TSG-RAN Working Group 1 (Radio layer 1)
New York, 12th October to 15th October1999

**TSGR1 WG1 #8(99)f58**

**Agenda Item:** Adhoc 3

**Source:** **Nokia**

**Title:** Proposal to have optional 20 ms RACH message length

**Document for:** Discussion and decision

# 1 Introduction

In the last WG1 meeting in Hanover, Nokia presented a contribution R1-99b82 where it was pointed out that RACH coverage does not match with AMR coverage. Simulation results showed that the mismatch in the link budget is in the order of 3 dB for FER=10 % between AMR 12.2 kbit/s and 20 octet RACH message transmitted with 10 ms message length.

Some ideas were given how to solve this problem. One idea was that higher FER level would be used for RACH and by using several retransmissions of RACH (repeated RACH procedure) the random access could be succeeded at the cell edge of AMR cell coverage. Increasing the FER target from 10 % to 50 % and repeating the RACH procedure 4 times would mean 3.3 dB gain.

However, this method will increase the delay in the random access, and thus we should think about also other methods how to match RACH and AMR coverage.

One idea was that there would be an alternative possibility to use 20 ms RACH message length. This would mean that BCH would contain one bit informing whether 10 ms or 20 ms RACH message is used in the cell. The minimum RACH payload would be the same in both cases, 20 octets, meaning that the required transmit power for 20 ms RACH message would thus be loosened and thus the problem in the link budgets would be solved.

# 2 Answers to the comments given in last meeting

## 2.1 Performance of RACH with 20 ms message length

In last meeting comments were given that the 20 ms message length might be too long due to fading, since there is no closed loop power control used in PRACH. Which would mean that the gain that we would like to achieve for link budget, might be lost in the RACH performance, and the net gain would actually be negligible. We show here simulation results for 20 octet RACH payload for both 10 ms and 20 ms RACH message length, at both 3 km/h and 20 km/h. The 3 km/h is the worst case for coverage planning. However, at 20 km/h the effect of longer message length together with lack of power control is also interesting to see. The simulation results are shown in detail in chapter 3.

## 2.2 Is there any need for coverage planning for AMR ?

The other comment that was given in last meeting to Nokia's proposal was that not all operators are not going to plan their networks for AMR coverage.

It may very well be the case that not all operators see the need for this. That is not however, good enough argumentation for excluding the possibility for some other operators to do their network planning based on AMR. If we have the approach that one bit in BCH informs which message length is used, 10 or 20 ms, it still gives those operators the possibility to use 10 ms message length, who are willing to do so.

One important thing to be noted is that the coverage planning for AMR is not going to be the only purpose for using 20 ms message length. One very possible scenario might be that we do indoor coverage planning for 64 kbit/s data service. The coverage planning is always done so that coverage is fulfilled with x % area, where e.g. x = 80 %. One idea could be that the gaps in the coverage (the 20 % of the cell area that does not have coverage for the 64 kbit/s data service) will still support AMR service (=have coverage for AMR). However, this AMR coverage is useless, if RACH coverage is not matched to that.

# 3 Simulation assumptions of RACH and speech/DCH

The simulation parameters for DCH / AMR and for RACH are shown below.

**Table 1. Simulation parameters of AMR speech**

| | |
|---|---|
| DPDCH SF | 12.2kbps: SF=64 |
| User bits per 20ms | 12.2kbps: 244 |
| CRC bits | 16 |
| Tail bits | 8 |
| Rate matching | Equal error protection<br>12.2kbps: 804 -> 1200 (repetition) |
| Data/control power | 3 dB |
| Target quality | FER=1% |
| Channel estimation | Weighted averaging over 3 slots |
| Power control | No fast power control, full constant power |

**Table 2. Simulation parameters of RACH**

| | |
|---|---|
| User bit rates | 16kbps = 20 octets |
| Message length | 10 ms or 20 ms message length, and correspondingly<br>10 or 20 ms 1st interleaver. |
| Rake allocation | Allocation based on preamble |
| Channel estimation | Adaptive channel estimation |
| Preamble / message power | 0 dB |
| Data / control power | 3 dB |
| Target quality | FER=10% |

**Table 3. Simulation environment**

| | |
|---|---|
| Multipath profile | ITU Pedestrian A |
| Mobile speed | 3km/h, 20 km/h |
| Number of receiver antennas | 2 uncorrelated antennas |

# 4 Simulation results

Simulation results are shown below. It can be seen that Eb/N0 degradation is 0.3…0.5 dB due to longer message length and lack of closed loop power control during the RACH message.

ITU pedestrian 3 km/h; FER=10 % :

10 ms RACH message length: Eb/N0 = 8.9 dB
20 ms RACH message length: Eb/N0 = 9.4 dB

ITU pedestrian 20 km/h; FER=10 % :

10 ms RACH message length: Eb/N0 = 8.4 dB
20 ms RACH message length: Eb/N0 = 8.7 dB

However, it can be also seen that 3km/h is the limiting speed which will be used for coverage planning, and not 20 km/h. 20 km/h was simulated just for curiosity's sake to see how the lack of power control will affect the results at that speed. So see table 4, where we show the coverage comparison between DCH and RACH at 3 km/h.

