3GPP TSG RAN Meeting #21 **RP-030464**
Frankfurt, Germany, 16 - 19 September 2003

3GPP TSG-GERAN Meeting #15 **TDoc GP-031730**
Fort Lauderdale, U.S.A.
23 - 27 June 2003

Title: LS on Implementability of MBMS Requirements and Architecture

Release: Rel-6

Work Item: MBMS

Source: TSG GERAN

To: TSG SA1, TSG SA2

Cc: TSG RAN, TSG SA4

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Attachments: GP-031430 SDU Requirements for PtM MBMS Radio Bearers
GP-031200 Bit rate and retransmission aspects for p-t-m MBMS in GERAN
GP-031390 Further analysis of MBMS bearer definition

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1. Overall Description:

TSG GERAN understands that MBMS can be realized through a unidirectional point-to-multipoint bearer service for which data is transmitted from a single source entity to multiple recipients over the radio. TSG GERAN also believes that MBMS can assist in utilizing network resources more efficiently, by decreasing the amount of data within the network. Bearing that in mind, TSG GERAN has been investigating the feasibility of providing point-to-multipoint bearer services over the radio interface and would like to inform TSG SA1 and TSG SA2 of the outcome.

Since point-to-multipoint radio bearers can only be provided using unacknowledged RLC, it places severe limitations on what can be offered:

- **Error-free delivery cannot be guaranteed** (due to the lack of acknowledgments over the radio).
- **Reasonable maximum SDU size is 500 bytes** (see GP-031430).
- **For these SDU sizes, it is difficult to provide SDU error rates below 1%** with reasonable throughput (see GP-031430). Note that it does not include the SDU losses due to cell changes.
- **High data rates cannot be offered**. Typical bit rate at cell border for a point-to-multipoint bearer is approximately 4.7 kbps per timeslot (see GP-031200 and GP-031390), which with 6 timeslots would give 28.2 kbps. An MBMS service targeting the same coverage as GSM speech should therefore not exceed this bit rate.

Nevertheless, TSG GERAN believes that satisfactory user experience can still be offered when considering the following:

- Even though the support of services requiring error-free delivery is difficult, services that do not require error-free delivery (e.g. audio and video) can still be provided efficiently.
- A number of applications already tolerate 1% SDU error rate (e.g. speech services). And MBMS applications designed for point-to-multipoint bearers have to take this limit into account.

- Even though high data rates cannot be provided, download and play services can still be offered. For instance a 128 kbit/s video clip can be downloaded over a 32 kbit/s radio bearer, with a download time of 4 times the length of the clip.

Furthermore, in order to optimise support of MBMS in GERAN, the two following points were considered:

- To avoid changes between point-to-point and point-to-multipoint radio bearers during an MBMS session (i.e. while data transfer is on-going) it was suggested to limit every MBMS session in time (e.g. less than 1 minute). MBMS clips longer than the limit could then be transmitted over concatenated MBMS sessions.

- To limit data loss at cell change, which cannot be avoided, application layer protection could be used even though it would require large buffers (storage to allow the error correcting code to be applied to the whole clip).

2. Actions:

To TSG SA1 and TSG SA2 groups.

ACTION: TSG GERAN kindly asks TSG SA1 and SA2 to take into account the four limitations that were listed for point-to-multipoint radio bearers and confirm if appealing services can still be provided. Especially, TSG GERAN would like to know whether the requirement for provision of background traffic class over a point-to-multipoint bearer is at all valid. TSG GERAN also asks TSG SA1 and SA2 to consider the 2 optimisations that were proposed.

3. Date of Next TSG-GERAN Meetings:

TSG-GERAN Meeting #16	25 - 29 Aug 2003	New York, U.S.A.
TSG-GERAN Meeting #17	17 - 21 Nov 2003	Budapest, Hungary

Bit rate and retransmission aspects for p-t-m MBMS in GERAN

1 Introduction

This contribution investigates what bit rates are possible to support for point-to-multipoint (broadcast or multicast) transmission of an MBMS service in GERAN. The focus is on the “worst case” scenario, i.e. the same coverage as GSM FR speech.

This contribution is a re-submission of a contribution to the GERAN MBMS workshop [4].

2 MBMS service scenario

One typical MBMS service could be video clip distribution to a large group of users. In this papers we therefore look at a service with similar properties as a streaming service.

The difference between real-time streaming and MBMS however is that in the MBMS video clip scenario it may not be nessessary to transmit the content in real-time to the users. Therefore the bit rate of the radio channel may be lower than the actual play out rate of the video clip.

A video codec typically varies the frame size [3], however to make the calculations simple a value of 500 bytes per IP packet is assumed in this document.

When using unacknowledged mode RLC it is hard to achieve very low error ratio at IP level. The streaming TR [3] only states a SDU error ratio of 10^{-4} (0.01%). This value is considered to be unrealistic to fulfil with unacknowledged RLC, so in this paper a target IP error ratio of 1% is assumed. It is FFS whether this has a substantial impact on service quality.

So to conclude, the following service scenario is assumed:

- IP packet size: 500 bytes
- IP error ratio: 1%

3 Radio link performance

To achieve 1% error ratio on the IP level, some form of redundancy is needed. The redundancy can be achieved by retransmissions or forward error correction (channel coding), or a combination of both. Since a p-t-m channel can not retransmit only the errornous packets, blind retransmissions are needed.

The retransmissions can either take place at application layer, or at the RLC layer. Both options are considered in this paper.

To have full coverage in the cell for the p-t-m MBMS channel the target radio quality should be the same as for full-rate speech, i.e. the reference sensitivity level. This level is typically assumed to be Eb/N0=7.5 dB, or –102 dBm (for MS).

3.1 Effect of RLC errors on IP level

Since the IP packets are relatively large compared to a RLC block, and due to the fact that p-t-m can not perform any selective retransmissions the RLC error ratio must be low compared to the target error ratio on IP level.

Assuming independent errors the following formula can be used to calculate error ratio on IP level given the RLC error ratio and number of RLC blocks per IP packet [1].

$$P_{e,IP} = 1 - (1 - P_{e,RLC})^{N} \quad (1)$$

$P_{e,IP}$: probability that the IP packet is erroneous.

$P_{e,RLC}$: probability that the RLC block is erroneous.

N: number of RLC blocks for transmitting one IP packet.

When MCS-1 is used to transport IP packets of 500 bytes, the IP packet has to be segmented into 23 RLC blocks. Setting N in the formula above to 23, the following figure is achieved:

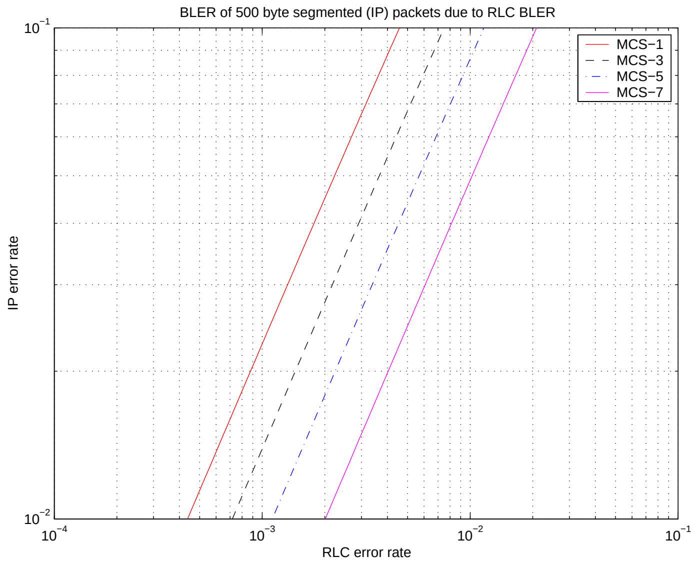


Figure 1: IP BLER as a function of RLC BLER for different MCS.

As can be seen in Figure 1 a 1% error rate on application level requires the MCS-1 RLC error rate to be approximately 0.05%. Alternatively 10% BLER on application can be used assuming that the application has a x2 retransmission, which will lower the 10% to 1% on application level. The required RLC error ratio is then 0.45%.

For higher MCS the number of RLC blocks per IP packet decreases, thus the RLC error ratio can be increased.

3.2 Comparison of retransmission strategies

Retransmissions can either be performed on application level or by the RLC layer. These two options are compared in this section. In addition, the effect of incremental redundancy (IR) is studied. For the case of application layer redundancy, a simple x2 repitition scheme is assumed here. It is most likely to do a more intelligent coding on the application layer, but this is a first approach to get a rough view on possible bit rates.

EGPRS, MCS-1 and MCS-5 have been assumed as a radio bearer since these coding schemes are already available in the standard. MCS-1 is studied at a Eb/N0 of 7.5 dB which typically corresponds to the coverage limit of GSM full rate speech.

For MCS-5 (8-PSK) other higher signal levels are studied to get an indication on how much the bit rate increases further into the cell. It is however very hard to say what a typical signal level is for smaller cells in urban areas. Typically such cells are rather interference than sensitivity limited.

Table 1 contains the number of blind retransmissions that have to be performed by the RLC layer to get sufficient low error rate to the application. In the “no application retransmission” case 1% SDU error rate is the target. For “x2 application retransmission” the target is 10%. Figure 1 gives the required BLER per RLC block to achieve these targets, and the figures in Annex A give the required number of retransmissions for the RLC target BLER.

		No app retrans (x1)		**App retrans (x2)**	
	E_b/N_0	**With IR**	**No IR**	**With IR**	**No IR**
MCS-1	7.5 (-102 dBm)	2	4	2	3
MCS-5	5.0 (-100 dBm)	4	N/A	4	10
MCS-5	7.5 (-97 dBm)	3	6	3	4
MCS-5	10.0 (-94 dBm)	2	4	2	2
MCS-5	12.5 (-92 dBm)	2	2	2	2

Table 1: Number of RLC transmissions required to achieve 1% application BLER.

