TSG-RAN meeting #4 **TSGR#4 (99)387**
Miami 16 - 18 June 1999

To: TSG RAN

Source: CEPT ERC TG1

Title: Cross-border co-ordination for UMTS systems.

1. Introduction.

During the last meeting of WG1 of ERC TG1 document TG1(99)95 rev1 (attached at Annex 1 to this document) was discussed and a number of questions were raised concerning how cross-border co-ordination for UMTS systems could be taken forward. The group concluded that an innovative and flexible solution must be developed to ensure the efficient use of the spectrum at border areas. In addition, it was suggested that the concept of preferential channels[1] may not be appropriate for UMTS 5 MHz channels.

TG1 would appreciate to receive information and clarification from 3GPP RAN on a number of issues in order to develop efficient and workable cross-border co-ordination procedures. These issues can be broadly sub-divided into two categories, those concerning the use of UMTS codes as a co-ordination mechanism, and those concerning more general parameters that would impact on cross-border co-ordination. Each is dealt with in a separate section below:

2. UMTS Codes.

(a) What is the group's opinion on using the division of codes between operators (*code co-ordination*) in different countries as a possible mechanism for efficient cross-border co-ordination ?
(b) What different types of codes are used by a UMTS system (i.e. uplink, downlink, scrambling, spreading, channelisation codes) ?
  - Are there any limitations on the way in which groups of codes can be divided for co-ordination purposes ?
  - Are there any reserved codes/groups for the system which cannot be exclusively allocated to an individual operator ?.
(c) Does the proposed change of chip rate affect the number of codes available ?
(d) Does limiting the number of codes available to each operator impact on the nature of services offered (e.g. How many codes are available for the cases of high and low bit rate services ?).

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[1] The term 'preferential channels' refers to a frequency co-ordination mechanism where operators on each side of the border each have priority access to a sub-set of the available channels.

(e) What is the effect on the capacity of a UMTS cell which does not have all codes available to it.
(f) What is the orthogonality factor between different codes ?
  - How is this orthogonality factor affected when the two co-ordinating channels are offset in frequency.

3. Other Parameters.

(a) What is the protection requirement for a UMTS system from another UMTS system operating on the same frequency in terms of acceptable interference level.
(b) Document TG1(99)95Rev.1 (attached at Annex 1) makes a number of assumptions concerning the likely values for parameters such as fading margin, indoor/outdoor margin (building loss), and cell overlapping. Are these valid ?
(c) How can co-ordination mechanisms best deal with the case where the centre frequency of the carriers of the two operators either side of the border are not alligned on the same raster ?
(d) If a mobile transceiver on the other side of its national boundary and transmitting on full power, what is the consequence for a local base station (uplink interference)?

4. Other Mechanisms.

TG1 would appreciate receiving from the group suggestions for any other solutions which would provide equitable access to the spectrum in border areas for UMTS systems.

5. Conclusions.

TG1 require this information to take forward its work on efficient cross-border co-ordination of UMTS services. The next meeting of TG1 takes place on the 2-3 September 1999. We would greatly appreciate a response in time for that meeting.

Document TG1(99)95 rev.1 "Proposal for UTRA cross-border co-ordination" is attached at Annex 1 to this document.

ERC TG1
Mainz
15-16 June 1999 **ERC TG1(99)95 rev 1**

Source: Germany

Proposal for UTRA cross-border coordination

0. Executive Summery

The planning of UTRA networks in border areas does not differ considerably from an operator's planning for co-frequency cells. Decoupling through cell-specific codes and the definition of field strength limits on the cell border seems to be a suitable and spectrum efficient method for cross-border coordination.

The limits for operators on the border calculated using values derived from literature and ETSI STC SMG2 documents are shown in section 2 (page 3). In order to prevent a distant high-power transmitter with a corresponding interference range from generating the calculated field strength, the field strength must be lower than the minimum wanted field strength $F_{min\,MS}$ at a distance of 6 km (range of a base station in the case of voice traffic in a car in motion) beyond the border.

The [512] cell-specific codes offer a very flexible distribution of channel capacity in the border areas. The division of the codes into 6 groups (section 3.1) ensures the uninterrupted provision of codes along the border of a country. However, the number of codes available to each country is 50% and 33% of the maximum number in the case of bilateral and trilateral coordination respectively.
This is therefore a very efficient solution in terms of the use of the codes.

The results of this study can be applied to other broadband IMT2000 systems using FDD CDMA but not to narrowband systems such as PHS or DECT.

This method also guarantees statistically equal opportunities for adjacent radio networks even if they are not set up at the same time.

Various studies show that frequency coordination for UTRA networks is not sensible or spectrum efficient. Frequency channel allocation would mean that not every network operator in a border area would be assigned a preferential frequency. Frequency channel allocation is therefore not suitable and can be excluded because of a number of disadvantages.

