3GPP TSG-RAN WG2 #109bise R2- 200XXXX

**Online meeting, 20th - 30th April 2020**

Agenda Item: 7.2.2.

Source: Ericsson (Rapporteur)

Title: Report - Email discussion [AT109bis-e][310][NBIOT eMTC] WUS open issues

Document for: Discussion, Decision

# 1 Introduction

RAN2 has made the following agreement in RAN2#109bis-e regarding UE group wake up signal (WUS):

“The following codepoints are used to indicate a paging probability threshold value: {p20,p30,p40,p50,p60,p70,p80,p90}”

The discussion is ongoing and in order to finalize the remaining open issues for UE group WUS, it was agreed to continue the discussion with the following offline discussion:

* [AT109bis-e][310][NBIOT/eMTC] WUS open issues (Ericsson)

Scope: Remaining open issues on WUS

Intended outcome: Finalise the open issues, report in R2-2004045

Deadline: 22-04-2020, 16:00 UTC

In this document, companies are invited to provide their views regarding the remaining open issues on UE groups WUS based on the agreements made so far.

# 2 Discussion

## 2.1 Configuration of paging probability thresholds

A UE that supports Rel-16 group WUS is configured by MME with a paging probability class via NAS layer, e.g. during attach or TA update. It is up to the CN how to determine the paging probability class as it can be based on e.g., information provided by the UE, subscription information, data collected by the CN etc. In CT1 it was agreed to introduce the following values for such configuration: ““p00, p05, p10, p15, p20, p25, p30, p35, p40, p45, p50, p55, p60, p65, p70, p75, p80, p85, p90, p95, p100”.

When the network needs to reach the UE, MME sends a paging request to the eNB including the configured paging probability class so that the eNB knows which WUS group the UE is supposed to monitor prior to its paging occasion. RAN3 has been discussing what value range and resolution are sufficient to be provided from the MME to the eNB along with the paging request. There are 2 options under discussion:

- Option 1 [5-6]: introduce a WUS Assistance Information IE in S1AP PAGING Message which contains the following codepoints “p00, p05, p10, p15, p20, p25, p30, p35, p40, p45, p50, p55, p60, p65, p70, p75, p80, p85, p90, p95, p100”. (same as CT1)

- Option 2 [7-8]: similar to option 1 but with a different set of codepoints such as “p10, p20, p30, p40, p50, p60, p80, p100”. The exact value range is FFS.

RAN2 has agreed to have a configuration where maximum number of probability thresholds is 3 giving 4 groups in a working assumption. Those thresholds are provided in *probabilityThresholdList*, as part of broadcast signalling in the serving cell, so that it would be possible for the UE to know which WUS group set and thus the WUS group, based on the formula agreed in RAN2#109e, it should use when monitoring for WUS.

In the paging request message from the MME, the eNB receives the configured paging probability class for the UE and pages the UE with WUS using the corresponding WUS group set and thus the WUS group by mapping it according to the probability thresholds eNB broadcasts in the serving cell.

Considering that RAN2 assumes maximum number of probability thresholds is 3 giving 4 groups, the codepoints, i.e., {p20,p30,p40,p50,p60,p70,p80,p90}, agreed during the online session on Monday, April 20th, to indicate a paging probability threshold value is associated with the configuration provided by MME via NAS layer and the information provided from the MME to the eNB along with the paging request via S1AP. Therefore, those codepoins are a recommendation to CN working groups and RAN3 from RAN2.

**Discussion point 1: Do you confirm the understanding provided above? If no, please elaborate on why and provide your interpretation.**

