TSG-RAN Working Group 1 (Radio layer 1)
Hannover, Germany
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**TSGR1 WG1 #7(99)b82**

**Agenda Item:**

**Source:** **Nokia**

**Title:** Comparison of RACH and AMR speech coverage

**Document for:** Discussion and decision

# 1 Introduction

The coverage of RACH is compared to the coverage of DCH/AMR speech in this document. A few proposal and simulation results are presented how to improve the RACH coverage.

# 2 References

[1] TDoc TSGR2#5(99)532 "Liason response to TSGR1#5(99)732, Liason Statement on RACH Payload Requirements"

[2] TS 26.010, v 1.0.0 1999-04, Mandatory Speech Codec speech processing functions AMR Speech Codec; General Description; Source: 3GPP TSG-SA Codec Working Group

[3] Tdoc TSGR2#4(99)415 "Contents of RRC Connection Request" (source: Ericsson)

[4] ETSI SMG2 UMTS L23 Expert Group Tdoc SMG2 UMTS-L23 541/98 "Initial UE identification and contention resolution" (source: Ericsson)

[5] Tdoc TSGR2#5(99)525 "Results of RRC Email Ad Hoc Discussion" (source: Rapporteur (Nokia))

[6] TS 33.105 V1.0.0 Cryptographic Algorithm Requirements (TSG SA WG3)

[7] TDoc TSGR2#5(99)614 "CR to TS25.301: Integrity control mechanism" (source Nokia)

[8] Tdoc TSGR2#3(99)211 "Liaison from WG3 regarding the length requirements for s-RNTI, c-RNTI and RNC-ID" (source: TSG RAN WG3)

[9] TS 25.331, ver 1.1.0

# 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 | 4.75kbps: SF=128<br>7.95kbps: SF=128<br>12.2kbps: SF=64 |
| User bits per 20ms | 4.75kbps: 95<br>7.95kbps: 159<br>12.2kbps: 244 |
| CRC bits | 16 |
| Tail bits | 8 |
| Rate matching | Equal error protection<br>4.75kbps: 357-> 600 (repetition)<br>7.95kbps: 549 -> 600 (repetition)<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<br>9.6kbps = 12 octets |
| 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%<br>FER=20%<br>FER=50% |

**Table 3. Simulation environment**

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

The RACH performance could be improved by using also the message part in the finger allocation. The DCH performance could be improved by using adaptive channel estimation and unequal error protection.

# 4 Simulation results

The coverage comparison is calculated as follows in Table 4

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

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

**Table 4. Coverage comparison of RACH (FER=10%) and DCH**

| | **DCH / AMR** | | **RACH / 20 octet (=16kbps)** | |
|---|---|---|---|---|
| | $E_b/N_0$ | Soft handover gain[1] | $E_b/N_0$ | Relative coverage |
| AMR 4.75kbps | 11.4dB | 3.0dB | 9.3dB | **-6.2dB** |
| AMR 7.95kbps | 10.7dB | 3.0dB | 9.3dB | **-4.6dB** |
| AMR 12.2kbps | 9.9dB | 3.0dB | 9.3dB | **-3.6dB** |

[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

RACH should not be the limiting factor in coverage. If, in any locations, the uplink DCH can provide the required quality, it should be possible to get also the RACH message through to be able to start the connection. Therefore, a coverage improvement of 3.6-6.2dB is needed for RACH to match with AMR speech coverage.

# 5 Solutions

## 5.1 RACH Coverage planning principle

In cellular systems, the coverage of common channels has generally been designed to be better than the traffic channels. That is, reference sensitivity defines the signal level at which quality of traffic channel is regarded as being adequate for the service, but the call can start several dB below the reference sensitivity. In addition, network and MS are able to exchange signaling information below the reference sensitivity of the traffic channel. WCDMA is targeted for a wide range of services, both high bit rate and low bit rate. Therefore, it is reasonable to assume that the coverage of common transport channels should be at least as good as the dedicated transport channels. The minimum requirement is to ensure in the cell area where low bit rate service can take place with adequate QoS, the Common channel coverage is sufficient for the call to start. Furthermore, it is an advantage to have the capability of signaling and short message exchange between UE and network over Common channels even at the cell area where coverage is not sufficent for normal services (e.g. Voice).