	E_b/N_0	**p-t-m With IR (x1)**	**p-t-m No IR (x1)**	**p-t-m With IR (x2)**	**p-t-m No IR (x2)**
MCS-1	7.5	4.4	2.2	2.2	1.5
MCS-5	5.0	5.6	N/A	2.8	1.12
MCS-5	7.5	7.5	3.7	3.7	2.8
MCS-5	10.0	11.2	5.6	5.6	5.6
MCS-5	12.5	11.2	11.2	5.6	5.6

Table 2: Application bitrate per timeslot.

As can be seen in Table 2 the bitrate delivered to the application per timeslot at the cell border is approximately 4.5 kbps using IR. Withouth IR or with application repetition the bit rate decreases. For better radio conditions the bit rate increases to >10 kbps per timeslot.

4 Open issues

This section lists possible further investigation areas, and some issues that may affect the results in this contribution.

- Effect of blind detection of modulation has not been considered.
- Effect of stealing bit detection has not been considered
- Effect of RLC/MAC header errors has not been considered for IR
- Can a more intelligent application layer FEC improve the results?
- What is the threshold between p-t-p and p-t-m channels?

5 Conclusion

To provide point-to-multipoint transmission of MBMS content using unacknowledged mode RLC a combination of FEC and blind retransmission (repetition) is needed. This contribution has shown that it is more effective to perform the blind retransmission at RLC layer compared to the application layer.

In addition the usage of incremental redundancy appoximately doubles the application bitrate for unacknowledged RLC.

The bitrate at cell border for a p-t-m channel is approximately 4.5 kbps, which with 7 timeslots would give 31.5 kbps. An MBMS service targeting the same coverage as GSM speech should therefore not exceed this bitrate. However, if transmission time could be longer than the video clip length, a higher play out rate is possible (e.g. a 64 kbps clip of 30 sec could be transferred in 60 seconds to the MBMS group).

Improving the link budget some 10 dB compared to the cell border gives a bit rate per timeslot of approximately 10 kbps. So if replanning is possible in areas where p-t-m MBMS should be supported higher bitrates are possible.

6 References

[1] TSG GERAN #13 GP-030185. “Radio Constraints for Conversational Services”, Ericsson.
[2] TSG GERAN #14 GP-030665. “Threshold for p-t-m MBMS delivery”, Siemens.
[3] 3GPP TR 26.937 ”Transparent end-to-end packet switched streaming service (PSS); RTP usage model” Version 1.4.0
[4] GMBMS-030014, “Bit rate and retransmission aspects for p-t-m MBMS in GERAN”, source Ericsson

Annex A: Simulation results

A.1 MCS-1

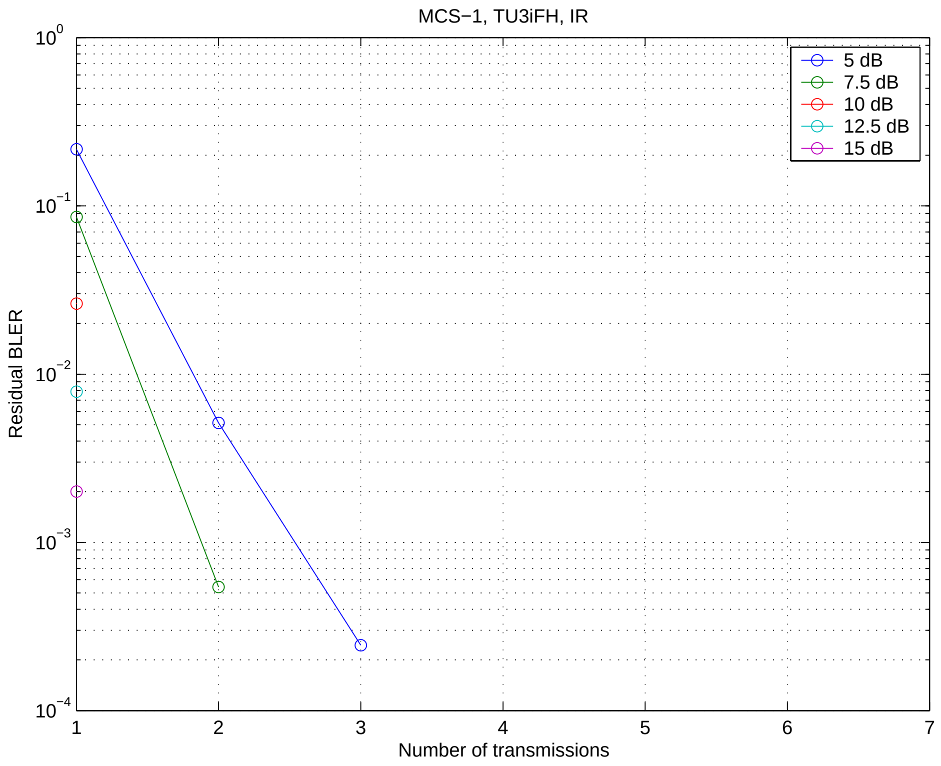


Figure 2: MCS-1 BLER as a function of # transmissions with IR.

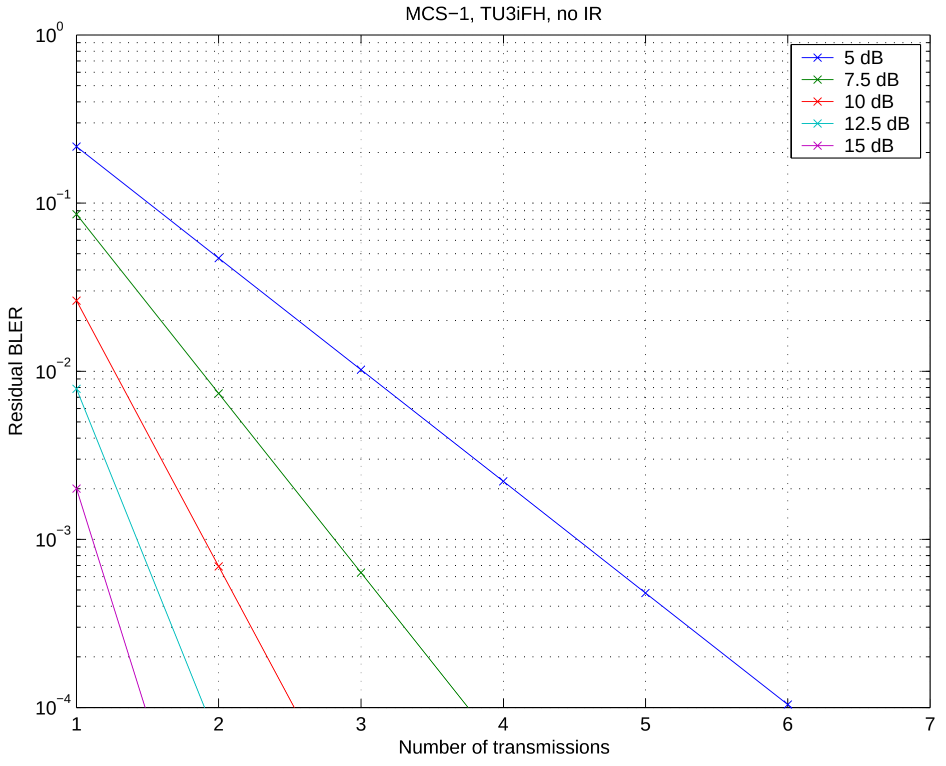


Figure 3: MCS-1 BLER as a function of # transmissions without IR.

A.2 MCS-5

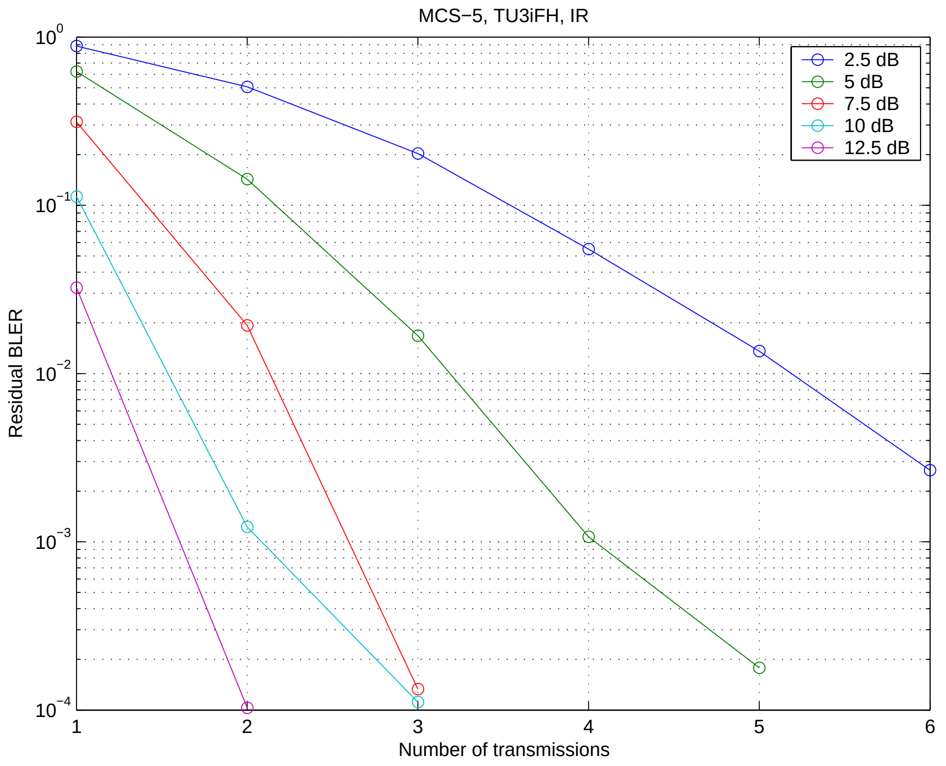


Figure 4: MCS-5 BLER as a function of # transmissions with IR.

