TSG-RAN Working Group 1 meeting #10
Beijing, China 18-21 January 2000

TSGR1#10(00)0113

Agenda Item:

Source: Nokia

Title: Physical channel BER and Downlink Outer Loop Power Control

Document for: Discussion and approval

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0. INTRODUCTION (to RAN WG1)

This document is a copy of TSGR4 #10 (00) 013, mainly targeted to be presented in RANWG4 meeting this week, in San Jose, California. Since the main conclusions are also relevant to RAN WG1, it is thus presented also in RAN WG1 meeting.

The main items/ conclusions of the paper are following:

There is a discussion going on in RAN WG4, that which one, Physical channel BER or TrCH BLER should/can be used as a basis for outer loop PC. In [1] it was claimed that physical channel BER gives better performance, when target is to maintain physical channel BER stable.

In this document, it is reminded that the main task that the outer loop should do, is to keep BLER stable, not physical channel BER, since BLER defines the final QoS.

It is shown here, that if outer loop does keeps physical channel BER stable, it means that the final QoS (=BLER) varies. In practice this means that either a) call is dropped or b) quality has to be kept part of the time at too good level which wastes capacity.

Since the physical channel BER cannot be used for outer loop, to ensure stable QoS, this measurement should not be required at all, since it just adds complexity.

Of course if some UE / Node B manufacturer wants to make the measurement for their own proprietary implementation related algorithms, that is of course possible. But for that purpose the measurement should not be in the specifications.

Thus we propose that Physical channel BER measurement is removed from TS 25.215. And instead TrCH BLER should be used for outer loop. If TrCH BLER is kept stable, then automatically the result is that QoS is also kept stable.

1. INTRODUCTION (TO RAN WG4)

This document discusses the behavior of Downlink Outer Loop Power Control (OL PC) algorithm when it is based on physical channel BER as suggested in 3GPP. First, two different downlink OL PC criteria are compared, one based on physical channel Bit Error Rate (BER) and the other based on jump algorithm using CRC checks. It is shown that simple jump algorithm performs equally well as OL PC based on physical channel BER in terms of downlink capacity. This result is contradictory to the result shown in [1], which was presented in RAN4#9 meeting in Bath. Furthermore, it is shown that when physical channel BER is maintained fixed by some controller the QoS may not be maintained fixed at all. This result raises serious questions and worries about the applicability of OL PC algorithm using physical channel BER.

Secondly, this document identifies other problems that appear if OL PC is based on physical channel BER, especially when it is located in a network as suggested in [1]. The list of problems is the collection of comments presented in RAN4 reflector and comments mentioned in previous RAN4 meetings added by conclusions that were drawn from simulation results presented in this document.

Finally, conclusions and the way forward are presented.

2. PERFORMANCE COMPARISON OF TWO OUTER LOOP POWER CONTROL ALGORITHMS

2.1 Capacity comparison

In [1] a performance comparison of physical channel BER, BLER and Jump Algorithm was presented. In that document it was found that outer loop PC based on a PID controller using physical channel BER performs better than the Jump or BLER controllers, especially for low BLER. Results in [1] are shown in Figure 1a. Figure 1b shows Nokia's results for the same comparison. Parameters used in simulations can be found in Annex A. It can be seen from Figure 1 that results are contradictory to results shown in [1], since Jump algorithm performs equally well than the controller using physical channel BER criterion, also with low BLER.

Title:
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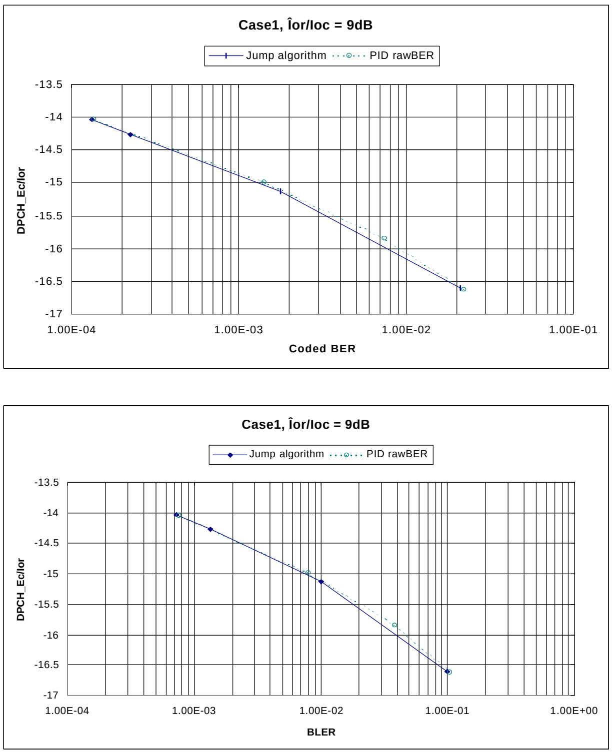

Figure 1a: Ericsson's results in [1].