The relative coverage is defined as below:

$$\text{Rel\_coverage} = 10 \cdot \log_{10}\left(\frac{\text{DCH\_bit\_rate}}{\text{RACH\_bit\_rate}}\right) + \left[Eb/N0_{DCH}(dB) - SHOgain(dB)\right] - Eb/N0_{RACH}(dB) \qquad (1)$$

Rel_coverage < 0dB ↔ RACH has poorer coverage than DCH
Rel_coverage > 0dB ↔ RACH has better coverage than DCH

**Table 4. Coverage comparison between DCH /12.2 kbit/s and RACH /20 octet message**

| | **DCH / AMR 12.2k** | | **RACH / 20 octet** | |
|---|---|---|---|---|
| RACH message length | $E_b/N_0$ | Soft handover gain[1] | $E_b/N_0$ | Relative coverage |
| 10 ms | 9.9dB | 3.0dB | 8.9 dB | **-3.2 dB** |
| 20 ms | 9.9dB | 3.0dB | 9.4dB | **-0.7 dB** |

[1]The soft handover gain in simulations with 10 ms interleaving and 3 km/h is 4.0dB with an equal attenuation to both soft handover base stations and 2.8dB if there is a 3dB-difference in the attenuation to the soft handover base stations

Table 4 shows that by having the possibility of 20 ms RACH message length, the RACH and AMR coverage can be matched to each other.

# 5 Conclusions and proposal

We propose that it is informed in BCH with one bit, whether RACH message length is 10 ms or 20 ms. Simulation results show that in that way we can match the RACH coverage with AMR coverage. Our opinion is that there is good argumentation available for having this possibility. And since it is still possible to use 10 ms RACH message length, all the operators should be satisfied with this proposal.

Of course it has to be mandatory for all UEs to support both 10 ms and 20 ms message lengths.

Text proposals are given for S25.211, S25.212, S25.213 and S25.215 in next sections. Since it is not known what kind of changes will be made to the specs in WG1 #7bis meeting, it should be, however, re-checked whether correct versions of the specs are used in these text proposals.

# 6 Text proposal to S25.211

## 5.2.2.1.1. RACH transmission

-snip-

The structure of the random-access transmission is shown in Figure 1. The random-access transmission consists of one or several *preambles* of length 4096 chips and a *message* of length 10 or 20 ms. The message length is informed in BCH.

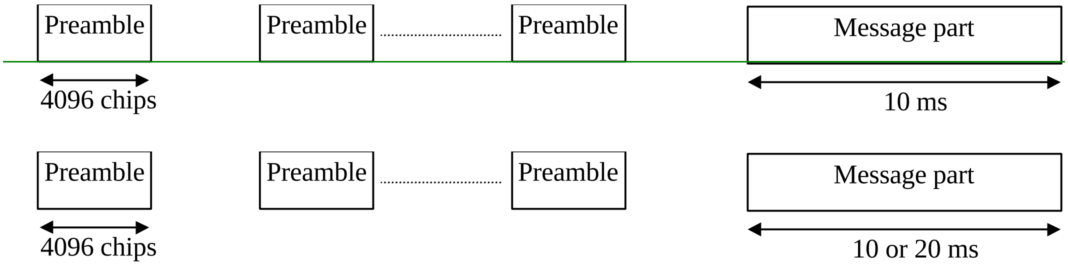


**Figure 1: Structure of the random-access transmission.**

## 5.2.2.1.2 RACH preamble part

The preamble part of the random-access burst consists of 256 repetitions of a signature, which is comprised of 16 complex symbols (±1+j). There are a total of 16 different signatures, based on the Hadamard code set of length 16 (see **Error! Reference source not found.** for more details).

## 5.2.2.1.3 RACH message part for 10 ms message

Figure 2 shows the structure of the Random-access message part for 10 ms message length. The 10 ms message is split into 15 slots, each of length $T_{slot}$ = 2560 chips. Each slot consists of two parts, a data part that carries Layer 2 information and a control part that carries Layer 1 control information. The data and control parts are transmitted in parallel.

The data part consists of $10*2^k$ bits, where k=0,1,2,3. This corresponds to a spreading factor of 256, 128, 64, and 32 respectively for the message data part.

The control part consists of 8 known pilot bits to support channel estimation for coherent detection and 2 TFCI bits. This corresponds to a spreading factor of 256 for the message control part. The pilot bit pattern is described in Table 7. The total number of TFCI bits in the random-access message is 15*2 = 30. The  TFCI value corresponds to a certain transport format of the current Random-access message.