The common channel coverage is specifically an issue for uplink, where UE has limited transmit peak power. In the following analysis, we compare the coverage of RACH with that of AMR Voice services.

## 5.2 Higher FER (more retransmissions) for RACH

The probability of not getting RACH through is $FER^n$, where $n$ is the number of transmissions. If we assume $n$=4 and we want to have the RACH failing probability below 5%, the maximum allowed FER on RACH is $0.05^{1/4}$=47%. Increasing the FER from 10% to 50% gives a gain of about **3.3 dB**. This could be achieved by setting preamble / message = –3dB, i.e. the message part is sent with 3dB higher power than the preamble. If the mobile cannot power up 3dB after the preamble, then the mobile sends the message part with full power and the FER is higher. With FER=50% the RACH performance is close to the AMR12.2kbps performance.

**Table 5. Coverage comparison of RACH (FER=20%) and DCH**

| | **DCH / AMR** | | **RACH / 20 octet (=16kbps)** | |
|---|---|---|---|---|
| | $E_b/N_0$ | Soft handover gain[1] | $E_b/N_0$ | Relative coverage |
| AMR 4.75kbps | 11.4dB | 3.0dB | 8.0dB | **-4.9dB** |
| AMR 7.95kbps | 10.7dB | 3.0dB | 8.0dB | **-3.3dB** |
| AMR 12.2kbps | 9.9dB | 3.0dB | 8.0dB | **-2.3dB** |

**Table 6. Coverage comparison of RACH (FER=50%) and DCH**

| | **DCH / AMR** | | **RACH / 20 octet (=16kbps)** | |
|---|---|---|---|---|
| | $E_b/N_0$ | Soft handover gain[1] | $E_b/N_0$ | Relative coverage |
| AMR 4.75kbps | 11.4dB | 3.0dB | 6.0dB | **-2.9dB** |
| AMR 7.95kbps | 10.7dB | 3.0dB | 6.0dB | **-1.3dB** |
| AMR 12.2kbps | 9.9dB | 3.0dB | 6.0dB | **-0.3dB** |

## 5.3 Lower RACH bit rate

The RACH coverage can be improved by making the RACH bit rate lower. The simulation results for 16kbps RACH and 9.6kbps RACH with FER=10% are shown in Table 7.

**Table 7. RACH results with 16kbps and 9.6kbps**

| RACH bit rate | $E_b/N_0$ | Coverage gain |
|---|---|---|
| 16kbps | 9.3dB | 0.0 dB |
| 9.6kbps | 10.0dB | 10*log10(16/9.6)-(10.0-9.3) =**1.5 dB** |

Reducing the RACH bit rate from 16kbps to 9.6kbps gives a gain of 1.5 dB in RACH coverage. The RACH bit rate could be lowered e.g. by making the minimum RACH payload smaller or by segmenting the RACH message to two parts.

## 5.4 Base station implementation techniques

The RACH coverage can be improved by base station implementation techniques, e.g. with smart antennas. It is not economical to make a separate antenna structure for RACH than for DCH. Those smart antenna solutions give gain also for the DCH coverage. Typically, it is even easier to obtain performance improvements for continuous DCH transmission than for RACH messages.

# 6 Conclusions and proposal

From radio network planning view point the coverage of RACH should be at least as good as that of low bit rate services offered by dedicated channels. In particular, the minimum rate of RACH should be designed such that its coverage matches up with that of the half-rate AMR services. Furthermore, low bit rate common transport channels are desirable in terms of offering good coverage of signaling and short message exchange capability between UE and network in general.

A coverage improvement of 3.3dB can be obtained for RACH by increasing FER from 10% to 50%. That can be realised by setting the preamble / message = –3dB. With FER=50% the RACH coverage is equal to DCH/AMR12.2kbps. Enough re-transmissions should be allowed with high FER to guarantee that RACH gets through.

In order to match the RACH coverage with DCH/AMR7.95kbps coverage an additional 1.3dB improvement is needed. That improvement can be obtained by reducing the bit rate in RACH from 16kbps to 9.6kbps. Therefore, we propose the minimum bit rate of RACH to be around 9.6kbps.

Earlier, WG1 has answered with a liaison statement to WG2 that minimum RACH payload of 20 octets is sufficient. We propose, that a new liaison statement is sent to WG2, to inform that minimum RACH payload should be 12 octets (=9.6 kbps).