Figure 1b: Nokia's results.

Figure 1. Performance comparison of OL PC using a Physical Channel BER and Jump algorithm.

2.2 Quality of Service comparison

In [1] a figure 2 is showing graphs for SIR target and physical channel BER in a scenario when number of taps in a multi-path profile changes from 1 to 4 and back. It could be seen from the graphs that SIR target was 3 dB higher when the number of taps were 4. This means that OL would ask more power from BS when extra diversity is achievable for a UE. We were confused with these results and wanted to show our understanding of OL PC behavior. In [1] it was also shown that mean physical channel BER can be maintained relatively stable (± 10 %) during simulations. However, it was not shown how BLER behaves during a simulation time, although CRC errors were shown. Behavior of physical channel BER

OL PC in [1] seemed bit strange since 7 out of 10 CRC errors happened during extra diversity. This implies that BLER during 4 tap channel is higher than during 1 tap channel. We think that extra diversity should help UE regarding the BLER and not vice versa.

In our opinion it is very important that BLER can be maintained stable during a call, since BLER defines the final QoS for a given bearer. This is the reason why we wanted to repeat simulations in [1] and to study how BLER varies when OL tries to maintain the required physical channel BER target.

In Figure 2 OL PC parameters are shown in 1-tap and 4-tap channels. Channels are the same as in [1] and are described in ANNEX A. Figure 2a shows that with these SIR target needs to be increased when UE has more diversity in order to keep the same physical channel BER value (RawBER). Thus this result is in line with figure 2 shown in [1]. However, Figure 2b shows how SIR target should be updated as a function of BLER target. It can be seen that curves are crossing and it is not so straightforward to determine how SIR target should be updated. It also can be seen from Figure 2b that BLER decreases always when SIR target is being increased. These two issues imply that when physical channel BER is kept fixed the BLER varies. This conclusion can be confirmed from Figure 2c where it can be seen that e.g. 7 % physical channel BER gives $7*10^{-4}$ BLER in 4-tap channel while it gives $2*10^{-2}$ BLER in 1-tap channel.

