TSG-RAN Working Group 2 meeting #6 *TSGR2#6(99)846*
Sophia Antipolis, France
August 16-20, 1999

Agenda Item:
Source: NEC and Telecom Modus
Title: Algorithm of outer loop power control
Document for: Discussion/Decision

---

1. Introduction

In TSG-RAN WG1, outer loop power control in downlink has been discussed, but the algorithm is considered a WG2 issue. An algorithm is described in the Annex of 25.214 with a note that this should be studied in WG2. In order to utilize the algorithm, which was originally part of the ARIB specification,we would like WG2 to consider this issue.

In this document, we describe the algorithm from the Annex of 25.214. We compare the two described schemes by means of computer simulation. The chosen scheme for downlink outer loop power control updates the reference SIR value asymmetrically, using CRC results. The signalling parameters between UTRAN and UE will be proposed in a separate contribution.

2. Algorithm

(1) Average scheme

Frame error rate over a pre-determined number of frames is calculated. Reference SIR value is updated at a constant interval in the following manner :

$$\text{IF } FER_{AVE1} > FER_{TARGET} \text{ then: } SIR_{REF}(i+N_{INT}) = SIR_{REF}(i) + S_{AVE} \quad (1)$$
$$\text{IF } FER_{AVE1} = FER_{TARGET} \text{ then: } SIR_{REF}(i+N_{INT}) = SIR_{REF}(i) \quad (2)$$
$$\text{IF } FER_{AVE1} < FER_{TARGET} \text{ then: } SIR_{REF}(i+N_{INT}) = SIR_{REF}(i) - S_{AVE} \quad (3)$$

where

FER_{AVE1} : frame error rate for N_{INT} frames
FER_{TARGET} : target FER
$SIR_{REF}(i)$: reference SIR in frame i [dB]
N_{INT} : number of frames between updates of reference SIR
S_{AVE} : update step of reference SIR

(2) Direct scheme

Reference SIR is updated asymmetrically utilizing CRC results in the following manner :

$$\text{CRC result = NG : } SIR_{REF}(i+1) = SIR_{REF}(i) + S_{INC} \quad (4)$$
$$\text{CRC result = OK : } SIR_{REF}(i+1) = SIR_{REF}(i) - S_{DEC} \quad (5)$$

where

S_{INC} : increase step of reference SIR
S_{DEC} : decrease step of reference SIR

S_{INC} and S_{DEC} meet the following equation so that the increase and decrease of $SIR_{REF}(i)$ are balanced in stationary environment :

$$FER_{TARGET}S_{INC} = (1-FER_{TARGET})S_{DEC} \quad (6)$$

With the algorithm, the following equation is derived.

$$SIR_{TARGET}(i+N) = SIR_{TARGET}(i) + N_{ERROR}S_{INC} - (N-N_{ERROR})S_{DEC} \quad (7)$$

where

N_{ERROR} : number of frame errors between frame i+1 and i+N

FER between frame i+1 and i+N (FER_{AVE2}) is derived from equations (6) and (7) :

$$\begin{aligned} FER_{AVE2} &= N_{ERROR}/N \\ &= \{ S_{DEC} + (SIR_{REF}(i+N) - SIR_{REF}(i))/N \}/(S_{INC} + S_{DEC}) \\ &= \{ S_{DEC}/(S_{INC} + S_{DEC}) \}\{ 1 + (SIR_{REF}(i+N) - SIR_{REF}(i))/(S_{DEC}N) \} \\ &= FER_{TARGET}\{ 1 + (SIR_{REF}(i+N) - SIR_{REF}(i))/(S_{DEC}\ N) \} \end{aligned} \quad (8)$$

Equation (8) means that FER_{AVE2} approaches FER_{TARGET} as N increases.

When channel interleaving depth is N_{ILD} frames, the updates of the reference SIR may be conducted together for N_{ILD} frames i. e. the reference SIR may be updated every N_{ILD} frames.