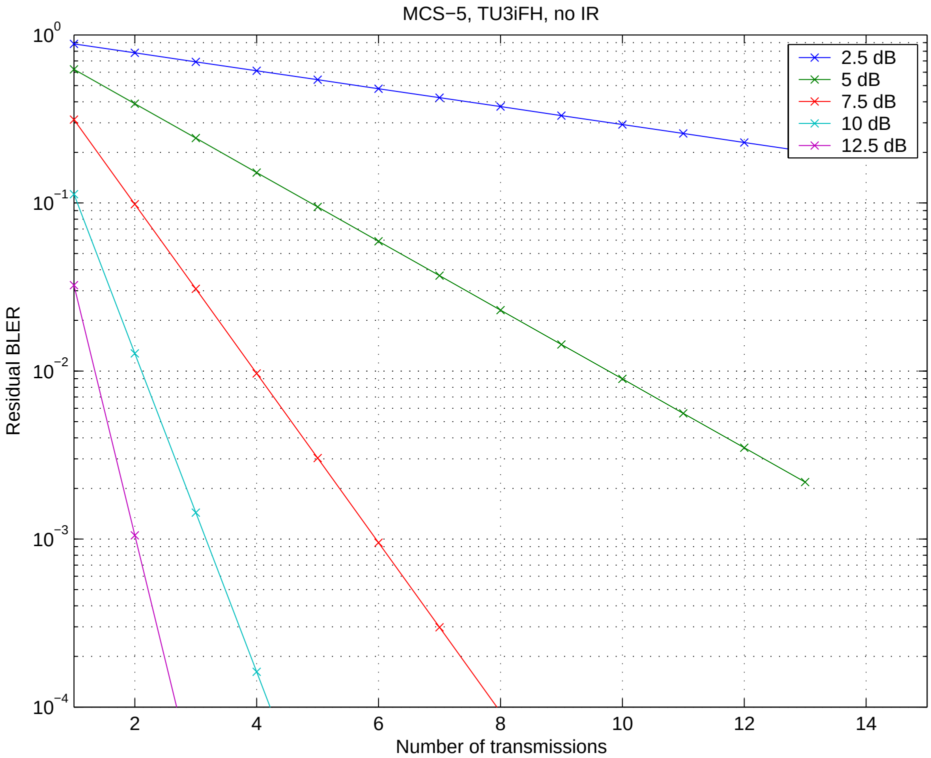


Figure 5: MCS-5 BLER as a function of # transmissions without IR.

Further analysis of MBMS bearer definition

1 Introduction

In [1] an analysis of possible solutions for the definition of the bearer for MBMS services is contained. In this document, further results are presented, some of which address comments raised during the discussion at the TSG GERAN MBMS Workshop.

2 Performance of p-t-m bearers

In [1] it was indicated that redundancy can be added both in the BM-SC or in the RAN. In the following sub-sections, the performance of these different cases is studied.

2.1 Redundancy in the BM-SC

Assuming that redundancy is added through the use of repetitions and that repetitions are added at the BM-SC, the SDU error rate is given by:

$$P_{SER} = \left[1-(1-P_{BLER})^{N}\right]^{K}$$

where N is the number of RLC/MAC blocks that an SDU is made up of and K is the number of times an SDU is repeated.

Figure 1 and Figure 2 show the curves of the required BLER to achieve a target SDU error rate of 10^{-2} and 10^{-3}, respectively, as a function of N (these figures had already been provided in [1]).

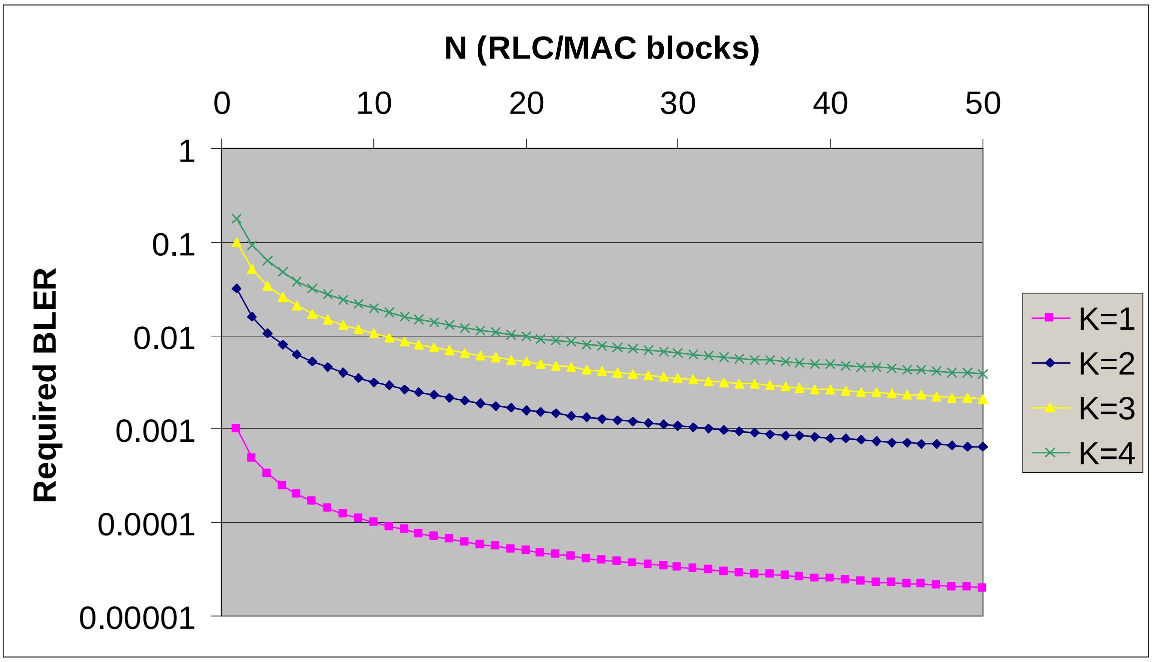


Figure 1 - BLER required to achieve a target SDU error rate of 10^{-3}

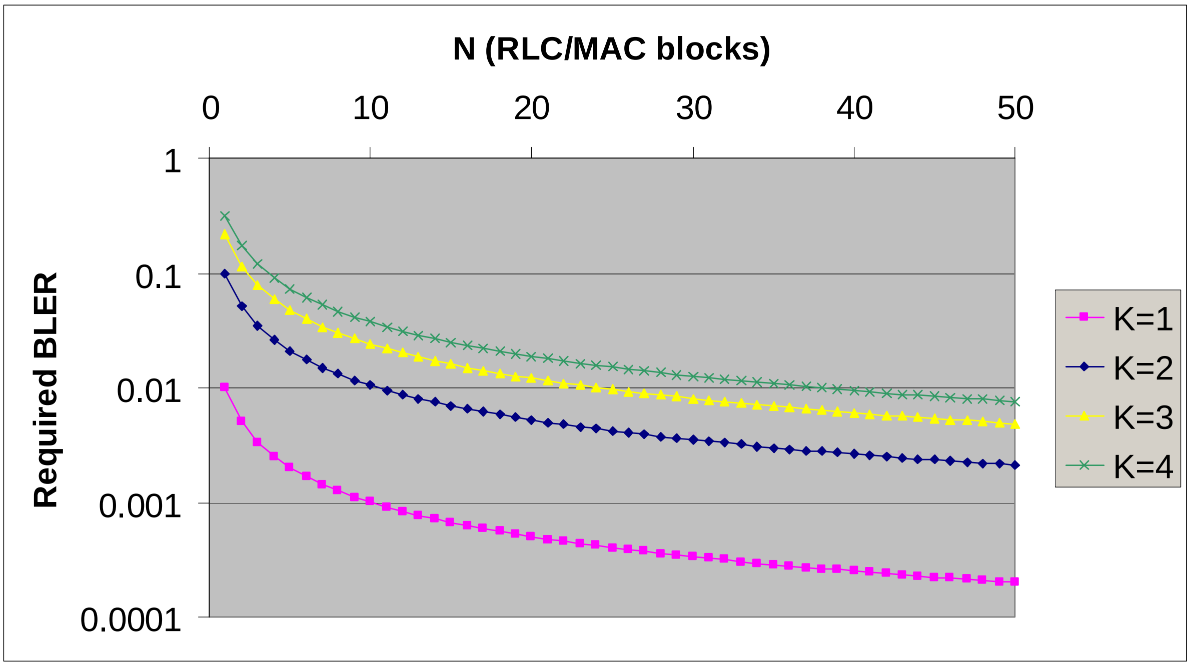


Figure 2 - BLER required to achieve a target SDU error rate of 10^{-2}

Let's assume that SDUs are 500 octets long, as indicated in [2]. If MCS-1 is used, each RLC/MAC block contains 22 octets of RLC data, which means that $N = \left\lceil \frac{500}{22} \right\rceil = 23$ RLC/MAC blocks are required. From Figure 1 and Figure 2 it can be seen that in order to achieve the target SDU error rate, the BLER needs to be lower than the values provided in the second column of Table 1 and Table 2.

Number of repetitions	Maximum BLER	C/I (MCS-1)
$K = 1$	4.34991E-05	≈ 16 ÷ 17 dB (*)
$K = 2$	0.001396136	≈ 13 dB
$K = 3$	0.004570416	≈ 12 dB
$K = 4$	0.008477151	≈ 11 dB

Table 1 - BLER required for SDU error rate = 10^{-3}

Number of repetitions	Maximum BLER	C/I (MCS-1)
$K = 1$	0.000436876	≈ 14 ÷ 15 dB (*)
$K = 2$	0.004570416	≈ 12 dB
$K = 3$	0.01049397	≈ 11 dB
$K = 4$	0.016391581	≈ 10 dB

Table 2 - BLER required for SDU error rate = 10^{-2}

Simulation for MCS-1 and MCS-3 have been performed; the results[1] are provided in [3] and are repeated for convenience in Figure 3.