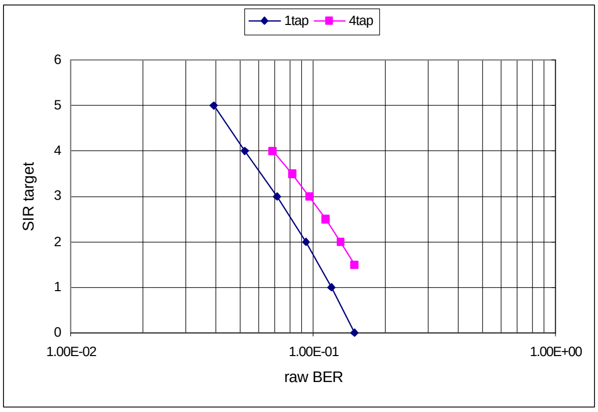

Figure 2a

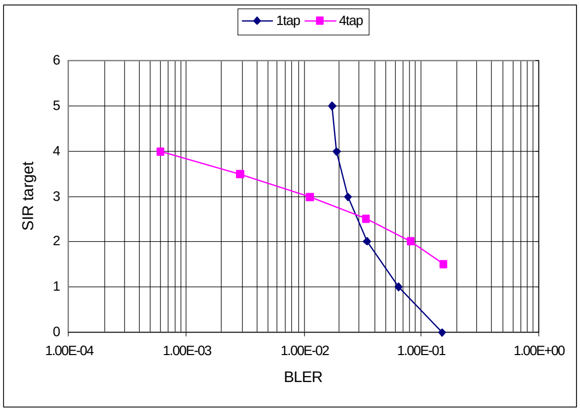

Figure 2b

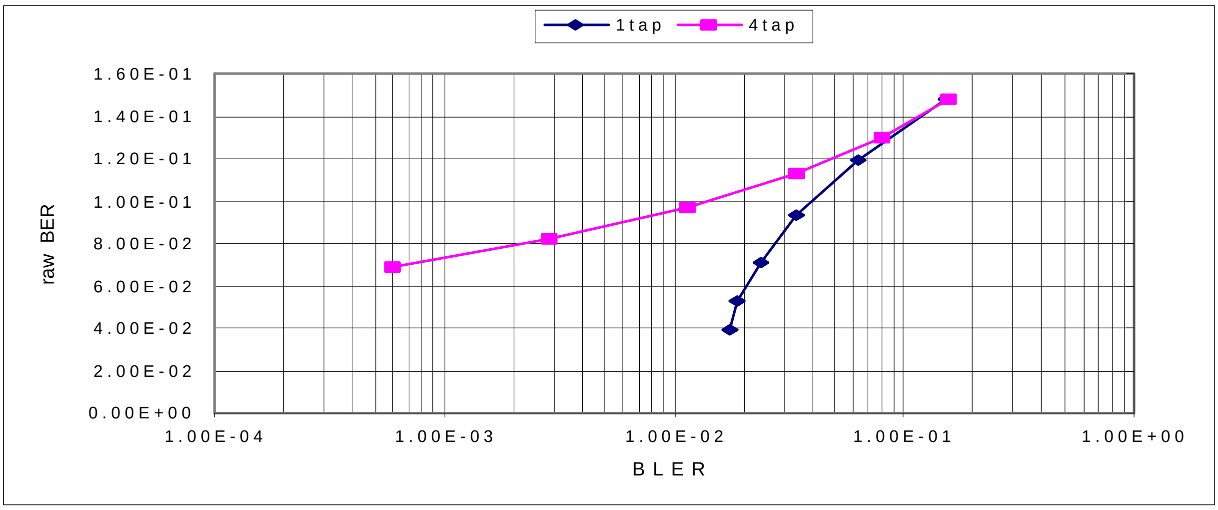

Figure 2c

Figure 2. Outer Loop PC parameters in 1-tap and 4-tap channels:

The behavior of OL PC based on physical channel BER is further illustrated in Figure 3. It can be seen that BLER goes between 10-3 and 10-2 while number of taps changes. It clearly shows that OL PC algorithm using physical channel BER has failed to maintain the QoS. In the worst case the degradation of QoS could be so severe that a call could be dropped.

