TSG-RAN Working Group 2 (Radio layer 2 and Radio layer 3) ***TSGR2#6 (99) 806***
Sophia Antipolis (France), 16-20th August 1999

Agenda Item: 14.4

Source: Alcatel

Title: Improvement of outer-loop power control in compressed mode

Document for: Decision

Introduction

The downlink compressed mode has been introduced in UMTS in order to make possible for a user equipment (UE) to perform measurements on a frequency different from its downlink transmission frequency. It consists basically in stopping the downlink transmission during a certain amount of time. Simultaneous uplink and downlink compressed modes can also be used when the measurement frequency is closed to the uplink transmission frequency.

Because the instantaneous bit rate will have to be increased during compressed frames (by increasing the coding rate or decreasing the spreading factor), the target SIR also needs to be approximately increased by the same proportion.

Additionally, since the closed-loop power control is no longer active during transmission gaps for downlink and uplink, the performance are significantly degraded, mainly during compressed frames and recovery frames (frames just following compressed frames). The degradation can reach several decibels as shown in [1], [2] and [3]. In order to keep the same quality of service as in normal mode, this effect would also need to be compensated by increasing the target SIR during these frames.

However, the outer-loop power control algorithm is a slow process and several frames will be probably required before changing the target SIR accordingly. Therefore, it is likely that this process is too slow to be able to increase the target SIR in compressed and recovery frames as required. Moreover, the target SIR even risks to be increased just after compressed and recovery frames where it would not be needed.

Thus, there is a need for a faster algorithm than the classical outer-loop power control algorithm in compressed mode to avoid degrading the performances.

Proposal

Since the uplink outer-loop power control is performed in the UTRAN, it has not to be standardized. Thus, we will mainly focus on the downlink outer-loop power control algorithm performed in the UE.

A simple solution that could solve the slow reaction of the current power control algorithm is to anticipate the target SIR increase required during compressed and recovery frames. Indeed, depending on parameters like the transmission gap length, the environment or the speed, we can estimate the target SIR variation required during the compressed and recovery frame. Once this target SIR variation has been estimated by the UTRAN, it would have to be signaled to the UE to be used for the downlink closed-loop power control.

In order to keep the signaling as low as possible, we propose to separate the target SIR increase due to the increased instantaneous bit rate and the target SIR increase due to degraded performances in compressed frames:

$$\Delta_{SIR} = 10\log(R_{CF}/R) + \delta_{SIR}$$

where R is the instantaneous net bit rate before and after the compressed frame and R_{CF} is the instantaneous net bit rate during the compressed frame. Since the bit rate variation will be known by the UE, we propose to only signal the additional target SIR increase δ_{SIR} due to degraded performances during compressed frames (this increase corresponds to the E_b/N_0 increase). The signaling overhead can be low if this variation is signaled with other compressed mode parameters. For example, 2 bits could enable to signal the following values of δ_{SIR}:
- 00: 0 dB
- 01: 0.5 dB
- 10: 1 dB
- 11: 2 dB

The UE will have to increase the target SIR by Δ_{SIR} just before the compressed frames and decrease it back by the same value just after the compressed frames. This target SIR variation is done additionally to the usual downlink outer-loop power control algorithm that will have to take it into account. We also propose that the UE increases simultaneously its transmit power by the same amount before the compressed frame and decrease it just after the compressed frames in order for the downlink received SIR to be as quickly as possible close to this new target SIR.

Moreover, at least when the transmission gap is at the end of the compressed frame, the performances in the recovery frames can also be degraded because of the power control interruption during the transmission gap. Therefore, it would be also desirable to increase the target SIR in recovery frames and to signal this target SIR increase to the UE.

Simulation results

In the following table, we give the required target E_b/N_0 increase for compressed frames and recovery frames to have an average BER of 10^{-3} in normal, compressed and recovery frames. These results were obtained with link level simulations in following conditions:
- Speech service (8 kbps),
- Pedestrian A environment,
- Downlink,
- Transmission gap period of 64 slots,
- Transmission gap length of 8 slots (the transmission gap being at the end of the frame),
- Fixed recovery period of 8 slots after each transmission gap.

Detailed simulation parameters are given in annex.

Mobile speed (km/h)	δ_{SIR} (dB) compressed frames	δ_{SIR} (dB) recovery frames
3	0.2	0.1
10	1.1	0.55
20	1.5	0.65
40	0.7	0.35
100	0.25	0.1

Table 1: Required target E_b/N_0 increase (δ_{SIR}) for compressed and recovery frames (compared to the target E_b/N_0 for normal frames) for speech service, in pedestrian environment.