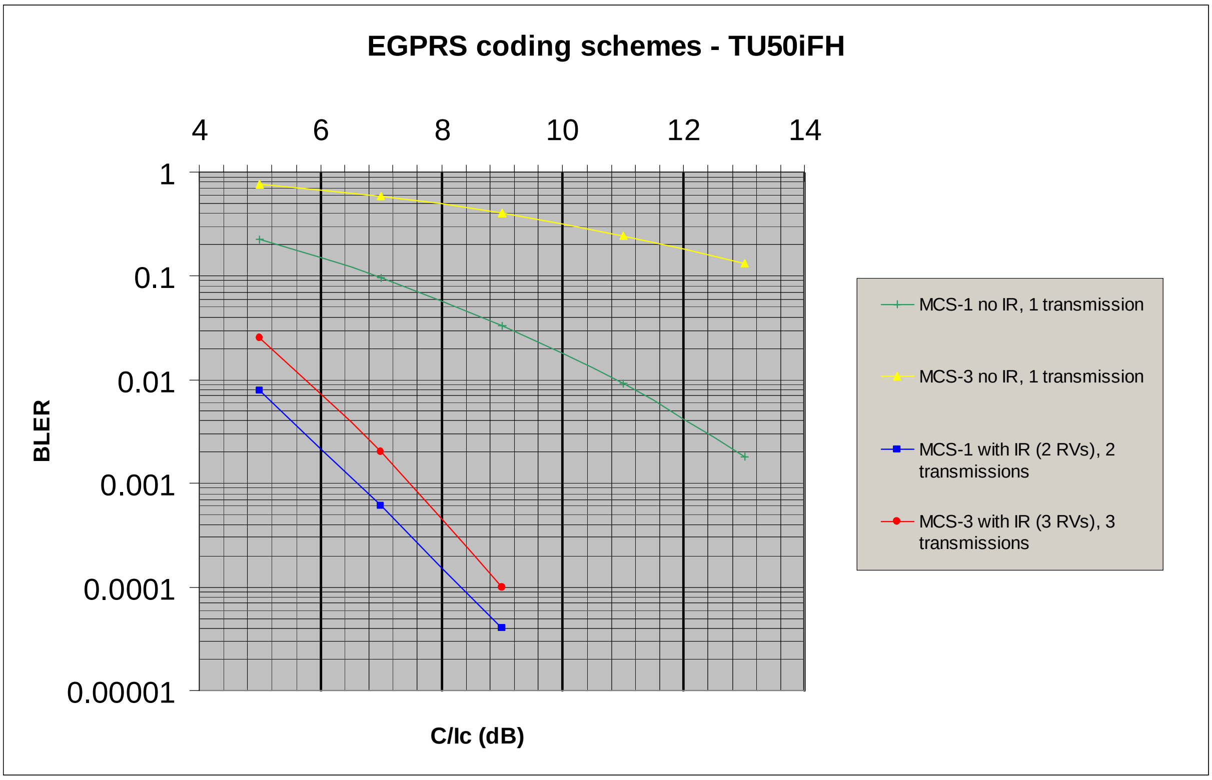


Figure 3 - Simulation results for MCS-1 and MCS-3

From the curves, the values of the C/I for which the maximum BLER is obtained when using MCS-1 can be derived. These are shown in the third column of Table 1 and Table 2. Note that the values are approximate; also, the results indicated with an asterisk (*) have been obtained extrapolating the curves in Figure 3. Depending on the C/I distribution across a cell (which depends on the radio network planning), the required quality of service might be guaranteed not over the whole cell, but only over a portion of it.

2.2 Redundancy in the RAN – Simple repetitions

During the MBMS Workshop it has been agreed that the addition of redundancy in the GERAN will be allowed for MBMS. If redundancy is added through simple repetition of the RLC/MAC blocks (e.g. no Incremental Redundancy), assuming that the error events are independent (e.g. no soft combining in the receiver), the formula for the SDU error rate is:

$$P_{SER} = 1 - \left(1 - P_{BLER}^{k}\right)^{N}$$

[1] Note that the curve with IR shows the BLER obtained when all the available redundancy versions of an RLC/MAC block (two for MCS-1 or three for MCS-3) have been combined in the receiver. No RF impairments have been included in the simulations, so a further 1-2 dB may need to be added to the values given in Table 1 and Table 2 (and to the results given in the remainder of the paper). Also, the effect of header errors has not been taken into account. For further information on the simulation assumptions, see [3].

where k is the number of times an RLC/MAC block is repeated. Inverting this formula, it is possible to calculate the required BLER to achieve a certain target SDU as a function of N and k:

$$P_{BLER} = \sqrt[k]{1 - \sqrt[N]{1 - P_{SER}}}$$

In this case the curves are given in Figure 4 and Figure 5.

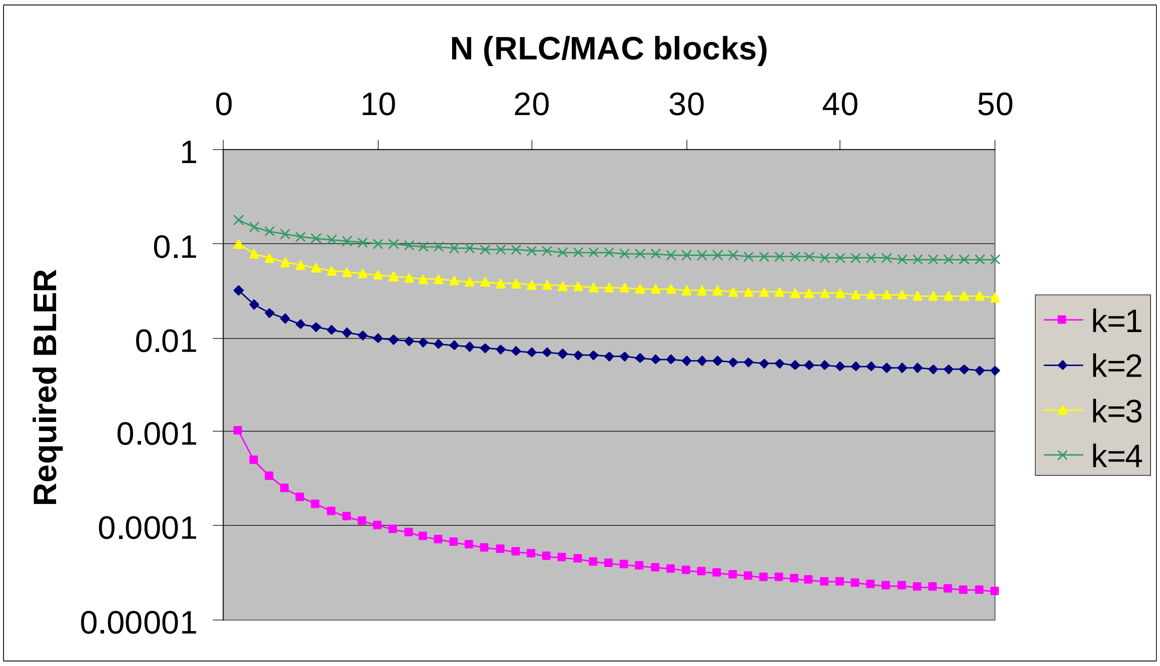


Figure 4 - BLER required to achieve a target SDU error rate of 10^{-3}

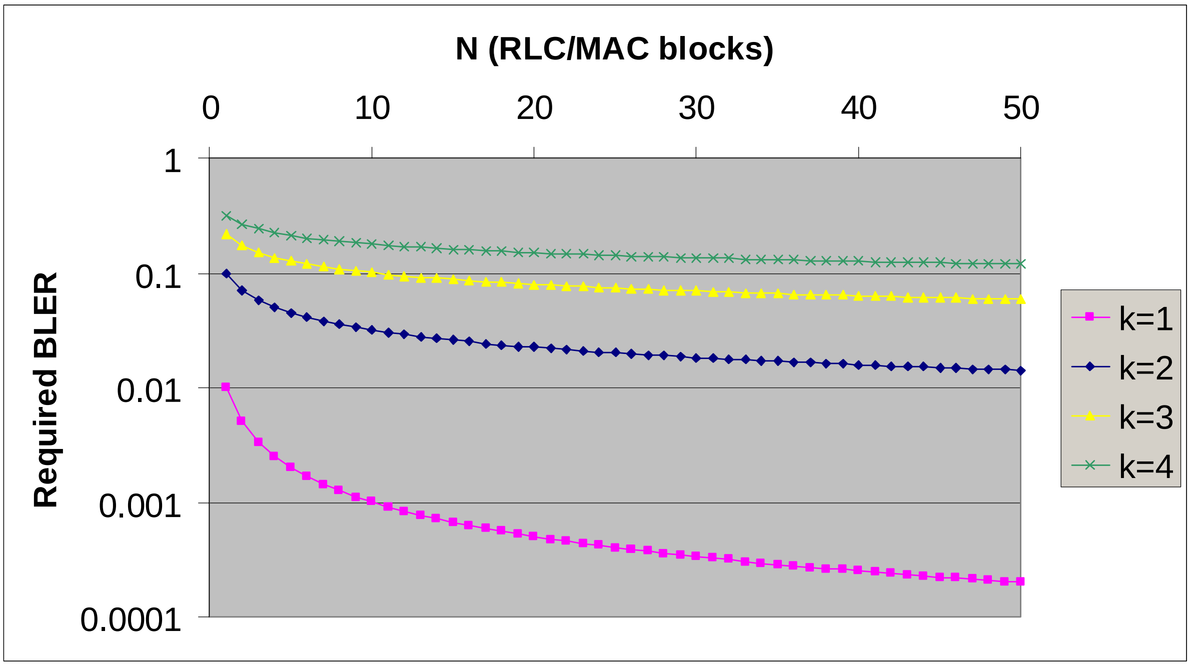


Figure 5 - BLER required to achieve a target SDU error rate of 10^{-2}

In order to achieve the target SDU error rate when SDUs are 500 octets long, the maximum values of the BLER allowed for each repetition are those given in the second column of Table 3 and Table 4. In the third column, the values of the C/I for which the maximum BLER is obtained when using MCS-1 are given[2].

