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Improving SACCH Performance

1. INTRODUCTION

AMR has very robust codecs (e.g. AMR4.75, AMR5.9) that allow the network to operate at very low CIR values. However, when AMR was standardized, the associated channels (SACCH, FACCH) were kept the same. In a high-capacity AMR network, the CIR values can be occasionally very low (only few dBs). For example, AMR4.75 can reach 1% Frame Error Rate with only CIR of 2.6 dB. However, at this level the SACCH and FACCH error rates are around 50%. Failed SACCH decodings will cause the call to be dropped, based on RADIO_LINK_TIMEOUT parameter. Failed decodings cause also problems with Layer 3 signalling, measurement reports and RRM algorithms (handover, power control). This contribution investigates possible solutions to improve the performance of the SACCH when operating at low CIR.

2. SYSTEM LEVEL SACCH AND TCH PERFORMANCE SIMULATION RESULTS

In order to verify the problem, burst-level network simulations were used to evaluate the SACCH and TCH FER error rates. A typical high-capacity, limited-spectrum macro cell network was simulated using 12 (1/1 RF) hopping frequencies with AMR Full Rate traffic. C/I-based fast link adaptation was used with four codec modes (12.2, 7.3, 5.9 and 4.75). Cell radius was 500 meters; power control and DTX were used.

Figure 1 shows the correlation between TCH and SACCH errors when the network was highly loaded (Effective Frequency load was 25%). For each AMR mode, the corresponding SACCH BLER was monitored. It can be seen that AMR LA is able to maintain the TCH FER at acceptable levels. But on the other hand, when the channel conditions are bad and the MS has to switch to more robust ARM modes, the SACCH channel starts to fail.

When the call has switched to AMR4.75 the SACCH error rate is over 30%. The call might get dropped. Changing the Radio Link Timeout to higher value helps to avoid dropping but it is not a very good solution. SACCH contains important information (PC commands, measurement reports, timing advance etc.) – if they are lost or have large delay the call quality will suffer and the call can interfere other users in the network.

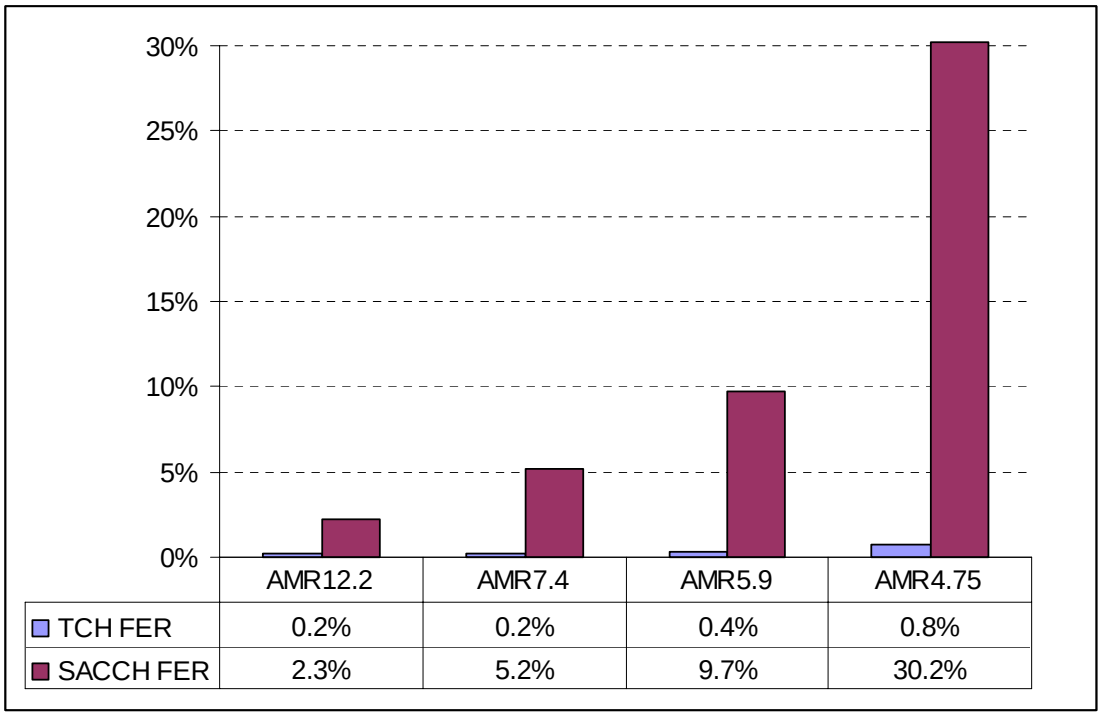

Figure 1. Correlation of SACCH and TCH error rates in a typical high-capacity AMR network.

3. BETTER SACCH PERFORMANCE

In order to improve the performance of the SACCH, the obvious solution is to increase its channel coding. There are three alternatives to allow this:

- keep the SACCH as it is and transmit additional coded bits somewhere;
- reduce the payload of the SACCH;
- slow down the duty cycle of the SACCH.

