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1. Introduction

In the previous WG1 meeting, WG1 #14, Nokia presented a contribution , R1-00-0856, where we showed UE battery life improvement calculations, with the assumption that tx gating is used during longer DTX periods in a packet connection. For this WG1 #15 meeting we prepared a contribution R1-00-1029, where we give further clarifications what kind of models were assumed in those calculations. The conclusion of both of those papers were that DPCCH gating is clearly a beneficial feature in DSCH+DCH case.

The operation time in DTX is fully dependent on operator connection release timer settings after packet call. And it should be understood that connection release times are not specified. Thus clear battery savings can be achieved with DPCCH gating, if longer connection release times are used. On the other hand long connection release times are justified with DSCH+DCH case. Together with DSCH+DCH and DPCCH gating concept , the connection release times could be adjusted to be approximately the reading times between the packet calls, which would mean that doing connection release and using RACH could be avoided between each packet call. However, if UE battery savings can be achieved during DTX , it should definitely be allowed.

Thus we think that DPCCH gating is definitely a beneficial feature. This paper gives some further ideas how we might further optimise the UE batteries during DTX.

As we explained in R1-00-1029, the battery improvement calculations in our contribution R1-00-0856 assumed that only tx side battery consumption can be saved due to DPCCH gating. Rx side has to be on all the time , since

- it was assumed that packet transmission can start again in any frame. So TFCI decoding has to be done in each frame, and the receiver has to be ready to decode each frame.
- handover measurements were assumed to be running continously according to the present requirements.

For this reason it was assumed that rx side battery consumption can not be saved during DPCCH gating.

Looking at the battery improvement calculations, we however started to think , that DPCCH gating would be even more attractive feature, if it could be defined in such way, that also rx side battery consumption could be saved. This could be done with following way:

- We could define that packet transmission cannot start in any frame after gating is started. It could start only e.g. in every Kth frame. Thus in this case rx side has to decode the whole frame only in every Kth frame. In the frames between, the Rx would have to wake up only during those slots that are transmitted during gating. Network would signal this parameter K to the UE along with the other DPCCH gating parameters.
- We could define somehow a bit looser handover measurement requirements during gating. E.g we could define that during gating it is required to do handover measurements only for those cells in the neighbor list, for which initial search has already being done. This is since initial search might be difficult to do during gating. Other handover measurements could work fine even during gating. The DPCCH gating is anyway probably going to be used only with low speeds , about 3 km/h, since with higher speeds we get more performance degradation due to slower power control cycle. Thus if we anyway have the knowledge that user is slowly moving, it might be so that there is not a need for requirement to do initial search for new cells very often. If avoiding this will save battery times, when nothing is anyway transmitted, the benefit for battery consumption should be exploited.

We agree that some more thorough thinking is needed what kind of handover measurements should be required in this case so that this does not lead to any catastrophic situations, but we still think that this idea might be worthwhile to explore further. And , of course it is always possible for the operator to use K=1, which means that continuous decoding is required at rx side. One possibility would be that if K=1, then normal handover measurement requirements are valid.

These new ideas are explained in more detail in the below chapters.

2. DPCCH gating method, allowing both tx and rx side battery life improvement

2.1 Higher layer scheduling method, avoiding unnecessary continuous decoding

If packet transmission can start in any frame, it means that

- either all slots in the frame in downlink have to contain TFCI bits , and rx has to be on during the whole frame in all frames, in order to decode the TFCI. With the help of TFCI, the UE detects whether DPDCH (packet) exists.
- If not all slots in the frame in downlink contain TFCI bits, then the UE has to use so called pilot energy comparison method first to evaluate , whether DPDCH exists in the frame. In this idea all the slots only contain pilot & TFCI only if DPDCH exists.

=> In both of these cases it means that rx side has to be on and doing decoding in each slot in the frame. Thus no rx side battery savings cannot be achieved during gating.

To avoid the requirement of continous decoding of each frame in downlink, we could define that there is some information delivered to UE that packet transmission is not supposed to start in any frame after gating is started. The packet transmission could start only e.g. in every Kth frame. Thus TFCI bits would exist in all slots only in those particular frames. In the frames between, the TFCI bits do not have to exist in every slot, since TFCI decoding would not be done in those slots. In the frames between, rx would have to wake up only for every 3rd slot with 1/3 gating, or every 5th slot with 1/5 gating, for making SIR estimation and decoding TPC symbols, so that inner loop power control continues working.