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| Company | Yes / No | Comments |
| Ericsson | Yes |  |
| Lenovo | Yes |  |
| ZTE | No? | We understand the {p20,p30,p40,p50,p60,p70,p80,p90} (the value range for paging probability threshold) in SIB is mainly for segmentation of different WUS group sets in RAN2. It only needs to kind of align with the value range of paging probability in NAS, e.g., the minimum value for paging probability threshold should be larger than the minimum value for paging probability, and the maximum value for paging probability threshold should be less than the maximum value for paging probability. That’s enough.  We don’t think setting of paging probability threshold in SIB is a recommendation to CN working groups and RAN3, also don’t think it needs to be associated with the configuration provided by MME via NAS layer or the information provided from the MME to the eNB along with the paging request via S1AP.  And we think the above option 1 (same as CT1) is more suitable for RAN3 paging request signalling. |
| Nokia | No | The granularity of paging probability threshold value used within RAN for division of WUS groups need not to be same as the granularity used for determining the actual value of paging probability thresholds. Because the method to derive the paging probability is upto SA2/CT1 to decide. |
| Qualcomm | No | We have same view as ZTE and Nokia. This is how we except the NAS probability configuration and AS probability thresholds are used:   1. The UE is configured with paging probability as per CT1 signalling and code points. 2. MME/AMF provides the same configured value to the eNB within the paging message sent over the S1/X interface. 3. UE and eNB use the mapping provided in 36.304 to map the NAS configured paging probability to one of the eNB configured probability groups (e.g. up to 4 groups).   The code points in the SIB are purely to set the thresholds for each group, it does not have to be exactly the same value as configured at NAS. It’s true that NAS has granularity of 5% while AS has granularity of 10%. It may be nice to have same granularity at NAS and AS but don’t see this would be beneficial unless AS also allows for same number of sets as the number of code points. |
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## 2.2 Support for 4 WUS group sets

**Discussion point 2: Do you think there is a need to** **support 4 WUS group sets considering that 1 WUS group set is assigned for UEs with no paging probability class? If no, please elaborate on why.**

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| Company | Yes / No | Comments |
| Ericsson | No | We think the agreed number of WUS group sets would be enough considering that Rel-16 group WUS is introduced mainly to reduce the impact on UEs with low paging probability due to false wake ups. |
| Lenovo | Yes or FFS. | In last RAN2#109e, there is a WA: Maximum number probability thresholds is 3 giving 4 group. Thus, we think the agreed number of WUS group sets for service-based grouping is 4. The WUS group set with highest paging probability class has been agreed to be applied by the UE without paging probability if no other UE-ID based group set is configured based on current agreement. This is our understanding to the WUS progress. If there is any issue on this point, we can further discuss it. |
| ZTE | Yes | Maybe I don’t clearly understand the question. Based on the current configuration in 36.331, we understand we can have at most 4 WUS group sets. And all the UEs without paging probability can belong to the “last” group set which is also for the UEs with “highest” paging probability. |
| Nokia |  | As per RAN2 signalling 4 WUS groups are supported. If the paging probability value is not configured for some UE, whether these UE always needs to share the same WUS group with higher paging probability value or can there be separate WUS group for those UE. As per current configuration UE without paging probability value always shares the WUS group belongs to high value of paging probability. |
| Qualcomm | Yes | RAN2 has already agreed to have up to three probability thresholds which automatically provides up to 4 WUS group sets. Therefore, signalling already allows for less then 4 WUS groups. |
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## 2.3 Assistance information for paging probability classes

**Discussion point 3: Do you think it would be beneficial for the eNB if the MME provides assistance information regarding a particular paging probability class.? Please elaborate on why.**

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| Company | Yes / No | Comments |
| Ericsson | Yes | MME can provide a relative measure to the eNB so that the eNB can configure the number of WUS groups in a particular WUS group set accordingly. This does not have to be an exact number, a relative measure will do, e.g., let’s assume MME uses the following codepoints to inform the eNB about the configured class as part of the paging request:  {p20,p30,p40,p50,p60,p70,p80,p90}. If MME indicates to the eNB that the number of UEs configured with a particular codepoint is represented with x units, which is a normalized absolute value so no actual value is needed, eNB can configure the number of WUS groups in a particular WUS group more realistically. Note that this does not need to be done with every paging request, once will be enough unless there has been in update in the CN. For example, for p40 let’s assume 1 unit is indicated whereas for p20 2 units are indicated. This would mean that there are roughly twice the number of UEs configured with a paging probability up to %20 compared to ones with a probability between %30 - %40. The eNB may use that information as a reference to configure twice the number of WUS groups in the corresponding WUS group sets. |
| Lenovo | Yes | We are positive to above point that MME could give some UE information, such as the number of UEs to the specific codepoint to help eNB configure the reasonable WUS resource to each WUS group set. Otherwise, eNB may not know how much the WUS resource could be allocated to the WUS group set in which a large number of UEs or a small number of UEs is applied, that will increase the wrong paging alarm of UE. |
| ZTE | Yes | We can understand such assistance information, e.g, a roughly statistics on UE distribution on different paging probabilities, would be helpful for eNB to set more suitable paging probability thresholds or configure the number of groups for a certain WUS group set more realistically. We are fine to have such information.  We also agree with Ericsson that once or few delivery of such information is enough. So we think it’s more suitable to send such information in an eNB-specific signalling, not UE-specific signalling (e.g., paging). Anyway, the details should be discussed and decided in RAN3. |
| Nokia | No | MME knows only the tracking are wise distribution of UE among different paging probability threshold values. Actual number of UE camped per cell level may differ from this.  The ENB can internally keep track of use of specific WUS Group set over period of observation and can also adjust the threshold value accordingly. This will be more real time update than based on statistical distribution of UE for given range of paging probability.  Moreover if the MME assigns this value as dynamic value based on actual paging traffic towards UE, then the distribution varies over time. In that case adjustment or update will be needed across all the ENB.  As the proposed change mainly impact SA2 and RAN3 the proposal needs to be discussed in SA2/RAN3. But the benefit of this approach for effective use of WUS group can be assessed from RAN2. For optimum division of WUS groups for paging probability, the actual WUS group loading can be used than the assistance information from MME. As there is alternative means without spec changes are possible, in our view this change is not required. |
| Qualcomm | May be | This is network configuration, not clear it needs to be discussed in RAN2. |
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## 2.4 Mechanism to minimize false wake-up