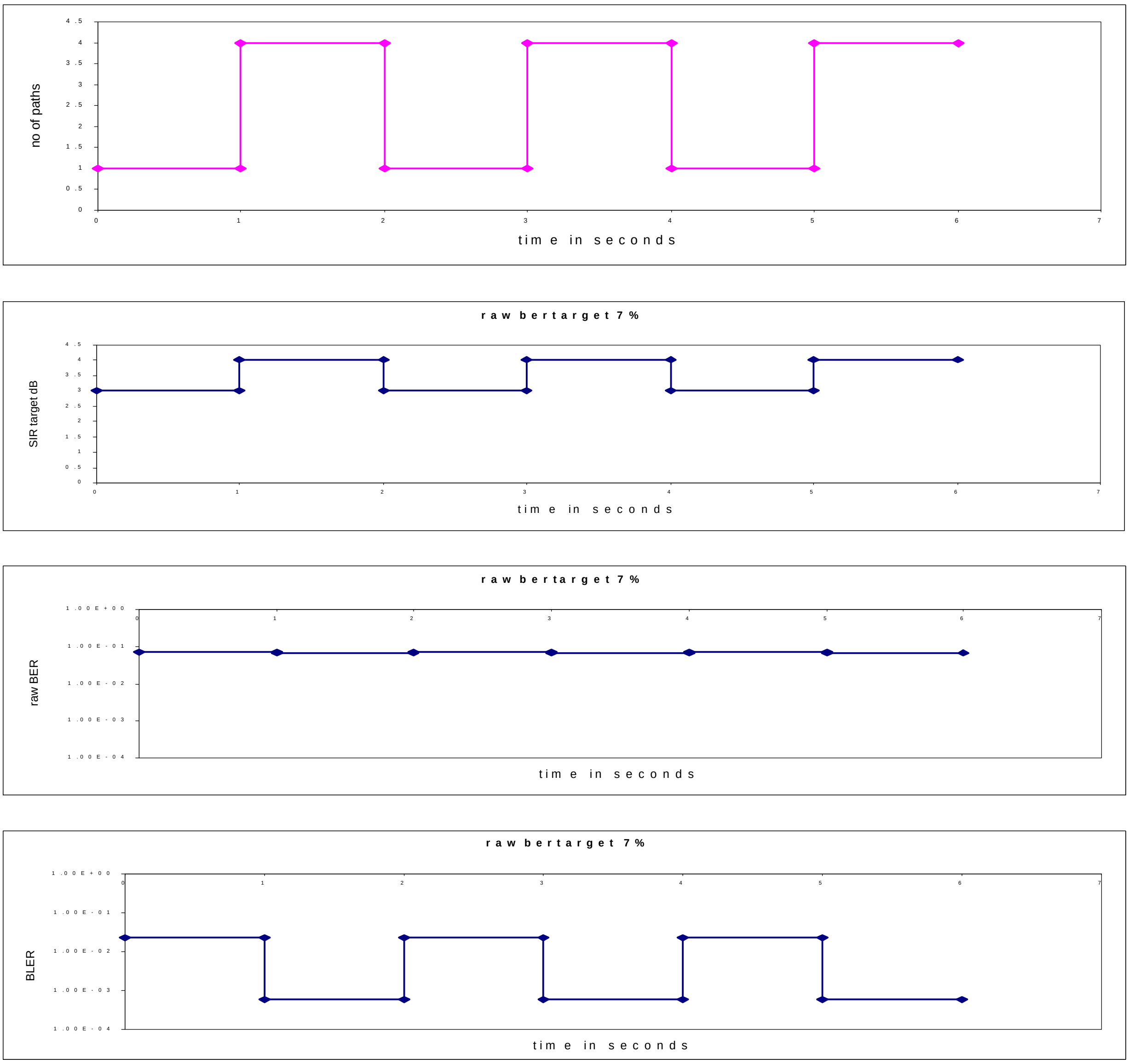

Figure 3. Behavior of QoS when OL PC is based on physical channel BER.

It seems that in [1] it is assumed that physical channel BER and BLER are connected and one could use either of them for OL PC. Based on our simulations this assumption is not always true. In other words we have shown that keeping the physical channel BER fixed does not ensure that QoS is kept fixed.

This behavior of OL PC using physical channel raises several questions and problems, and it gives us a good reason to doubt the applicability of OL PC based on physical channel BER. These problems are discussed in more detailed in Section 3.

In figure 4 the correct behavior of OL PC algorithm is presented. OL PC algorithm using some form of feedback from BLER has no such problems as a OL PC algorithm using physical channel BER. For example, jump algorithm performs well since it is using CRC checks.