3. Performance evaluation

We have evaluated the performance of the average scheme and the direct scheme by means of computer simulation. In the simulation, frame error probability is assumed to be 10**(-SIR_{REF}), where SIR_{REF} is reference SIR in dB. In the average scheme, N_{INT} is 1000, which means that reference SIR value is updated every 10 seconds. In the direct scheme, update intervals of reference SIR are one and eight.

Figures 1 and 2 show distribution of FER in 1000 frames with the average scheme and the direct scheme respectively. For comparison, distribution with the constant reference SIR of 2 dB is shown. In the average scheme, reference SIR does not change for 1000 frames, and each sample of FER is calculated in that duration. Figures 3 and 4 shows distribution of reference SIR with the average scheme and direct scheme respectively. Table 1 shows average FER and average value of reference SIR which is proportional to average transmission power from BS. The FER_{TARGET} is 0.01 in Figs. 1-4 and Table 1. Figure 5 shows average value of reference SIR for different average FER in the average scheme and direct scheme. In Figures 1 - 5, the update interval in the direct scheme is one frame. In Table 1, the results with the update intervals of one and eight frames are shown.

Figure 1 shows that, with the average scheme, the FER in 10 seconds changes more greatly than the FER with the constant reference SIR, and it suggests that duration of high FER and low FER appears alternately. Figure 2 shows that, with the direct scheme, the variation of FER is much smaller than the that with the constant reference SIR. Figure 3 and 4 shows that variation of reference SIR with the direct scheme is slightly larger than that with the average scheme. Table 1 shows that the average FER with the direct scheme is equal to the target FER while the average FER with the average scheme is slightly larger than target FER. On the other hand, the average value of reference SIR with the direct scheme is larger than that with the average scheme. However, Figure 5 shows that the difference of the average value of reference SIR is 0 - 0.05 dB. Table 1 shows that the difference in update intervals does not have significant influence on the performance.

Table 1 Average FER and average value of reference SIR.

S_{AVE}, S_{INC}	0.2 dB		0.5 dB		1.0 dB	
	FER	SIR_{REF} [dB]	FER	SIR_{REF} [dB]	FER	SIR_{REF} [dB]

Average scheme	0.010705	1.999763	0.011857	2.016328	0.017381	2.029605
Direct scheme (Every frame)	0.010000	2.056489	0.010000	2.144385	0.010000	2.299573
Direct scheme (Every 8 frames)	0.010000	2.056909	0.010000	2.150343	0.010000	2.338111

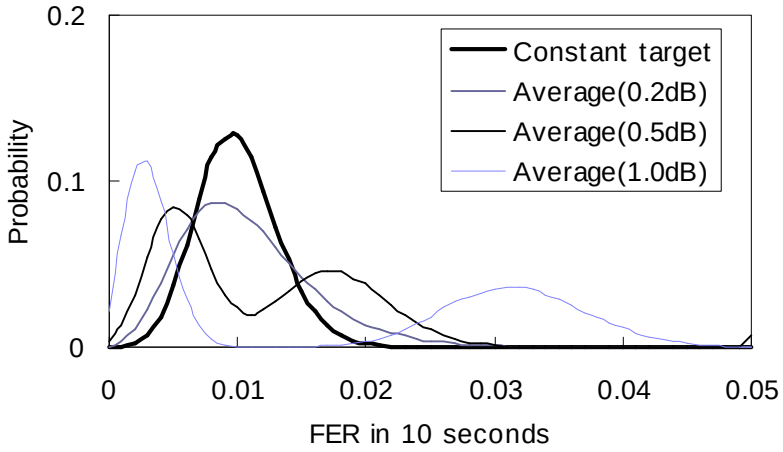

Figure 1 Distribution of FER in 10 seconds with the average scheme.