In SA2 WG a mechanism has been proposed in Rel-15 to reduce the impact on UE power consumption due to false wake-up signalling caused by paging “mobile” UEs. In RAN2#109e, it was discussed whether a mechanism is needed for Rel-16 and companies stated their preference regarding whether there is a need and if yes how the mechanism should work [4].

Based on the feedback provided to the email discussion prior to the meeting; 4 + 1 companies think that the mechanism proposed in SA2 for Release 15 to reduce false wake-up be should be used in Rel-16. The support from one company, i.e., representing + 1 above, depends on whether their interpretation on how the mechanism is supposed work is correct. The rapporteur assumes that this is the case and counted their support. 2 companies think that it would be better to utilize the Rel-16 WUS mechanism to address the issue for various reasons.

The following proposal was made by the rapporteur: “The mechanism proposed in SA2 for Release 15 to reduce false wake-up is used in Rel-16.”

**Discussion point 4: Considering the outcome of the email discussion above, please comment only if you think the proposal above is not agreeable and elaborate on why.**

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| Company | Comments |
| ZTE | We have a little strong view that we’d better not to use the R15 SA2 scheme in R16. With R16 GWUS, the (bad) impact of using WUS in all the cells is far less compared to Release 15 WUS. In previous discussion, I can see more companies can agree with such thinking. But as no enough time to discuss, they are still ok to take R15 scheme as baseline. Per our understanding, to give such restriction of stopping using R16 GWUS in non-serving cell would cause worse result of greatly reducing the benefits of R16 GWUS.  As we provide our comments a little late in last email discussion, our comments may not be completely understood by everyone, here we want to emphasize the reasons again:  For the R15 scheme itself, it has the following two issues:  - First issue, per our roughly evaluation, with a general (not so high) paging density or paging possibility, to stop using WUS in the non-serving cell would cause more power consumption for the target mobile UE. This is the obvious shortcoming for the R15 scheme.  - Second issue, the bad impacts in R15 cause by mobile UE is, when a target mobile UE moves to a non-serving cell and if WUS is still used, this cell-specific WUS for this target UE would false wake up all the other UEs in the non-serving cell. But one thing we want to indicate is, when we say the bad impacts is big, we may have a very “ideal” assumption that there has no real paging for any other UEs, then we can say those other UEs are false waken up. But if there have real paging for some of those other UEs at the same time when the target UE is paged, the wake up of these UEs is not “false” but “intentional”. In summary, how big the bad impacts of false wake up may be very depend on the possibility of multiple UEs being paged at the same time.  For R16, different from in R15 all the other UEs in the non-serving cell would be false waken up, only the UEs (maybe 1/16 of all the UEs) belong to same service or UE-ID group as the target UE will be possibly false waken up.  Furthermore, if this target UE also belongs to a low paging probability group and the paging for this target UE is anyway sparse, the bad impacts will further reduce. On the other hand, if this target UE belongs to a high paging probability group, e.g., the paging for this target UE may be very dense, as we can assume the possibility of paging the other UEs in the same service group is also high, with reference to the second issue mentioned above, we think the false wake up for other UEs can be seen very low, e.g., among all the wake up of other UEs in this high paging probability group, only a small part is “false” wake up caused by target UE and the other wake up are normal or intentional.  With all the above analysis, we think the disadvantage of re-using R15 scheme in R16 is obvious (more power consumption for the mobile UE) while the benefit may be unclear (even how big the false wake up issue in R16 is also unclear). We don't think it's a good idea to introduce R15 scheme in R16 or set restriction on usage of R16 GWUS in a hurry. |
| Nokia | We agree that the impact of false wake up is reduced significantly for Rel-16 based WUS grouping. Mainly for the paging probability based WUS grouping. So allowing the GWUS usage for mobile UE can be considered for Rel-16. Further enhancements to optimise the performance can be taken up in later release.  We are OK to remove the Rel-15 restriction for Rel-16 GWUS if it is agreeable. |
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## 2.5 Support of Rel-16 WUS vs. Rel-15 WUS