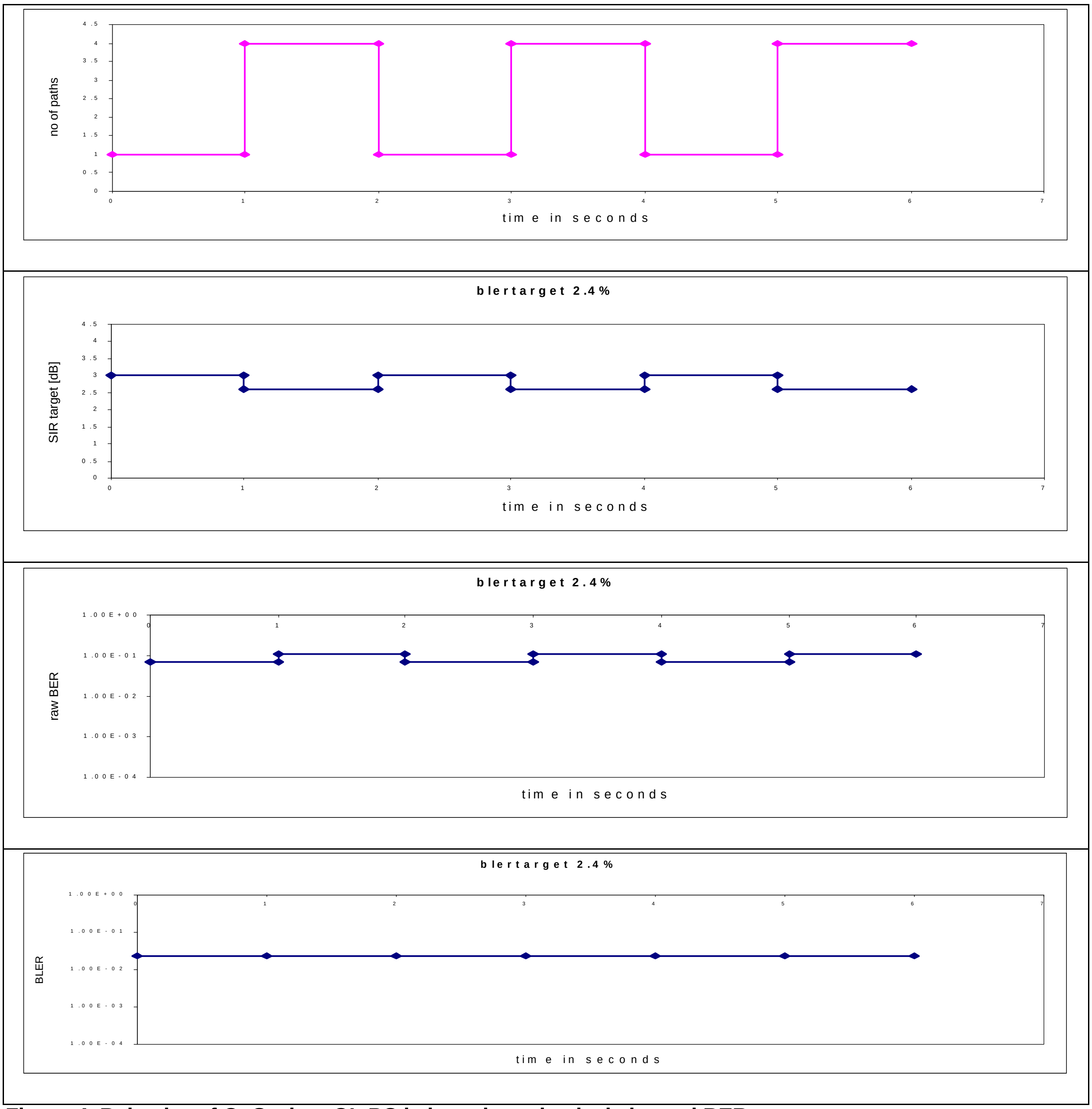

Figure 4. Behavior of QoS when OL PC is based on physical channel BER.

3. PROBLEMS RELATED TO OUTER LOOP PC BASED ON PHYSICAL CHANNEL BER

We encourage that items listed below should be solved and studied before physical channel BER is being proposed to be used in OL PC, especially if the OL algorithm is located in a network. In 3GPP there has not been any contribution discussing about the listed items, which are very crucial from the good system operation point of view.

- Mapping of physical channel BER to BLER, especially in a network based OL
- Relevance of a UE's ability to maintain the target physical channel BER

- The effect of signaling delay on the performance of network based OL utilising physical channel BER

In the following subsections each of these items is explained further.

3.1 Mapping of physical channel BER to BLER

From our simulation experience with physical channel (raw) BER values, they tend to be quite flat over the range of Ec/Ior (hence Eb/Nt) values, in particular if Turbo coding is used. In Figure 5 a set of simulations results are presented showing how physical channel BER is varying over the BLER change in different propagation conditions. For example over the range of 1 dB variation in Ec/Ior, BLER varies from 16% down to 0.55%, while physical channel BER varies from only 13% to 9.4%. What this means is that a control loop based on physical channel BER may well be subject to relatively high inaccuracy, especially in fading conditions. It should be also kept in mind that latest specification [2] states that required accuracy of physical channel BER measurement is ± 10 %. In a worst case this may mean that BLER varies between 10^{-3} and 0.5 while physical channel measurement fulfills the accuracy requirement. Based on this we feel that in order to base the OL PC solely on physical channel BER, it needs to be an extra ordinate accurate mapping from physical channel BER to BLER together with an extra ordinary accurate measurement in order to avoid call dropping.

