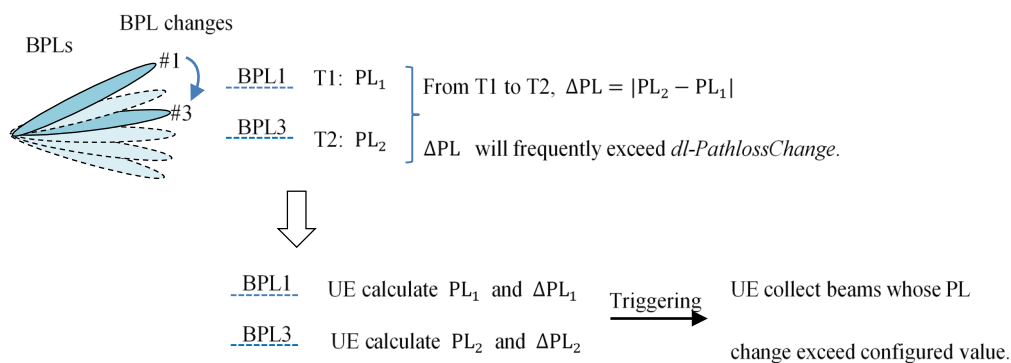


Figure 1. Illustration of BPL based PHR

Also, PL can be measured on a BPL group level. Thus PL can be averaged from multiple BPLs within one group. Change of PL for PHR triggering is also be based on a BPL group level. It would be simpler but suffer minor PH accuracy loss, due to one PH for a group of BPLs.

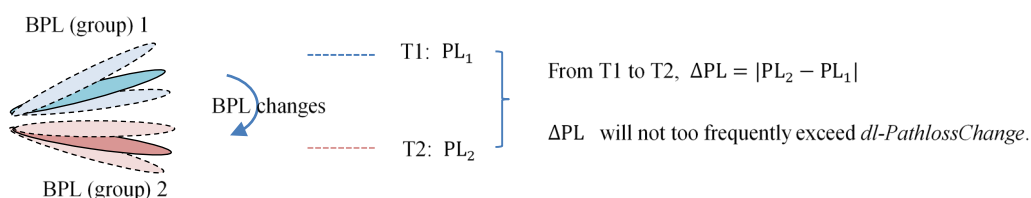


Figure 2. Illustration of BPL group based PHR

Meanwhile, when beam management occurs beam failure and recovery, PH calculation and reporting for one specific beam would be beneficial. If one beam failure is detected and recovery of another beam is achieved, new BPL may be added into current maintained beam management. So, as an optimization option, calculation of new beam's power headroom would be helpful for data transmission scheduling.

Moreover, if simultaneous multi-beam transmission is supported, PH calculation should also take multi-beams into account. If multiple beams are transmitted from different port groups, PH calculation should be separate for each port group. In this transmission scheme, one or more PH(s) is/are generated to L2 for one serving cell in one subframe.

Proposal 1: Power headroom calculation should be based on BPL/BPL group.

2.2 PHR for supporting of DFT-s-OFDM and CP-OFDM waveforms

NR supports both DFT-s-OFDM and CP-OFDM waveforms. Since PAPR would be different for the two waveforms, the power back-off of power management would be different. Power headroom calculation should address different waveform aspects, at least for the impact on P_{cmx} . To better support gNB scheduling of UE's waveforms, the UE need to report the two PHs considering different P_{cmx} due to power back-off, and also P_{cmx} values with possible different MPRs.

While fast-scheduling request may not always exist, for example, when the UE stays in center area for a long time (much longer than PH timers), the gNB may not to know the exact power offset of two waveforms. Considering the fact, though waveform-specific PH calculation needs to be supported, it can be based on gNB's indication of whether to report the two PHs.

Proposal 2: NR should support gNB indication of waveform-specific PHRs.

3 Power headroom type considerations

In LTE system, PH types are defined for CA operation. Depending on CC type, type1 and type2, or type 1 only PHR is generated per CC. The different of type 1 and type 2 focus on whether PUCCH can be or is transmitted on the serving cell.

In NR, short-PUCCH and long-PUCCH are supported, and more than one PUCCH can be TDM-ed transmitted in one slot. The multiple PUCCHs can carry same or different UCI, and have different multiplexing manner with PUSCH. In this way, PHR would be quite complicated for the channels. For virtual PH, a default manner need to be defined for PUCCH and PUSCH PH calculation, e.g. calculation based on short-PUCCH. Otherwise, either PUSCH or PUCCH is transmitted, PH calculation should address short-PUCCH part and long-PUCCH part. A general consideration is to combine type1 and type2 calculation, and allow the UE to calculate PH the headroom of all FDM-ed transmitted channels. That is, $\text{PH} = P_{\text{cmx}} - \text{PUSCH Power} - \text{PUCCH Power}$. Here, only real transmitted channel power can be taken into the formula. For example, if short-PUCCH and PUSCH are TDM-ed transmitted, for PUCCH part, the PUSCH Power of PH calculation is zero. In conclude, NR PH general design should adapt to various PUCCH structures and multiplexing manners.

Proposal 3: NR PH calculation design should adapt to various PUCCH structures and multiplexing manners.

4 Conclusions

The proposals in this paper are summarized as follows.

Proposal 1: Power headroom calculation should be based on BPL/BPL group.

Proposal 2: NR should support gNB indication of waveform-specific PHRs.

Proposal 3: NR PH calculation design should adapt to various PUCCH structures and multiplexing manners.

References

- [1] 3GPP, "RAN1 Chairman's Notes", Spokane, USA, January 16 – 20, 2017.
- [2] 3GPP, "RAN1 Chairman's Notes", Athens, Greece, February 13 – 17, 2017.

[3] 3GPP, “RAN1 Chairman’s Notes”, Spokane, USA, April 3 – 7, 2017.

[4] R1-1709948 “General considerations on UL power control design for NR”, Qingdao, China 27-30, June, 2017.