**Discussion point 5: Do you think RAN2 should confirm the following working assumption: “Support of Release 16 WUS is independent to support of Release 15 WUS”? Please elaborate on why.**

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| Company | Yes / No | Comments |
| Lenovo | Yes | In last RAN2#109e meeting, some other company said maybe they would apply only the R16 network and UE, it is the reason leading to this work assumption. We think it is reasonable. |
| ZTE | No | Such working assumption may cause confusion on whether R15 common WUS can be sent when multiple R16 UE groups need to be waken up (if R15 common WUS has been configured).  Therefore, we are ok to revert the working assumption or at least to clarify a Rel-16 group WUS capable UE shall be able to monitor R15 WUS sequence for common WUS. |
| Nokia | Yes with further clarification | UE implementing Rel-16 WUS will only monitor WUS group and common WUS based on the group it belongs to based on UE ID. Whether this UE also needs to support simple WUS monitoring in cell where Rel-16 WUS is not configured is upto UE implementation.  In our understanding, use of Rel-15 WUS or Rel-16 WUS for paging, ENB will decide based on separate capability information. If yes, the working assumption is right.  From RAN1 perspective, Rel-16 WUS UE can also consider Rel-15 WUS sequence as common WUS. This does not mean that this UE need to implement both GWUS based and WUS based paging via single capability. |
| Qualcomm | No | UE supporting Release 16 WUS will support the following:   * Decoding and using wus-Config-r15 * An extreme eNB GWUS configuration with just one WUS resource (in legacy time/frequency) which has just one group WUS. With this configuration GWUS is like WUS with the only difference being the sequence is different from Release 15.   Therefore, we see no technical reason why UE supporting R16 WUS should not be required to support R15 WUS. The cost of implementation and testing is negligible. |
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# 3 Summary

TBD

# 4 Conclusion

Based on the discussion and summary, the following proposals are made:

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# 4 References

1. [RP-192875](http://3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_86/Docs/RP-192875.zip), “Additional MTC enhancements for LTE”, Ericsson, RAN#86, Sitges, Spain, 9th – 12th December 2019.
2. [RP-193224](http://3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_86/Docs/RP-193224.zip), “Additional enhancements for NB-IoT”, Futurewei, RAN#86, Sitges, Spain, 9th – 12th December 2019.
3. [R2-2001886](http://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_109e/Docs/R2-2001886.zip), “RAN2 agreements for Rel-16 additional enhancements for NB-IoT and MTC”, Blackberry, Rel-16, LTE\_eMTC5-Core, NB\_IOTenh3-Core
4. [R2-2001789](http://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_109e/Docs/R2-2001789.zip), “Report of WUS: Progress the FFS from Email Discussion 108#94 and Summary”, Qualcomm, Rel-16, LTE\_eMTC5-Core, NB\_IOTenh3-Core.
5. R3-201676, Consideration on UE group wake up signal (WUS), Huawei, Vodafone
6. R3-201677 Support of WUS grouping, S1AP CR#1762, Huawei, Vodafone
7. R3-202190, Introduction of WUS grouping, Ericsson, ZTE
8. R3-202191, Introduction of WUS grouping, S1AP CR#1772, Ericsson, ZTE