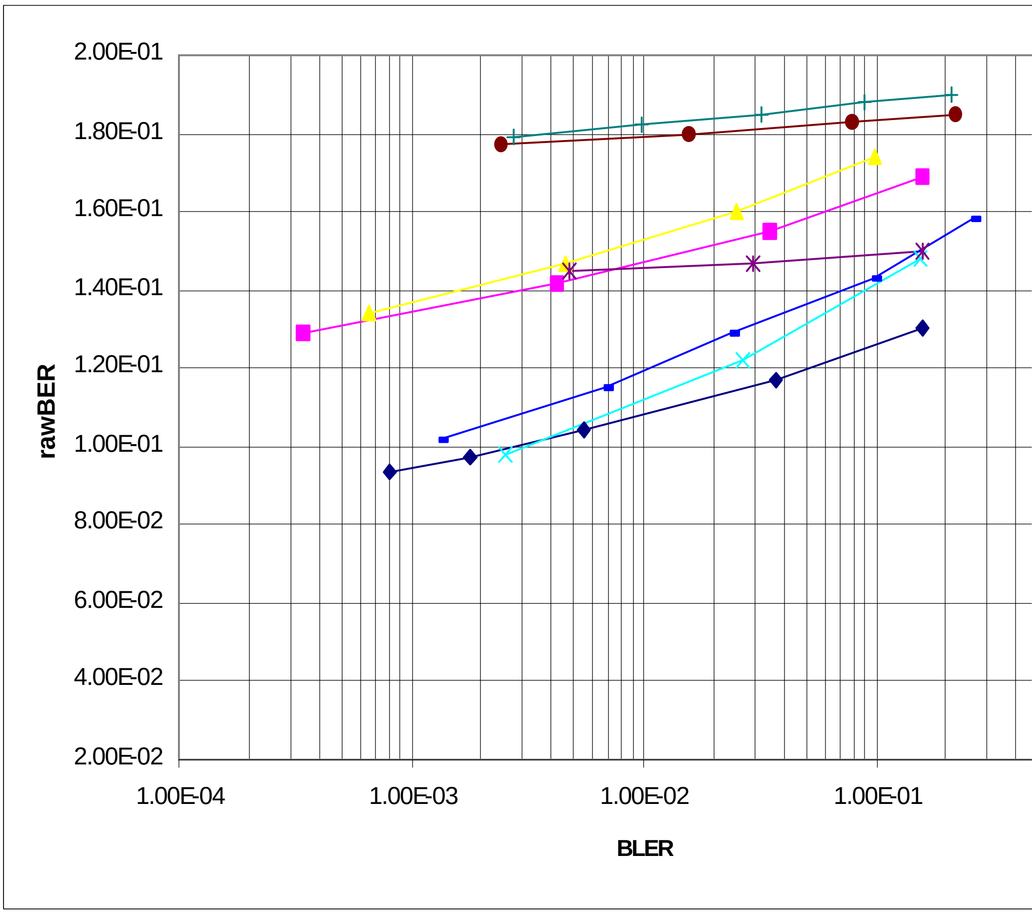

Figure 5. Physical channel BER as the function of BLER. Results collected from RAN4 simulations with 12.2 kbps, 64 kbps, 144 kbps and 384 kbps measurement channels in AWGN channel and in Case 3 channel (UE speed 120 km/h).

It was stated in [1] that "Since the network has more information regarding the environment this mapping should be made there". It should be noted that simulations in [1] were using UE based OL thus simulation results are not supporting this conclusion. Our opinion is that this mapping from physical channel BER target to BLER target is a very challenging mission for a network. Based on our simulation results physical channel BER can be very flat changing only very little while BLER goes from 10^{-1} to 10^{-3}. Furthermore, actual physical channel BER value, which gives a certain BLER depends at least on following items: bit rate, interleaving depth, a number of multipaths, UE speed, number of iterations in turbo decoding, used word length in a base band and a number of bits in a block. Many of these are unknown for a network and a small error in mapping can cause huge differences in BLER values. Also the effect of the dynamic bit rate of possible other services will lead to dynamically changing rate matching/coding thus changing a physical channel BER target suddenly while BLER target remains the same. Thus we have strong doubts that this mapping can not be done in practice and therefore we do not think that physical channel BER is a good QoS indicator.

So far we have not seen any feasibility study in 3GPP showing how this mapping could be done in a network and whether it's accuracy is enough together with UE's physical channel BER measurement accuracy.