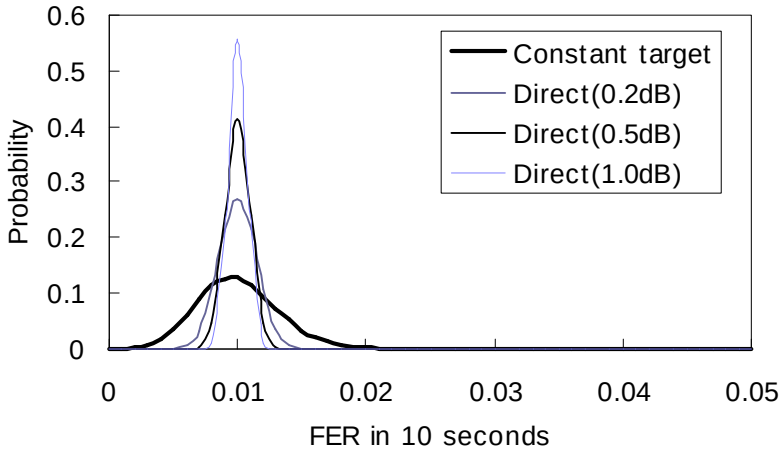

Figure 2 Distribution of FER in 10 seconds with the direct scheme (Update: Every frame).

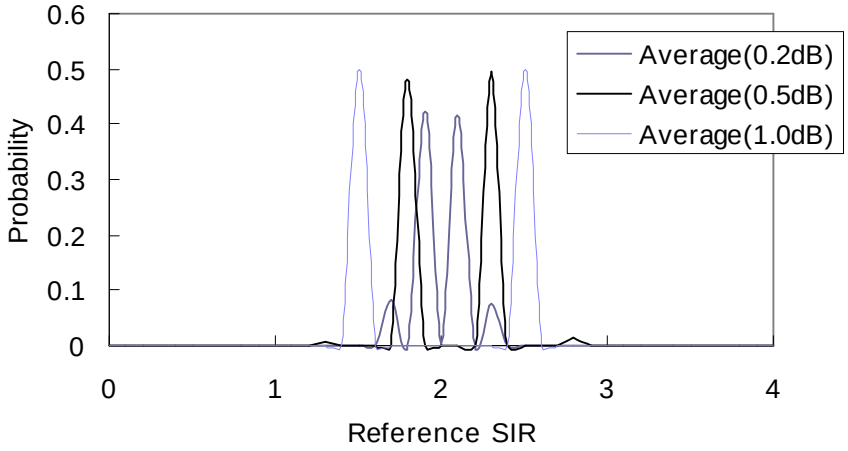

Figure 3 Distribution of reference SIR with the average scheme.

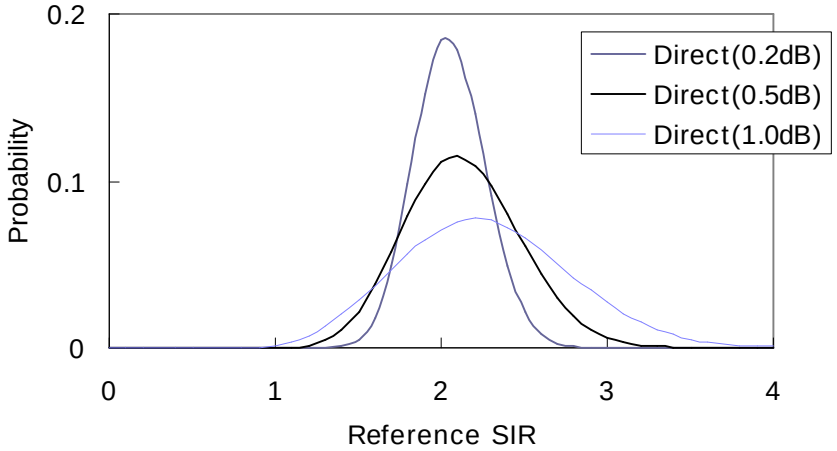

Figure 4 Distribution of reference SIR with the direct scheme (Update: Every frame).