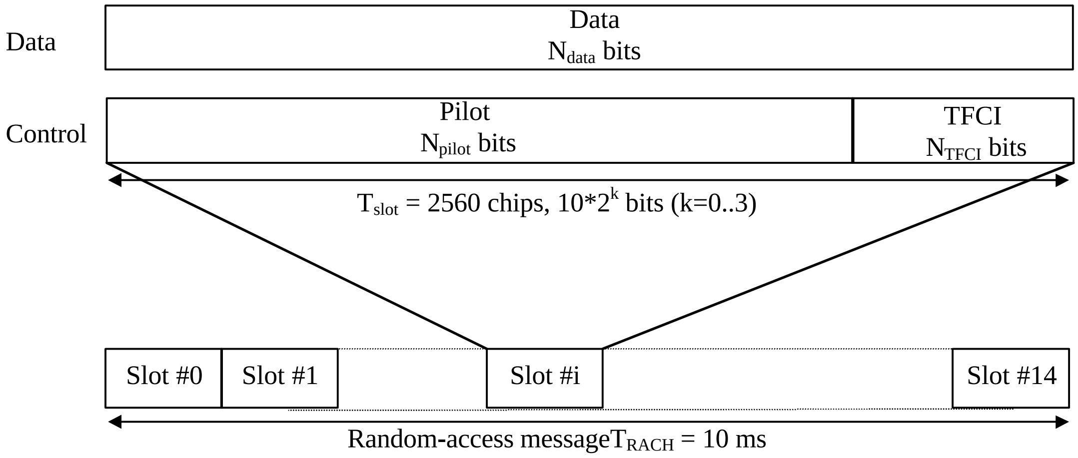


**Figure 2: Structure of the random-access message part for 10 ms message.**

**Table 5: Random-access message data fields.**

| Channel Bit Rate (kbps) | Channel Symbol Rate (ksps) | SF | Bits/ Frame | Bits/ Slot | $N_{data}$ |
|---|---|---|---|---|---|
| 15 | 15 | 256 | 150 | 10 | 10 |
| 30 | 30 | 128 | 300 | 20 | 20 |
| 60 | 60 | 64 | 600 | 40 | 40 |
| 120 | 120 | 32 | 1200 | 80 | 80 |

**Table 6: Random-access message control fields.**

| Channel Bit Rate (kbps) | Channel Symbol Rate (ksps) | SF | Bits/ Frame | Bits/ Slot | $N_{pilot}$ | $N_{TFCI}$ |
|---|---|---|---|---|---|---|
| 15 | 15 | 256 | 150 | 10 | 8 | 2 |

**Table 7: Pilot bit patterns for RACH message part with $N_{pilot}$ = 8.**

| | $N_{pilot}$ = 8 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bit # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Slot #0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 2 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 4 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 6 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| 7 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 8 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 11 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 13 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 14 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |

#### 5.2.2.1.4 RACH message part for 20 ms message

The structure of Random-access message part for 20 ms message length is the same as two 10 ms Random-access messages sent consecutively.

# 7 Text proposal to S25.212

### 4.2.13.2 Random Access Channel (RACH)

- There can only be one TrCH in each RACH CCTrCH, i.e. $I$=1, $s_k = f_{1k}$ and $S = V_1$.
- The maximum value of the number of transport blocks $M_1$ on the transport channel is given from the UE capability.
- The transmission time interval is ~~always~~ either 10 ms or 20 ms, i.e. $e_{1k} = c_{1k}$ and $N_1 = E_1$.
- At initial RACH transmission the rate matching attribute has a predefined value.
- Only one PRACH is used, i.e. $P$=1, $u_{1k} = s_k$, and $U = S$.

# 8 Text proposal to S25.213

### 4.3.3.5 Scrambling code for the message part

In addition to spreading, the message part is also subject to scrambling with a 10 ms or 20 ms complex code, depending on the message length. The scrambling code is cell-specific and has a one-to-one correspondence to the scrambling code used for the preamble part.

$S_{r\text{-}msg,n} = C_{scramb,n}$ ,for chip indexes 4095…42495 of $C_{scramb,n}$ for 10 ms message length and for chip indexes 4095…76800 of $C_{scramb,n}$ for 20 ms message length.

The generation of these codes is explained in 4.3.2.2. The mapping of these codes to provide a complex scrambling code is also the same as for the dedicated uplink channels and is described in 4.3.2.1.

# 9 Text proposal to S25.214

## 6.1 RACH Random Access Procedure

Before the random-access procedure is executed, the UE should acquire the following information from the BCH :

- The preamble spreading code(s) / message scrambling code(s) used in the cell
- The message length in time, either 10 or 20 ms
- The available signatures , and sub RACH channel(s) groups for each ASC, where a sub-channel group is defined as a group of some of the sub-channels defined in **Error! Reference source not found.**, and is indicated by upper layer.
- The available spreading factors for the message part
- The uplink interference level in the cell
- The primary CCPCH transmit power level
- The AICH transmission timing parameter as defined in 25.211.
- The power offset $\Delta P_{p\text{-}m}$ between preamble and the message part.
- The power offsets $\Delta P_0$ (power step when no acquisition indicator is received, step 7.3) and $\Delta P_1$ (power step when negative acquisition is received, see step 8.3)