We are not opposing if some manufactures want to use physical channel BER as a additional information source for UE based OL algorithm. This may be useful in some special cases. However, in this case UE shall have total freedom to set it's SIR target based on different information sources, and physical channel BER should not be considered as a parameter nor the requirement of the OL PC test. In other words we think that UE based OL PC using a physical channel BER does not belong to UE minimum performance requirement as such, but more of implementation details by the choice of individual manufacturers. We see that BLER is the most suitable measure to reflect how well UE performs the outer loop.

3.2 Relevance of UE's ability to maintain the target physical channel BER

In a network based OL PC network sends physical channel target for a UE. The UE tries to maintain the given target. The big question is that is it relevant from QoS perspective how well the UE is able to maintain the physical channel BER target? This issue is even more important since the mapping of physical channel BER to BLER depends on many things such as the multipath profile and UE speed as mentioned in previous sections.

The measure of the target quality value, in our opinion, should be BLER, since this parameter is commonly regarded as the QoS in UTRAN radio bearer services. It is of no relevance how well UE is able to maintain the physical channel BER, what really matters is how well UE can maintain the QoS target.

We are not aware of any 3GPP contribution giving confidence that when UE's is able to maintain the physical channel BER target, QoS is ensured in all possible conditions. We think that such a study should be presented in 3GPP before physical channel BER is proposed to be used in RAN4 OL PC tests. On the other hand simulations results presented in Section 2 indicated that fixed physical channel BER target does not ensure stable QoS in a environment, in which a number of multi-paths suddenly changes.

3.3 Effect of signaling delay on the performance of network based OL using physical channel BER

One of the major benefits of physical channel BER is that it is much faster to get an adequate estimate of physical channel BER value compared to BLER value. This has been stated in RAN1, RAN4 and was also included in [1]. This is true, but it only means that UE is able to achieve relatively fast the target physical channel BER. The key point here is, however, how fast the physical channel BER target can be updated. Hence taking into account a possible mapping error in physical channel BER target UE may have achieved fast the physical channel BER target but its QoS is not adequate. Thus OL algorithm needs feedback from the real QoS indicator in order to retune the physical channel BER target. The faster it gets the feedback the better.

If OL algorithm is in UE, then fastest way to get a feedback from QoS is to check CRC. Thus this solution is as fast as jump algorithm proposed in [1]. The other solution is to wait that UE has achieved an adequate estimate of BLER value and based on this physical channel BER target is being updated. This solution takes more time than a previous solution. As a conclusion, OL PC in UE based on physical channel BER is no faster than jump algorithm when mapping error is taken into account.

If OL algorithm using physical channel BER is located in a network as proposed in [1], then a fast physical channel BER estimate is totally non-relevant. Since mapping errors exist, network needs feedback from real QoS in UE. This is only possible by waiting a reliable BLER measurements reports. This is very time consuming as stated in [1]. In practice this solution is wasting capacity or otherwise the probability of call dropping is increased. This phenomena is illustrated by a following example.

Let us assume that OL is in a network and BS signals the initial target physical channel BER value to a UE in a beginning of a call. Since the accuracy of mapping may not be good in all conditions, BS needs to set high enough target physical channel BER value to a UE to ensure that call is not dropped in a beginning of a call. UE can adapt very fast to this target BER, but network does not know what is the QoS in UE. So it needs to wait for BLER reports from UE to adjust physical channel BER into correct direction. This take a lot of time and interleaving length is just a small part of the total time. This means that unnecessary high power is allocated to a UE for a long period. This is wasting the system capacity. If OL were located in UE, then physical channel BER value could be updated as fast as one block have been demodulated i.e. once in TTI. Thus when OL is located in a UE, system capacity is improved and probability of dropped calls are decreasing.

We are not aware of any 3GPP contribution, which shows the effect of signaling delay on the performance of a network based OL using physical channel BER. It also should be known and studied how much signaling capacity is needed in network based OL so that it performs equally well than UE based OL PC.