Number of repetitions	Maximum BLER	C/I (MCS-1)
$k = 1$	4.34991E-05	≈ 16 ÷ 17 dB (*)
$k = 2$	0.006595382	≈ 11.5 dB
$k = 3$	0.035168997	≈ 8.5 dB
$k = 4$	0.081211959	≈ 7.5 dB

Table 3 - BLER required for SDU error rate = 10^{-3}

Number of repetitions	Maximum BLER	C/I (MCS-1)
$k = 1$	0.000436876	≈ 14 ÷ 15 dB (*)
$k = 2$	0.020901571	≈ 10 dB
$k = 3$	0.075878596	≈ 7.5 dB
$k = 4$	0.144573756	≈ 6 dB

Table 4 - BLER required for SDU error rate = 10^{-2}

It can be seen that even when adding repetitions in the RAN, at least 3 repetitions are needed in order to achieve a satisfactory QoS at 9 dBs when using MCS-1 for SDUs of 500 octets, for a target SDU error rate of both 10^{-2} and 10^{-3}.

As already pointed out in [1], this is a simplified analysis. For example, the impact on the SDU error rate of erroneous RLC/MAC blocks not being detected by the CRC check [4] is not taken into account.

2.3 Redundancy in the RAN – Incremental Redundancy

If soft combining or Incremental Redundancy is used, the formula for the SDU error rate becomes:

$$P_{SER} = 1 - \left(1 - P_{BLER}^{(n)}\right)^N$$

where $P_{BLER}^{(n)}$ is the BLER after n replicas or Redundancy Versions of the same block have been combined in the receiver[3]. In this case, the required QoS is guaranteed if $P_{BLER}^{(n)}$ is lower than the value given by the curve for $k = 1$ in Figure 4 and Figure 5. It is expected that $P_{BLER}^{(n)} < \left[P_{BLER}^{(1)}\right]^n$, as repetitions with soft combining in the receiver or Incremental Redundancy are expected to give a better performance than simple repetition.

For SDUs of 500 octets, the number of RLC/MAC blocks required is $N = 23$ for MCS-1 and $N = \left\lceil \frac{500}{37} \right\rceil = 14$ for MCS-3. In Table 5 and Table 6 it is analysed whether with the two coding schemes it is possible to fulfil the requirements on the SDU error rate for MBMS services:

[2] As in the previous section, these results are approximate; also, the results indicated with an asterisk (*) have been obtained extrapolating the curves in Figure 3.
[3] Note that the performance could vary depending on the particular combining algorithm used.

	BLER required to achieve $P_{SER} = 10^{-3}$	BLER @ 9 dB (from Figure 3)	SDU FER requirement fulfilled?
MCS-1 (with IR)	$4.35 \cdot 10^{-5}$	$4 \cdot 10^{-5}$	yes
MCS-3 (with IR)	$7.15 \cdot 10^{-5}$	10^{-4}	no

Table 5

	BLER required to achieve $P_{SER} = 10^{-2}$	BLER @ 9 dB (from Figure 3)	SDU FER requirement fulfilled?
MCS-1 (with IR)	$4.37 \cdot 10^{-4}$	$4 \cdot 10^{-5}$	yes
MCS-3 (with IR)	$7.17 \cdot 10^{-4}$	10^{-4}	yes

Table 6

From Table 5 it is possible to see that using MCS-1 (with two redundancy versions transmitted) it is possible to achieve an SDU error rate of 10^{-3} at 9 dB. The throughput that can be achieved is 4.4 kbit/s per timeslot. From Table 6 it can be seen that an SDU error rate of 10^{-2} at 9 dB can be achieved both with MCS-1 (with two redundancy versions transmitted) and with MCS-3 (with three redundancy versions transmitted). In this case, it is better to use MCS-3 because the throughput obtained with this coding scheme is higher: 4.93 kbit/s per timeslot.

As indicated in [3], further validation of the simulation results will be required before firm conclusions can be reached from them. For example, when including the effect of RF impairments in the simulations, the results could change in such a way that the conclusions just reached are no longer valid.

3 Changes required to the RLC protocol

At present, for (E)GPRS, the RLC can operate in only two possible modes: Acknowledged mode (RLC-AM) and Unacknowledged mode (RLC-UM). With MBMS, no acknowledgements are sent by the terminals receiving an MBMS service. Therefore RLC-AM cannot be used. If redundancy is added in the BM-SC, for p-t-m services the existing RLC-UM will be used, and no modifications are required to the RLC protocol. On the other hand, if redundancy is added in the RAN, a new RLC operating mode, specific to MBMS, will need to be introduced.

At present, in RLC-UM:

- the transmitter sends each block only once;
- because of the previous point, no Incremental Redundancy is performed, and no soft combining of the blocks in the receiver;
- the order of transmission of the RLC/MAC blocks needs to such that the blocks are RECEIVED in the correct order (no rearrangement of the received blocks is performed in the receiver)

If redundancy is added in the RAN, even if unacknowledged mode is used, each RLC/MAC block should be transmitted more than once (whether in each transmission each block is the exactly the same for the case of simple repetition, or a different redundancy version in the case of IR). Also, in the case of IR, the receiver should perform combining of the blocks even if RLC-AM is not used.

Assuming that all the channels allocated to an MBMS service have the same data rate[4], the requirement in the third bullet point should not be affected by MBMS, provided that all blocks are transmitted sequentially and that all repetitions or redundancy versions of a block are sent one after the other. The only problem would be if (re)transmissions of the same block are not consecutive, but are staggered in time. This could be done to increase time diversity; however, it will probably not be needed if frequency hopping is used.

The modifications highlighted above are not considered to be major changes, and it is likely that it will be possible to implement them in existing EGPRS networks only through software upgrades in the BSC.

As an additional enhancement, it may possible to define a new RLC/MAC block structure for MBMS, removing from the header all the fields that are not required for MBMS, as explained in more detail in [1] and [3]. This would require the introduction of new coding schemes for MBMS.

4 Conclusions

In this contribution, Siemens has presented further analysis for MBMS p-t-m bearers. It has been shown that with the existing EGPRS coding schemes it would be possible to fulfil (some of) the SDU error rate requirements for MBMS, however the throughput that can be achieved is low. One possibility to improve the performance is to introduce new channel coding schemes for MBMS, more robust than those currently available on the PDTCH. This is investigated in [3].

The document also discussed the changes required to the RLC protocol required to support p-t-m data transmission. The conclusion is that a new RLC mode of operation will be needed for MBMS if redundancy is added in the RAN.

5 References

[1] GMBMS-030007, “On MBMS bearer definition”, Siemens, TSG GERAN MBMS Workshop, Espoo (Finland), 12-13 May 2003

[2] GMBMS-030014, “Bit rate and retransmission aspects for p-t-m MBMS in GERAN”, Ericsson, TSG GERAN MBMS Workshop, Espoo (Finland), 12-13 May 2003

[3] GP-031391, “Channel coding schemes with Incremental Redundancy for MBMS”, Siemens, TSG GERAN#15, Fort Lauderdale (USA), 23-27 June 2003

[4] GP-030784, “SDU error ratio for streaming when using unacknowledged LLC”, Ericsson, GERAN #14, Munich (Germany), 7-11 April 2003

[5] 3GPP TS 23.107, “Quality of Service (QoS) concept and architecture”

[4] Subclause 9.3.0 of TS 44.060 (version 6.2.0) states: “When one or more PDCH/Fs are used in conjunction with one PDCH/H in the same direction, the RLC/MAC data blocks may not be received in the same sequence they were sent, due to the different data rates of the channels. In RLC unacknowledged mode, the sending entity shall re-order the RLC/MAC data blocks before transmission to ensure their reception in sequence.”

6 Annex A - Ranges of Radio Access Bearer Service Attributes

The following table, which is an excerpt from Table 5 of TS 23.107 [5], lists the value ranges of the radio access bearer service attributes for the two traffic classes supported by MBMS (Streaming and Background). The value ranges reflect the capability of UTRAN. The values in the GERAN are still under discussion and may be different.

Traffic class	Streaming class	Background class
Maximum bitrate (kbps)	<= 2 048 (1) (2)	<= 2 048 - overhead (2) (3)
Delivery order	Yes/No	Yes/No
Maximum SDU size (octets)	<=1 500 or 1 502 (4)	<=1 500 or 1 502 (4)
SDU format information	(5)	
Delivery of erroneous SDUs	Yes/No/-	Yes/No/-
Residual BER	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}	$4*10^{-3}$, 10^{-5}, $6*10^{-8}$ (6)
SDU error ratio	10^{-1}, 10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	10^{-3}, 10^{-4}, 10^{-6}
Transfer delay (ms)	250 – maximum value	
Guaranteed bit rate (kbps)	<= 2 048 (1) (2)	
Traffic handling priority		
Allocation/Retention priority	1,2,3	1,2,3
Source statistic descriptor	Speech/unknown	
Signalling Indication		

1) Bitrate of 2 048 kbps requires that UTRAN operates in transparent RLC protocol mode, in this case the overhead from layer 2 protocols is negligible.

2) The granularity of the bit rate attributes shall be studied. Although the UMTS network has capability to support a large number of different bitrate values, the number of possible values shall be limited not to unnecessarily increase the complexity of for example terminals, charging and interworking functions. Exact list of supported values shall be defined together with S1, N1, N3 and R2.

3) Impact from layer 2 protocols on maximum bitrate in non-transparent RLC protocol mode shall be estimated.

4) In case of PDP type = PPP, maximum SDU size is 1502 octets. In other cases, maximum SDU size is 1 500 octets.

5) Definition of possible values of exact SDU sizes for which UTRAN can support transparent RLC protocol mode, is the task of RAN WG3.

6) Values are derived from CRC lengths of 8, 16 and 24 bits on layer 1.