1. Introduction

Cross-border coordination is a basic prerequisite for the successful introduction of radio systems. In the light of the large number of countries bordering Germany, the German Administration is interested in finding a flexible and simple solution to the problem of the cross-border coordination of UTRA networks as quickly as possible.

According to ERC Decision ERC/DEC(99)HH UTRA network operators are assigned one or more frequency channels with a bandwidth of 4.2-5 MHz. Coordination between European

UTRA systems could be effected through one of two possible decoupling mechanisms, both of which have advantages and disadvantages: frequency, and field strength and code.

1.1 Frequency coordination

The coordination of non spread spectrum mobile radio systems on the edge of national or subnational mobile radio network coverage areas is solved through the use of preferential frequencies.

In the critical areas along the national boundaries, the UTRA network operators in neighbouring countries could each be assigned preferential frequencies, ie certain frequencies from the whole set of frequencies available.

- The advantage would be that UTRA network operators would not suffer a loss of capacity owing to inter-cell interference caused by cells operated on the same frequency in neighbouring countries.

- The disadvantage would be that UTRA network operators would suffer a heavy loss of capacity in their coverage of border areas. The number of frequency channels available to the operators would decrease by 50% in the case of bilateral coordination and by 33% in the case of trilateral coordination. Uninterrupted coverage along the borders in the case of bilateral and trilateral coordination would no longer be possible for UTRA network operators with only one or two frequency channels.

1.2 Field strength and code coordination

UTRA networks operate with a frequency reuse factor of 1, hence no internal frequency coordination is necessary within a UTRA network. If an operator uses the same frequency for different CDMA cells in the same network, decoupling is effected by coordinating cell-specific codes and by defining for mobile stations on the edge of a cell the field strength at which handover is to take place. The cell-specific spreading code of the received signal tells a mobile station whether or not handover is permissible. This basic characteristic of CDMA systems has, inter alia, the following advantages:

- the coordination of preferential frequencies is not necessary;
- the [512] cell-specific codes offer a considerably more flexible distribution of channel capacity in the border areas than the allocation of the smaller number of frequency channels per operator; and
- adjacent radio networks have statistically equal opportunities even if they are not set up at the same time.

However, the disadvantage is the same as for a UTRA network operator's national network planning: the minor reduction in maximum cell capacity owing to intra-cell interference. Calculations show that the reduction in the maximum number of subscribers per cell in the case of co-channel operation, field strength and code coordination with the neighbouring country or countries, and voice traffic (8 kbit/s) is 18%.

In the case of terrestrial UTRA systems, the 18% reduction in cell capacity owing to inter-cell interference given optimum field strength and code coordination on the border is lower than the 50% (bilateral) and 66.6% (trilateral) reduction in the case of preferential frequency allocation.

A comparison of these two alternatives and their advantages and disadvantages leads to the proposal to base all further work on field strength and code coordination.

2. Calculation of the maximum field strength on the border for terrestrial UTRA systems

In order to prevent operators of adjacent UTRA networks from continually increasing their base station radiated power in turn with the aim of improving coverage on the edge of their own network at the other's expense, it is necessary

a) to define a maximum permissible field strength on the border, and
b) for the field strength to be below the minimum wanted field strength at a distance of 6 km (range of a base station in the case of voice traffic in a car in motion) beyond the border.

The maximum permissible field strength on the border should be high enough to ensure indoor mobile telephone coverage for voice traffic (8 kbit/s) irrespective of the compatibility between two adjacent co-frequency networks. The maximum permissible field strength can be calculated using the following formula:

$$F_{max} = F_{min\,MS} + \Delta F_{outdoor/indoor} + \Delta F_{fading} + \Delta F_{cell\,overlap}$$

where $F_{min\,MS} / [dB\mu V/m] = p_{eirp\,min} / [dBm] + 20\lg(f/[MHz]) + 77.2dB$

and where

F_{max} = maximum permissible field strength on the border,

$F_{min\,MS}$ = minimum wanted field strength for hand-held mobile stations,

$\Delta F_{outdoor/indoor}$ = average difference between indoor and outdoor field strength,

ΔF_{fading} = change in field strength caused by motion,

$\Delta F_{cell\,overlap}$ = increase in field strength caused by cell overlap on the border,

$p_{eirp\,min}$ = minimum input level for hand-held mobile stations (assuming an isotropic radiator), and

f = carrier frequency.