4. CONCLUSIONS

Simulations results for OL PC were presented. A comparison of two different OL algorithms was made. It was found that jump algorithm is not wasting capacity more than physical channel BER OL PC as stated in [1]. Furthermore we showed that, if physical channel BER is maintained fixed by OL PC, it does not mean that QoS is maintained at the required level. On the contrary, it was shown that in a certain environment BLER was moving between 10^{-2} and 10^{-3} while the physical channel BER was kept ideally fixed. This means that OL PC using physical channel BER target fails to maintain the QoS at the required level. In a worst case it means that calls may be dropped if OL PC is based only to keep physical channel BER at required level. If target physical channel is increased to avoid dropped calls, then this solution is not capacity efficient.

We also listed many problems related to OL PC using physical channel BER, especially if the OL algorithm was located in a network. We think that the pointed problems need further studies, solutions and simulations results before physical channel BER can be accepted to be used for OL PC, especially if it OL is suggested to be located in a network.

We think that applicability of physical channel BER for OL PC has been now seriously questioned, especially if OL PC is planned to be network based. We encourage RAN4 to draw conclusion on this issue and to write appropriate liaison statements to other relevant 3GPP working groups.

REFERENCES

[1] R4-99850. Performance requirements of Downlink outer loop power control. Ericsson.

[2] TS 25.133 v.3.0.0. Requirements for Support of Radio Resource Management (FDD).

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ANNEX A SIMULATION ASSUMPTIONS

Table 1 shows assumptions used for simulations.

Table 1. Simulation assumptions

<table>
<tr><td>Parameter</td><td colspan="4">Explanation/Assumption</td></tr>
<tr><td>Chip Rate</td><td colspan="4">3.84 Mcps</td></tr>
<tr><td>Closed loop Power Control</td><td colspan="4">ON</td></tr>
<tr><td>AGC</td><td colspan="4">OFF</td></tr>
<tr><td>Channel Estimation</td><td colspan="4">Ideal</td></tr>
<tr><td>Number of samples per chip</td><td colspan="4">1</td></tr>
<tr><td rowspan="5">Propagation Conditions</td><td colspan="4">Capacity comparison: Case 1 as specified in TS 25.101</td></tr>
<tr><td colspan="4">QoS comparison: speed 3km/h</td></tr>
<tr><td colspan="2">Period 1</td><td colspan="2">Period 2</td></tr>
<tr><td>Relative Delay [ns]</td><td>Average Power [dB]</td><td>Relative Delay [ns]</td><td>Average Power [dB]</td></tr>
<tr><td>0</td><td>0</td><td>0
260
521
781</td><td>0
0
0
0</td></tr>
<tr><td>Number of bits in AD converter</td><td colspan="4">Floating point simulations</td></tr>
<tr><td>Number of Rake Fingers</td><td colspan="4">Equals to number of taps in propagation condition models</td></tr>
<tr><td>Downlink Physical Channels and Power Levels</td><td colspan="4">As specified in TS25.101</td></tr>
<tr><td>BLER target</td><td colspan="4">Simulation dependent</td></tr>
<tr><td>BLER calculation</td><td colspan="4">BLER has been calculated by comparing with transmitted and received bits. So CRC is not used for BLER estimation. Note that both methods give the same results in practice when 16 bit CRC is used.</td></tr>
<tr><td>PCCPCH model</td><td colspan="4">Random symbols transmitted, ignored in a receiver</td></tr>
<tr><td>PICH model</td><td colspan="4">Random symbols transmitted, ignored in a receiver</td></tr>
<tr><td>DCCH model</td><td colspan="4">Random symbols transmitted, ignored in a receiver</td></tr>
<tr><td>TFCI model</td><td colspan="4">Random symbols, ignored in a receiver but it is assumed that receiver gets error free reception of TFCI information.</td></tr>
<tr><td>Used OVSF and scrambling codes</td><td colspan="4">Codes are chosen from the allowed set</td></tr>
<tr><td>$\hat{I}_{or} / I_{oc}$ values</td><td colspan="4">Capacity comparison: 9 dB. QoS comparison 0 dB</td></tr>
<tr><td>SCH position</td><td colspan="4">Offset between SCH and DPCH is zero chips meaning that SCH is overlapping with the first symbols in DPCH in the beginning of DPCH slot structure</td></tr>
<tr><td>Measurement Channel</td><td colspan="4">64 kbps as specified in Annex A of TS 25.101 v3.0.0</td></tr>
<tr><td>Other L1 parameters</td><td colspan="4">As Specified in latest L1 specifications.</td></tr>
</table>