SDU Requirements for PtM MBMS Radio Bearers

1. INTRODUCTION

In [1] a few aspects of the unacknowledged MBMS Radio Bearers for point to multipoint (PtM) connections were investigated. This contribution updates the relation there is between the RLC SDU error ratio, the radio block error ratio and the segmentation in order to assess realistic requirements on SDU size and BLER.

2. BLER AND SEGMENTATION

At RLC layer, when SDUs are segmented into PDUs (radio blocks), the SDU BLER increases as a function of the PDU BLER. Generally, assuming no correlation at radio block level (iFH), if one SDU is segmented into n radio blocks, the SDU BLER can be obtained theoretically by:

$$BLER_{SDU} = 1 - (1 - BLER_{PDU})^{n}$$

Table 1 lists a few cases. Obviously the larger the SDU is, the more the segmentation and the stronger the BLER requirement is at radio block level. For instance if an SDU is segmented into 20 radio blocks and the BLER for each radio block is 1%, the SDU BLER is 18.21%.

Table 1 - BLER and Segmentation

Segmentation	BLER RLC PDU	BLER RLC SDU
1	0.1%	0.10%
1	1.0%	1.00%
1	10.0%	10.00%
2	0.1%	0.20%
2	1.0%	1.99%
2	10.0%	19.00%
5	0.1%	0.50%
5	1.0%	4.90%
5	10.0%	40.95%
10	0.1%	1.00%
10	1.0%	9.56%
10	10.0%	65.13%
20	0.1%	1.98%
20	1.0%	18.21%
20	10.0%	87.84%
50	0.1%	4.88%
50	1.0%	39.50%
50	10.0%	99.48%

Conversely the PDU BLER can also be given as a function of the SDU BLER (still assuming no correlation between the radio blocks):

$$BLER_{PDU} = 1 - \exp\left[\frac{\ln(1 - BLER_{SDU})}{n}\right]$$

With this formula, Figure 1 depicts the relation there is between the SDU BLER, the PDU BLER and the segmentation (number of PDUs). Four different SDU BLER are shown: 0.001%, 0.1%, 1%, and 10%. Here again we can see that for the same SDU BLER, the larger the SDU, the more the segmentation, the more the PDUs, and the tighter the PDU BLER requirement is. For unacknowledged services, the typical average PDU BLER can hardly go below 0.1%. In practise this means that the SDU BLER cannot go below 0.1% and that a realistic requirement for the SDU BLER is between 1% and 10%.

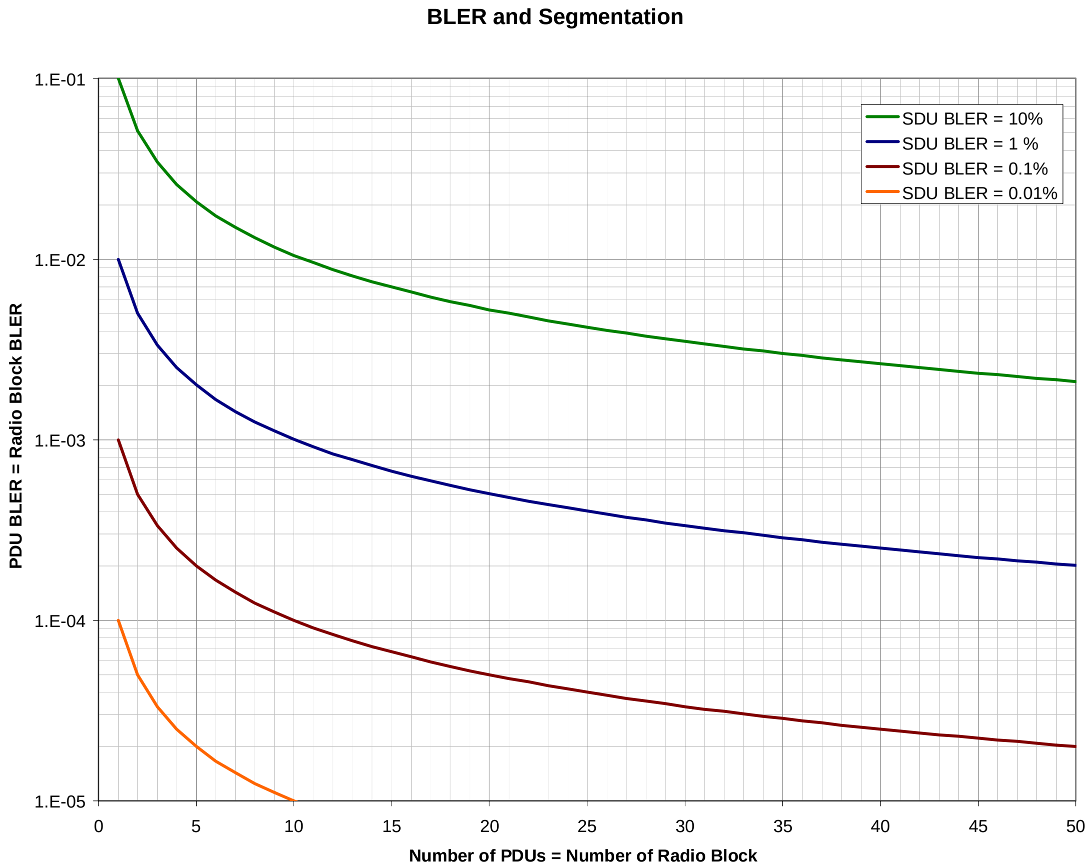


Figure 1 - BLER and Segmentation

3. USE CASE FOR VIDEO

Video “streaming” being a typical MBMS service, it is interesting to see what are its requirements. In specifications, two different requirements for the SDU BLER and maximum SDU size can be found depending on whether video is considered as a streaming or conversational service:

- For video conversational, the maximum SDU BLER is 0.1% and the maximum SDU size 500 bytes [2].
- For video streaming, the maximum SDU BLER is 0.01% and the maximum SDU size 1400 bytes [3].

With the formulas of section 2 we can translate the SDU BLER requirement in PDU BLER requirement as a function of the segmentation, i.e. the coding scheme. Requirements for video conversational are listed in Table 2 and requirements for video streaming in Table 3. In all cases, the PDU BLER requirement is well below 0.1%. With the EGPRS performance figures of Annex A, we can see that the required C/I is well above 15dB in TU3iFH and well above 24dB in TU3nFH using MCS1.

This shows that for PtM MBMS radio bearers, i.e. unacknowledged radio bearers, the existing requirements for video are not appropriate and should be relaxed.

Table 2 - PDU BLER requirement for Video Conversational
(SDU error ratio = 0.1% / maximum SDU size = 500 bytes)

MCS	Segments	PDU BLER
1	22.73	0.0044%
2	17.86	0.0056%
3	13.51	0.0074%
4	11.36	0.0088%
5	8.93	0.0112%
6	6.76	0.0148%
7	8.93	0.0112%
8	7.35	0.0136%
9	6.76	0.0148%

Table 3 - PDU BLER requirement for Video Streaming
(SDU error ratio = 0.01% / maximum SDU size = 1400 bytes)

MCS	Segments	PDU BLER
1	63.64	0.0002%
2	50.00	0.0002%
3	37.84	0.0003%
4	31.82	0.0003%
5	25.00	0.0004%
6	18.92	0.0005%
7	25.00	0.0004%
8	20.59	0.0005%
9	18.92	0.0005%

4. REALISTIC REQUIREMENTS

In this section we are going to assess what are realistic requirements in terms of maximum SDU size and SDU BLER for unacknowledged PtM MBMS radio bearers.

4.1 SDU BLER

In *unacknowledged mode*, one way to measure the effectiveness of the SDU BLER is the average SDU throughput. It can be calculated as follows:

$$Throughput_{SDU} = \frac{(1 - BLER_{SDU}) \times Payload_{MCS}}{TransmissionTime_{MCS}}$$

Note that the average SDU throughput does not depend on the SDU size but on the MCS payload. Using this formula, Figure 2 shows the SDU throughput as a function of the SDU BLER requirement, for different MCSs. For all MCSs, the SDU throughput does not change significantly with SDU BLER requirements below 1%. In other words, SDU BLER requirements below 1% do not increase the average throughput in unacknowledged mode. Therefore, a realistic requirement for the SDU BLER is probably somewhere between 1% and 10%, as pointed earlier in section 2.