These results enable to highlight that there is a real need to increase the target SIR for compressed and recovery frames and that this increase is highly dependent on the UE speed. It is also dependent on many other parameters like the environment or the transmission gap length.

Therefore, the increase of target SIR for compressed and recovery frames cannot have a fix value but need to adapted to the environment, the UE speed, the transmission gap length, … Thus, the target SIR increase for compressed and recovery frames need to be signal. As already mention, we propose to signal it with other compressed mode parameters, only once at the beginning of compressed mode, in order to have a low signaling overhead.

Conclusion

We showed a need for a faster algorithm than the classical outer-loop power control algorithm in compressed mode to avoid a severe degradation of the performances. The proposed solution is simple and only consists in increasing the target SIR for compressed and recovery frames. The need for such scheme was already recognized in WG1 and liaised to WG2 in [5].

Some signaling is required since the required target SIR increase has been shown to vary significantly with the UE speed and would also vary with many other parameters like the environment or the transmission gap length. Thus we propose to signal the required target Eb/N0 increase for compressed and recovery frames with other compressed mode parameters (see [4] for the text proposal).

References

[1] UMTS RAN WG1 TSGR1#4(99)342, "Improved closed loop power control algorithm in slotted mode" (Alcatel), *April, 99*.

[2] UMTS RAN WG1 TSGR1#5(99)542, "Additional results for fixed-step closed loop power control algorithm in compressed mode" (Alcatel), *June, 99.*

[3] UMTS RAN WG1 TSGR1#5(99)544, "Parameters setting for fixed-step closed loop power control algorithm in compressed mode" (Alcatel), *June, 99.*

[4] UMTS RAN WG1 TSGR2#6(99)795, "Proposal for control of the downlink outer loop power control " (Alcatel), *June, 99.*

[5] UMTS RAN WG2 TSGR2#6(99)736, "Liaison statement to WG2, WG3 and WG4 on power control issues" (WG1), *June, 99.*

Annex

Below are described the detailed parameters used in the simulations previously presented in this document.

Parameters	Values, assumptions, …
Service	**Speech**
Carrier frequency	2 GHz
Chip period	4.096 Mcps
Number of slots per frame	16
Channel	Indoor to Outdoor and Pedestrian A channel where the delays of the different paths are multiple of the chip period.
Link direction	Downlink
Power control	- Fix step of 2 dB during recovery periods, 1 dB otherwise. - 1 slot delay (=0.625 ms) - Infinite dynamic range - Error rate on TPC commands: 7% in recovery period, 4% elsewhere. The SIR estimation is ideal (the channel energy is used), or performed with pilot bits.
Eb/N0 scaling	Eb is computed as the received power for each information bit including all overhead (coding, tail, pilot, TPC, TFCI, rate matching, 16-bit CRC)
Rake receiver	2 fingers An ideal path searcher with fixed delays is used. The oversampling rate is the chip rate.
Channel estimation method	Channel estimation is based on the present pilot group and pilot groups before and after the present slot. The different pilot groups are multiplied by a weighting factor. The different weights only depend on speed and are : - 3 km/h : (1, 1, 1, 1, **1**, 1, 1) - 10 km/h : (1, 1, 1,1, **1**, 1, 1) - 20 km/h : (0.9, 1, 1, 1, **1**, 1, 1) - 40 km/h : (0.7, 0.8, 0.9, 1, **1**, 1, 0.9) - 100 km/h: (0.2, 0.6, 0.9, **1**, 0.9, 0.6) where the current slot has the weight in bold font.
Compressed mode	- Transmission gap period (TGP) = 64 slots. - Transmission gap length (TGL) = 8 slots. - Fix recovery period of 8 slots. - Power control step of 2 dB during recovery periods and error rate on TPC commands of 7% during the recovery periods. - Transmission gap at the end of the frame.
Information bit rate	8 kbps
Physical channel rate	32 kbps (sf=128)
Number of info bits per frame	80

CRC	16 bits
Coding	Convolutional coding Constraint length 9, rate 1/3, 8 tail bits
Rate matching	Repetition: 8 bits
Interleaving	10 ms
Pilot/TPC/TFCI bits per slot	8/2/0
Number of bits in first and second data fields (per slot)	6/14
Number of reception antennas	1
DPCCH/DPDCH power	0 dB
Inter-users interference	Modeled as AWGN noise. It is assumed constant and known in the simulations.

Table 2. Simulation parameters