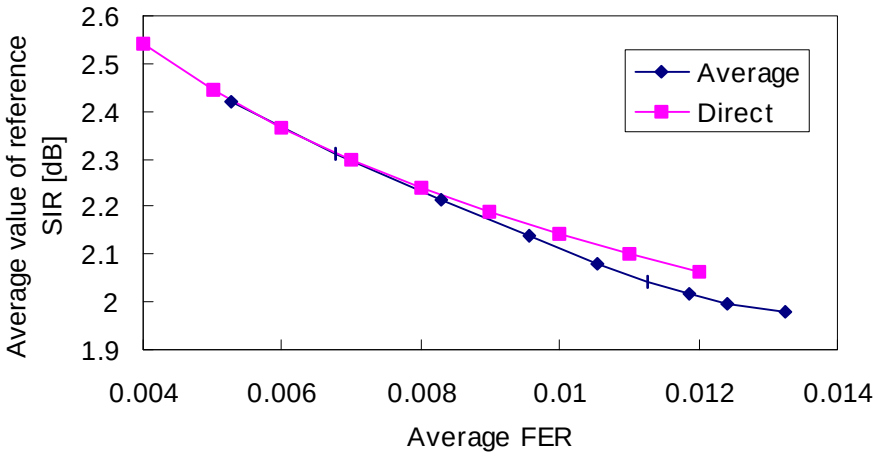

Figure 5 Average value of reference SIR (S_{AVE} = S_{INC} = 0.5 dB).

4. Discussion

(1) Interval of frame errors

In the direct scheme, frame errors are not likely to occur for a while after occurrence

of a frame error because it makes the reference SIR higher. If frame error does not occur for a longer time than the average interval of frame errors, frame errors are very likely to occur because reference SIR becomes lower than the reference SIR that gives target FER. This means that occurrence of frame errors is periodic, and the number of frame error in short duration is close to a constant value.

(2) Convergence time

In the direct scheme, when reference SIR required for the target FER becomes high, the reference SIR is adjusted after a few additional frame errors i.e. in a few seconds. When reference SIR required for the target FER becomes low, reference SIR is adjusted after a few average intervals of frame errors i. e. it takes a few seconds. In the average scheme, reference SIR is adjusted after a few update intervals of reference SIR i. e. it takes more than 10 seconds. This means that it takes shorter time with the direct scheme than with the average scheme to adjust reference SIR.

(3) Increase and decrease steps of reference SIR in the direct scheme

Increase and decrease steps of SIR should be determined considering convergence time, average value of reference SIR and distribution of FER. Large increase and decrease steps give short convergence time, and make FER close to target FER. However, it increases average value of reference SIR i. e. average transmission power from BS. Considering this tradeoff, the increase step of 0.5 dB is preferable among the evaluated parameters.

5. Conclusion

With the direct scheme, it is possible to adjust reference SIR in a few seconds when propagation environment changes. It is also possible to keep the FER very close to target FER. We propose to apply the direct scheme for the outer loop in the forward link TPC.

6. Text proposal

Outer loop power control

In outer loop, UE shall update the reference SIR when UE receives a frame that includes an error detection code (CRC). If CRC result is not OK, the reference SIR shall be raised by SIR_{INC} dB. If CRC result is OK, the reference SIR shall be reduced by SIR_{DEC} dB. SIR_{INC} is 0.5 dB (tentative), and SIR_{DEC} is derived from the following equation :

$$SIR_{DEC} = SIR_{INC} \quad FER_{TARGET} / (1 - FER_{TARGET}) ,$$

where FER_{TARGET} is the target frame error rate. Initial reference SIR (SIR_{INIT}) is dependent on services, and the maximum/minimum value of reference SIR is limited to SIR_{MAX}/SIR_{MIN} dB. SIR_{INIT} ,SIR_{MAX}, and SIR_{MIN} are designated via Layer 3 message. The updates of the reference SIR may be conducted together for N_{ILD} frames when channel interleaving depth is N_{ILD} frames.