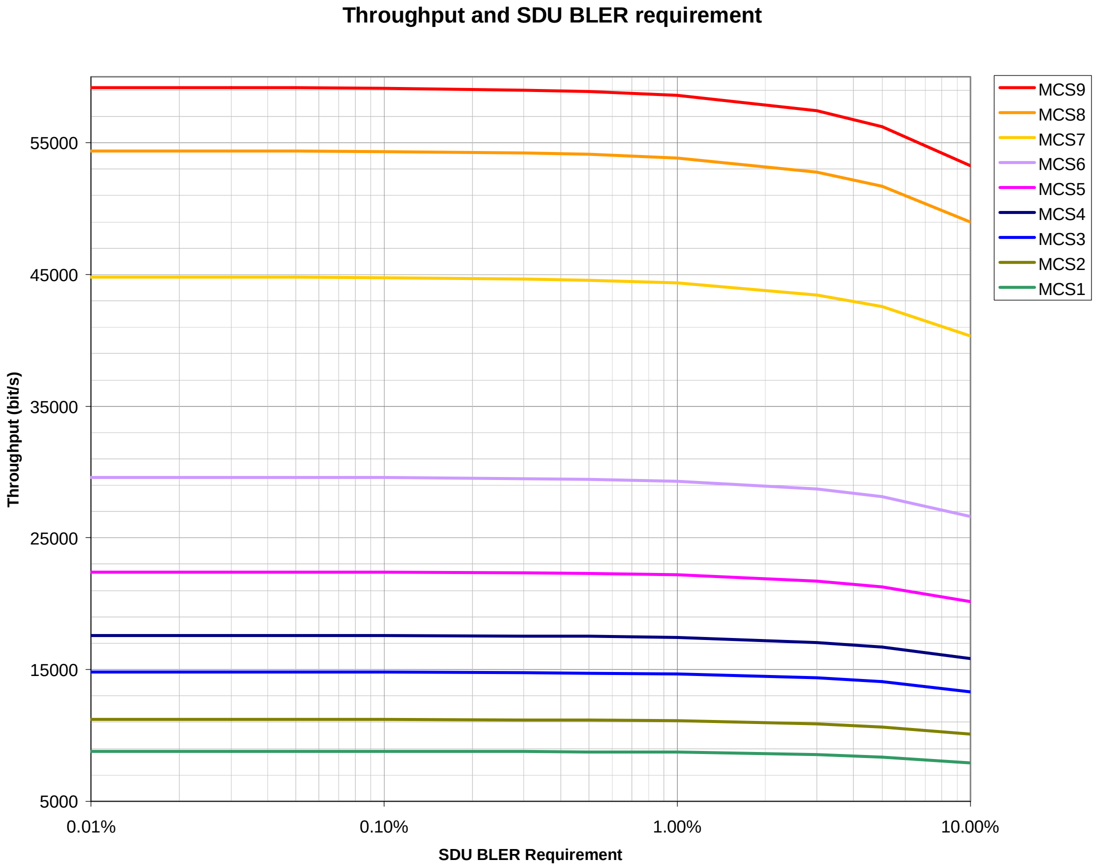


Figure 2 - Throughput and SDU BLER Requirement

4.2 SDU Size

For unacknowledged PtM MBMS radio bearers, only the strongest coding schemes are likely to be used: MCS1, MCS2 and MCS5. In Annex B, curves showing the PDU BLER requirements as a function of the SDU BLER can be found for these 3 coding schemes and for SDU sizes ranging from 100 to 1400 bytes (using formulas of section 2). The conclusions that can be drawn are:

- With a fixed SDU BLER of 1% and PDU BLER between 1% and 0.1%, only 100 and 200 bytes SDU can be carried over MCS1 and MCS2, while MCS5 allows SDUs up to 500 bytes.
- With a maximum SDU BLER of 10% and a minimum PDU BLER of 0.1%, all SDU sizes can be carried over MCS1, MCS2 and MCS5.
- With a fixed PDU BLER of 1%, the SDU BLER cannot be 1%.
- With a fixed PDU BLER of 1%, the largest SDU that can be carried over MCS1 is 200 bytes with a BLER of 9%.

- With a fixed PDU BLER of 1%, the largest SDU that can be carried over MCS2 is 300 bytes with a BLER of 10%.
- With a fixed PDU BLER of 1%, the largest SDU that can be carried over MCS5 is 500 bytes with a BLER of 9%.
- With a fixed PDU BLER of 0.1%, the largest SDU that can be carried over MCS1 is 1400 bytes with a BLER of 6%.
- With a fixed PDU BLER of 0.1%, the largest SDU that can be carried over MCS2 is 1400 bytes with a BLER of 5%.
- With a fixed PDU BLER of 0.1%, the largest SDU that can be carried over MCS5 is 1400 bytes with a BLER of 2 or 3%.
- SDUs of 1400 bytes always require a PDU BLER well below 1% and can never reach a SDU BLER of 1% when setting the minimum PDU BLER to 0.1%.

In brief if the maximum SDU BLER is 10%, a maximum SDU size of 1400 bytes is possible. However if the maximum SDU BLER is 1%, a maximum SDU size of 500 bytes should be considered.

5. CONCLUSION

This contribution has analysed several aspects of the unacknowledged PtM MBMS radio bearers. It was shown that since the segmentation makes the PDU BLER requirement stronger and since the SDU throughput does not increase significantly with SDU BLER below 1%, a realistic requirement for the SDU BLER should be set between 1% and 10%. Concerning the maximum SDU size, it was shown that if the maximum SDU BLER is 10%, a maximum SDU size of 1400 bytes is possible. However if the maximum SDU BLER is 1%, a maximum SDU size of 500 bytes should be considered instead. In both cases, existing requirements for video streaming and video conversational should be relaxed for PtM MBMS services.

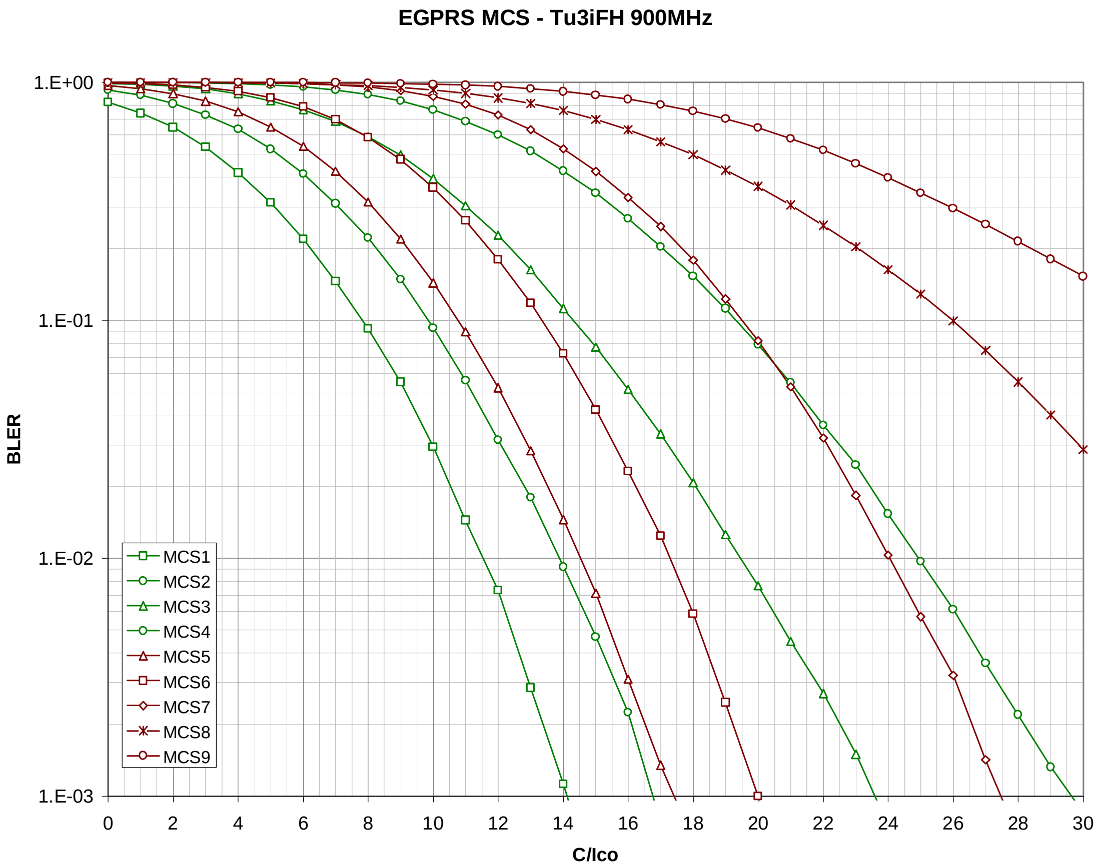
REFERENCES

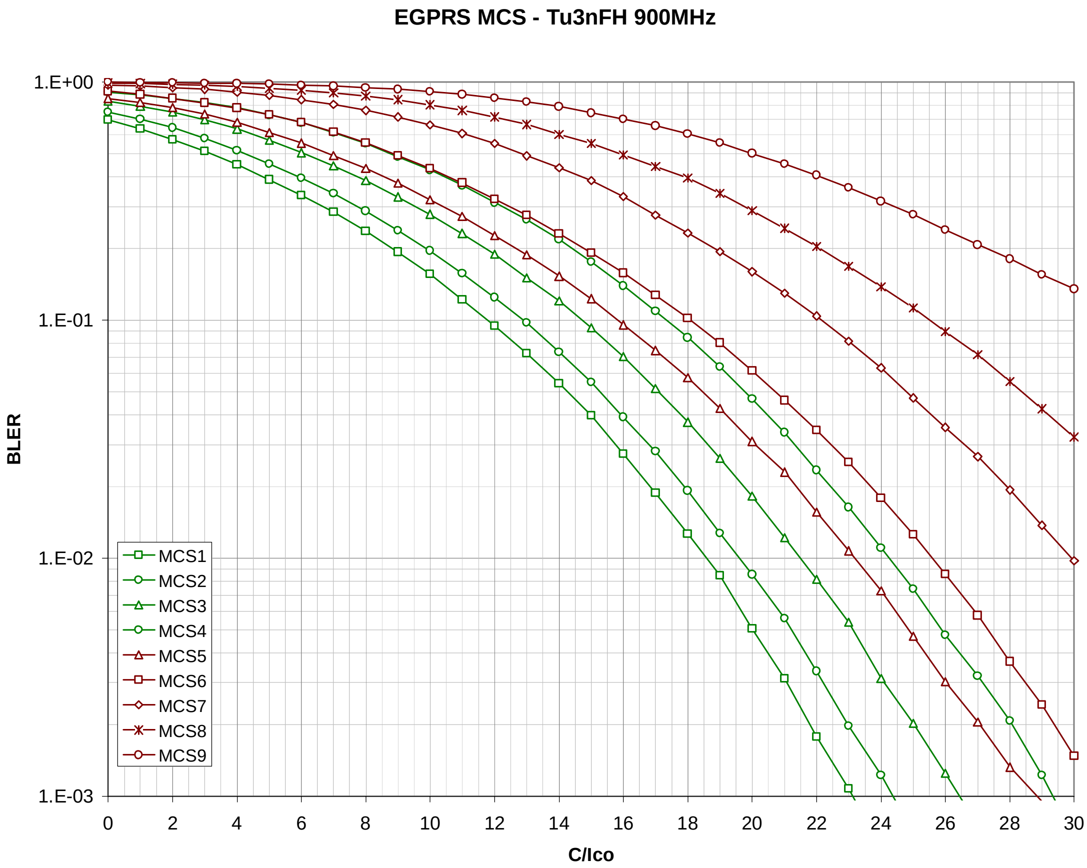
[1] TDoc GMBMS-030002, *Performance of MBMS Radio Bearers*, Nokia