If we know that there is anyway going to be quite long DTX period between two packet calls, it does not sound so controversial limitation, to limit the starting instant of the new packet call with a certain resolution. And of course there is always the possibility to use K=1, which means that then we have the same scheme that has earlier been proposed, meaning that packet transmission can start in any frame during gating.

Figure 1 shows the idea of higher layer signaling method. In this case the network will define the period where UE need to perform a decoding of the whole frame in order to detect is the packet transmission active. In case it is not, the next active period will follow after agreed period of time. There is no limitation how long the packet transmission period can be after it has started. Thus it is only limited, that at which frames it can start. The period is triggered to the point where last transmitted frame has occurred. It's only an agreement issue whether it is the start or the end of the last frame, and will have no impact to procedure in general.

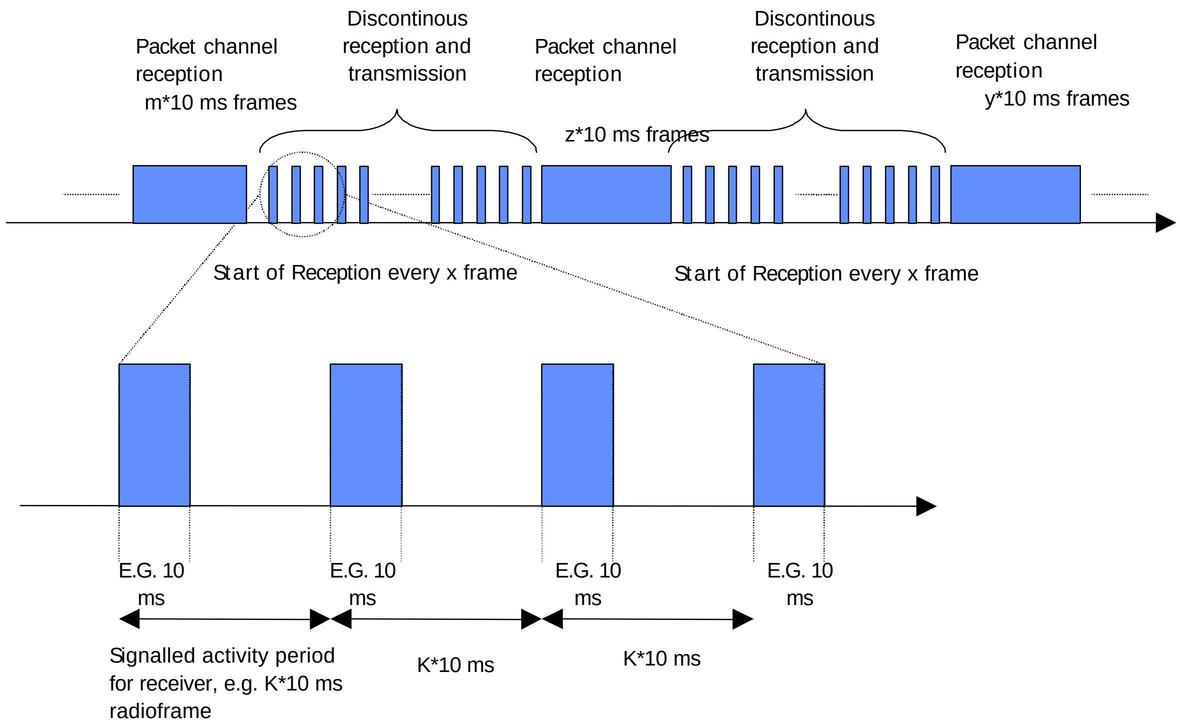

Figure 1. Example of higher layer signalling scheme for discontious reception. It shows in which frames the UE has to detect whether packet transmission starts again. In these frames the rx has to be on during the whole frame

2.2 Handover measurements during gating

We could define somehow a bit looser handover measurement requirements during gating. E.g we could define that during gating it is required to do handover measurements only for those cells in the neighbor list, for which initial search has already being done. This is since initial search might be difficult to do during gating. Other handover measurements could work fine even during gating. The DPCCH gating is anyway probably going to be used only with low speeds , about 3 km/h, since with higher speeds we get more performance degradation due to slower power control cycle. Thus if we anyway have the knowledge that user is slowly moving, there is probably not a need for requirement to do initial search for new cells very often. If avoiding this will save battery times, when nothing is anyway transmitted, the benefit for battery consumption should be exploited.