In all cases, the criteria to trigger one or a combination of the mechanism(s) could either be:

- when the network detects high SACCH BLER (e.g. the radio link counter S goes below certain threshold); or
- when the reported RXQUAL goes above a certain threshold; or
- when the command mode request of AMR link adaptation signalling goes below a certain threshold.

In the sections below, three solutions are proposed.

4. PARALLEL SACCH

This idea was first presented in GERAN#03 [1]. In the 26-multiframe shown on Figure 2, there is an idle slot, which is not used to transmit or receive data. It allows the MS to perform pre-synchronization.

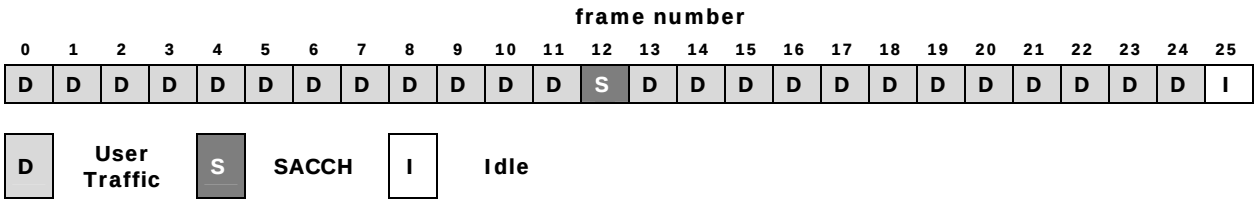

Figure 2 - 26-multiframe in Full Rate channel

Whenever pre-synchronisation is not required, for instance once the mobile has finished reading the SCH bursts of all its neighbours, the idle slot could be used to convey additional signalling. It is therefore proposed to use this idle slot to convey a “parallel” SACCH in order to improve the link level performance of SACCH (Figure 3) [1]. A “parallel” SACCH burst is a simple copy of the previous SACCH burst. Chase combining between SACCH and the “parallel” SACCH can then be performed in the receiver.

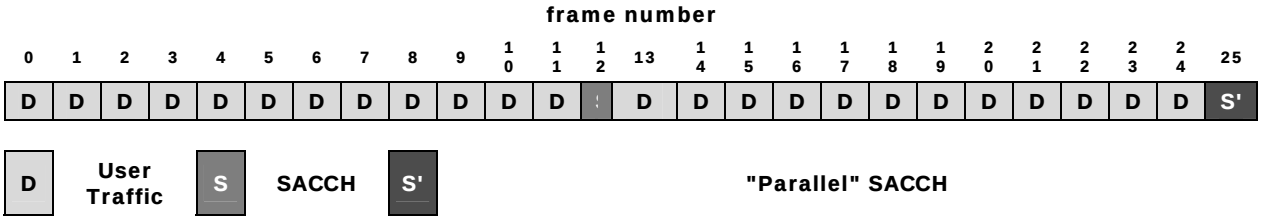

Figure 3 - Enhanced SACCH for Full Rate channel

Table 1 shows the improvement when using the idle timeslots to convey parallel SACCH bursts. Curves can be found in [1]. At 4.9 dB, only 2 idle bursts are needed to reach 6.4 % BLER, whereas at 2.6 dB, SACCH using 4 idle bursts reach 6.3 % of BLER. These results are comparable to the TCH/AFS12.2 case.

Table 1 - SACCHBLER using 1 to 4 parallel bursts

Speech Channel	TCH/AFS4.75	TCH/AFS7.4
C/Ico (dB) @ 1% FER	2.6 dB	4.9 dB
SACCH/TF BLER	45.4 %	22.3 %
SACCH/TF + 1 idle burst BLER	33.1 %	13.1 %
SACCH/TF + 2 idle bursts BLER	21.5 %	6.4 %
SACCH/TF + 3 idle bursts BLER	12.4 %	2.7 %
SACCH/TF + 4 idle bursts BLER	6.3 %	0.9 %

5. SHORT SACCH

In short SACCH messages, only a subset of the information usually sent in normal SACCH messages could be sent: the time critical information. In the DL, for instance, the PC information could be omitted as it is very likely that at low CIR, the maximum output power is used in the MS anyway. Also in the DL, it may not be necessary to send the L2 frame at all (System Information 5, 6, 5bis, 5ter and L2 fill frames may be omitted). In the UL, not all neighbouring cells could be reported. For instance, only the two strongest cells could be reported instead of 6 in the measurement reports.

Naturally, sending fewer bits would allow the channel coding to be increased and the performance of the SACCH to be improved.

6. SLOW SACCH

With a slow SACCH approach, the content of SACCH messages are left unchanged but the channel coding is performed over 8 bursts instead of 4 as currently specified. As a result, the coding rate it twice lower leading to an improved (but slower) SACCH.

7. CONCLUSION

This contribution has investigated three possible solutions to improve the performance of the SACCH when operating in low CIR: “Parallel SACCH” using the idle slot, “Shorter SACCH” where only time critical information are sent and “Slow SACCH” where the duty cycle is e.g. 960ms.

REFERENCES

[1] TDoc GP-010246, *ACCH enhancements for Full Rate AMR speech TCH*, Nokia