[2] 3GPP TS 26.236, *Packet-switched conversational multimedia applications; Transport Protocols*

[3] 3GPP TR 26.937, *Transparent end-to-end packet switched streaming service (PSS); RTP usage model*

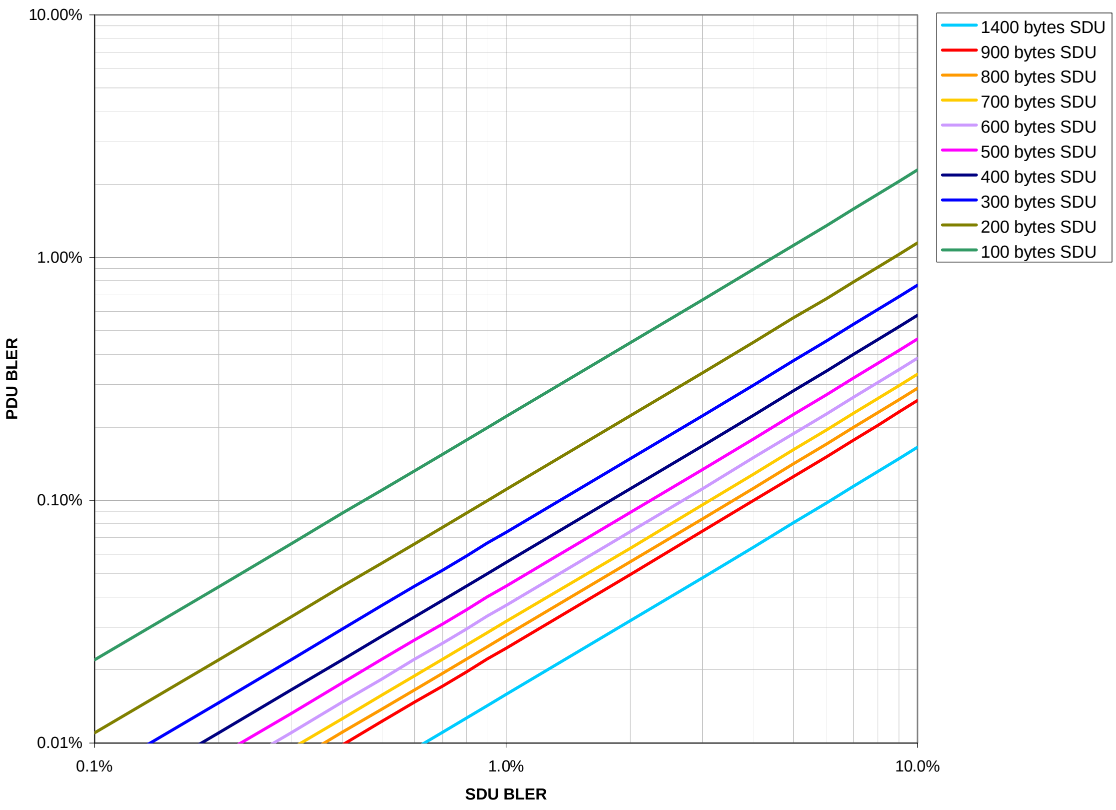
Annex A - EGPRS Performance



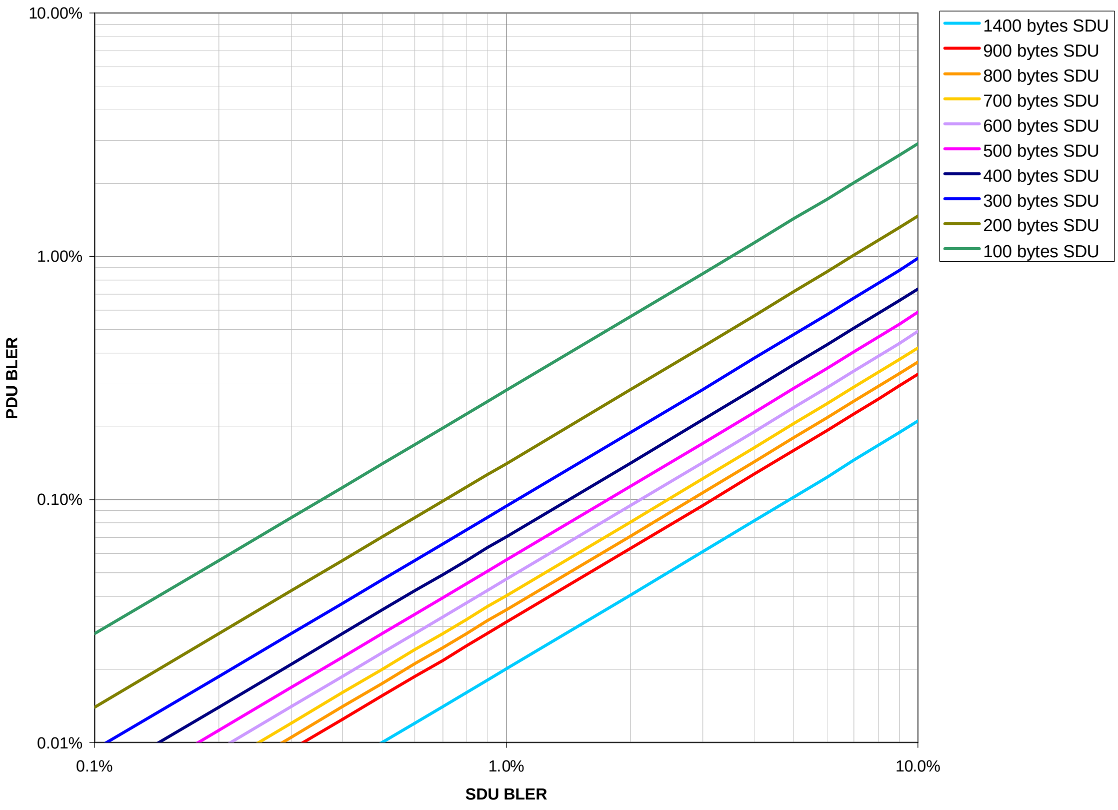


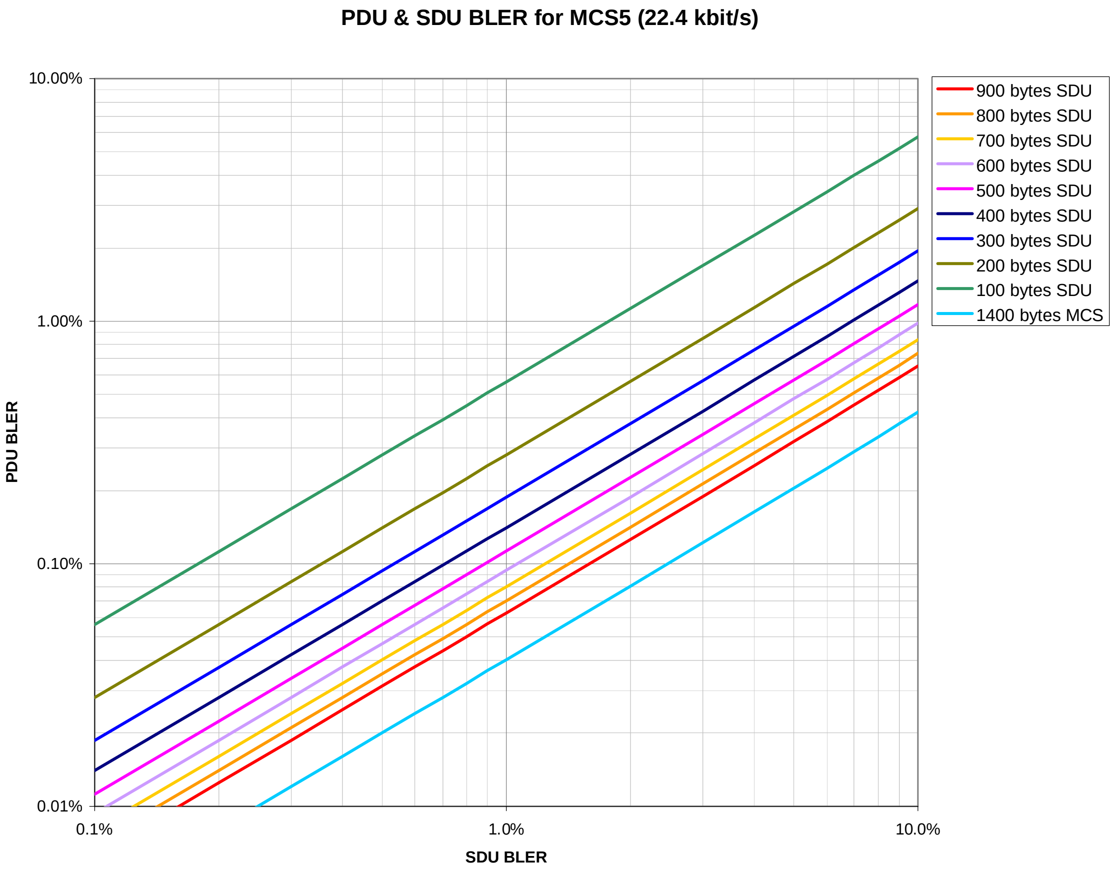
Annex B - PDU and SDU BLER

PDU & SDU BLER for MCS1 (8.8 kbit/s)



PDU & SDU BLER for MCS2 (11.2 kbit/s)




PDU & SDU BLER for MCS5 (22.4 kbit/s)
10.00%
1.00%
0.10%
0.01%
PDU BLER
0.1%
1.0%
10.0%
SDU BLER
900 bytes SDU
800 bytes SDU
700 bytes SDU
600 bytes SDU
500 bytes SDU
400 bytes SDU
300 bytes SDU
200 bytes SDU
100 bytes SDU
1400 bytes MCS