We agree that some more thorough thinking is needed what kind of handover measurements should be required in this case so that this does not lead to any catastrophic situations, but we still think that this idea might be worthwhile to explore further. And , of course it is always possible for the operator to use K=1, which means that continuous decoding is required at rx side. One possibility would be that if K=1, then normal handover measurement requirements are valid.

3. Battery life calculations with both tx and rx gating

3.1 Assumptions in UE battery life calculations with tx and rx gating

Following assumptions have been used in the simplified UE battery life calculations with tx and rx gating.

1) First it was assumed what is the percentage of battery consumption of tx side and rx side, respectively, for certain tx power level, when gating is not used. Let's say that with tx power level , txpwr, this results in :

    - tx side consumes N1 mA @ txpwr
    - rx side consumes N2 mA

    No specific data rates were assumed here either in uplink or downlink, for simplification.

2) Then it was calculated , what is the tx side battery consumption , if tx gating is used. Separate values were calculated for 1/3 gating and 1/5 gating, with the same corresponding tx power level txpwr. This resulted in following value:

    - tx side consumes N1_gating mA, during gating @ txpwr

3) It was also calculated, what is the rx side battery consumption (average battery consumption over K frames), if rx gating is used. Here rx is on the whole frame in every Kth frame. And in the frames in between the rx is on only in every 3rd slot or every 5th slot, with 1/3 gating or 1/5 gating , respectively. This resulted in following value:

    - rx side consumes N2_gating mA, during gating

4) Finally it was calculated what is the overall battery life improvement:

$$Battery\_life\_improvement = \frac{N1 + N2}{N1\_total\_new + N2\_total\_new}$$

where:
N1_total_new = (1-DPCCH_gating_%)*N1 + DPCCH_gating_%*N1_gating
N2_total_new = (1-DPCCH_gating_%)*N2 + DPCCH_gating_%*N2_gating

3.2 UE battery life improvement calculations with tx and rx gating

Here we show the UE battery life improvement calculations with tx and rx gating, where higher layer scheduling idea has been used, to allow battery savings also in rx side. Values K=1,4 and 8 are used in the calculations, where K defines that rx side has to be on the whole frame in every Kth frame. Note, K=1 gives the same result, as was given in our previous UE battery improvement calculations, where only tx side improvement could be achieved, since K=1 means that rx side has to be on in every frame.

Thus table 1 and 2 show UE battery lifetime improvements for DCH+DSCH case, with DPCCH_gating_%=0.66, for medium range tx pwr level and high tx power level, respectively. This time we did not calculate the case for DCH only case (DPCCH_gating_%=0.3), since the main point here is to evaluate, whether rx gating is giving clear enough improvement, or whether tx only gating (K=1 case) is sensible alone.

Gating rate	K	UE battery life improvement
1/3	1	21 %
	4	32 %
	8	34 %
1/5	1	34 %
	4	56 %
	8	60 %

Table 1. UE battery life improvement due to gating, with medium range tx power level and DPCCH_gating_%=0.66, which refers to DSCH+DCH case.

Gating rate	K	UE battery life improvement
1/3	1	26 %
	4	35 %
	8	37 %
1/5	1	44 %
	4	61 %
	8	65 %

Table 2. UE battery life improvement due to gating, with medium range tx power level. DPCCH_gating_%=0.66 which refers to DSCH+DCH case.

It can be seen that rx gating clearly further improves the UE battery life. Thus , if there are good ideas for the handover measurement requirements during DPCCH gating state, and if we can get a consensus about it, we could include the usage of parameter K into the definition of DPCCH gating feature.

4. Conclusion

It can be seen that there are more benefits from DPCCH gating concept, if we can achieve UE battery savings both from rx and tx side. However, we agree, that it should be more thought about how the handover measurement requirements should be then defined during DPCCH gating state. If people are interested in this issue, we could further explore it.

However, as a main conclusion, Nokia opinion is that tx gating concept , what has earlier been proposed by Samsung, should definitely be included to the specification, since in that concept there is no problems how the handover measurements will be done, since there it is implicitely required that rx is continuously on, for decoding TFCI in each frame. Clear battery savings (K=1 case in the tables above) can already be achieved with tx gating concept.

But if a good solution for doing tx & rx gating + handover measurements can be found , we should think about it. At least we should define the tx gating concept in such way, that it does not prohibit us later to add the idea of doing both tx & rx gating.