The maximum field strength calculated using the above formula and values derived from literature and ETSI STC SMG2 documents, eg

$\Delta F_{outdoor/indoor}$ = 15 dB,

ΔF_{fading} = 15 dB,

$\Delta F_{cell\,overlap}$ = 5 dB,

$p_{eirp\,min}(TDD)$ = -111 dBm,

$p_{eirp\,min}(FDD)$ = -122 dBm, and

f = 2000 MHz,

is

$\boxed{F_{max} = F_{min\,MS} + 35dB}$, $\boxed{F_{min\,MS}(TDD) = 32dB\mu V/m}$, $\boxed{F_{min\,MS}(FDD) = 21dB\mu V/m}$

$\boxed{F_{max}(TDD) = 67dB\mu V/m}$, $\boxed{F_{max}(FDD) = 56dB\mu V/m}$.

In order to prevent a distant high-power transmitter with a corresponding interference range from generating this field strength, the field strength must be lower than the minimum wanted field strength $F_{min\,MS}$ at a distance of 6 km (range of a base station in the case of voice traffic in a car in motion) beyond the border.

These values need to be determined using a field strength prediction method based on Recommendation T/R 20-08 and not through measurements. The field strength prediction method needs to be used to calculate the field strength at a height of 1.5 m and not 3 m. In addition, the propagation curves need to be adapted to the carrier frequency of 2 GHz.

<u>Notes</u>

- The ETSI STC SMG2 documents give two values for ΔF_{fading}: 11.3 dB for outdoor operation, and 15.4 dB for indoor operation. The value of 15 dB was taken to provide for indoor coverage.
- A margin of $\Delta F_{cell\,overlap}$ needs to be added because a base station is not able to generate the calculated wanted field strength evenly at every point on the border. The edge of the cell's coverage area may be circular while the border may be straight.
- The condition that the field strength be lower than $F_{min\,MS}$ 6 km beyond the border is needed to ensure that the operator concerned in the neighbouring country remains able to serve higher traffic densities on its side without any unnecessary additional effort. This can be justified as follows: in the UHF band, the field strength decreases by approx 50 dB per decade of distance (Rec ITU-R PN.370-7 propagation curves for land paths, 50% of the time and 50% of the locations); this decrease increases to approx 65 dB per decade of distance at 2 GHz; if the field strength must decrease from F_{max} to $F_{min\,MS}$ (ie by 35 dB) 6 km beyond the border, then F_{max} can only be generated if the base station is no further than $d = \frac{6\text{ km}}{10^{\frac{35dB}{65dB/decade}}} = 17\text{ km}$ from the border.
- It is proposed that the same prediction method be used internationally, namely the calculation tool under development by the Vienna Agreement's HCM Group. The Rec ITU-R PN.370-7 UHF curves for 50% of the time and 50% of the locations extrapolated to cover shorter distances (down to 100 m) can be used. The method described in Rec ITU-R PN.370-7, § 1.3.1 can be used to calculate the field strength for lower effective transmitting antenna heights (h1). The field strength for a receiving antenna height (h2) of 1.5 m instead of 2 m as assumed in Rec ITU-R PN.370-7 can be calculated using the following equation:

$$h1 = h_{effTx} \cdot \frac{15\text{ m}}{10\text{ m}}$$

The larger decrease in the field strength at higher frequencies can be taken into account using the following calculation (which is sufficiently accurate for distances shorter than 100 km): $F_{2\,GHz} = F_0 - (F_0 - F_{UHF}) \cdot S_{(UHF...2\,GHz)}$

where $S_{(UHF...2\,GHz)} = 3 \cdot 10^{-4} \cdot 2000\,MHz / MHz + 0.814$

and where

$F_{2\,GHz}$	=	field strength at 2 GHz,
F_0	=	free space field strength,
F_{UHF}	=	predicted field strength for the middle of the UHF band, and
$S_{(UHF...2\,GHz)}$	=	steepness factor for higher frequencies.

Neither the calculation of the values for F_{max} and $F_{min\,MS}$ nor the prediction method needs to be particularly accurate. The calculated field strengths are average field strengths which reflect the real field strengths. Hence, there is no need to make measurements to verify the values. It is sufficient to predict the values through calculations. What is more important is that adjacent radio networks have statistically equal opportunities even if they are not set up at the same time.

3. Allocation of cell-specific codes for terrestrial UTRA systems in the border area

Decoupling between UTRA networks in neighbouring countries can be effected simply and effectively through the use of cell-specific codes on the basis of the above-mentioned field strength limits on the border and the agreed propagation models. The cell-specific codes comprise 32*16 = 512 codes which are numbered 0 to 511. The coordination of codes is only necessary if a network operator exceeds the minimum wanted field strength on the border.

3.1 Code allocation (similar to the preferential frequency allocation arrangements for GSM 900)

The allocation of the codes on the borders based on the bilateral and trilateral coordination scenarios enables the network operators to use all the available codes. The codes are grouped in 6 groups which are allocated to the neighbouring countries (see Table 1).

However, the number of codes available to each country increases to 50% and 33% of the maximum number in the case of bilateral and trilateral coordination respectively.
This is therefore a very efficient solution in terms of the use of the codes.

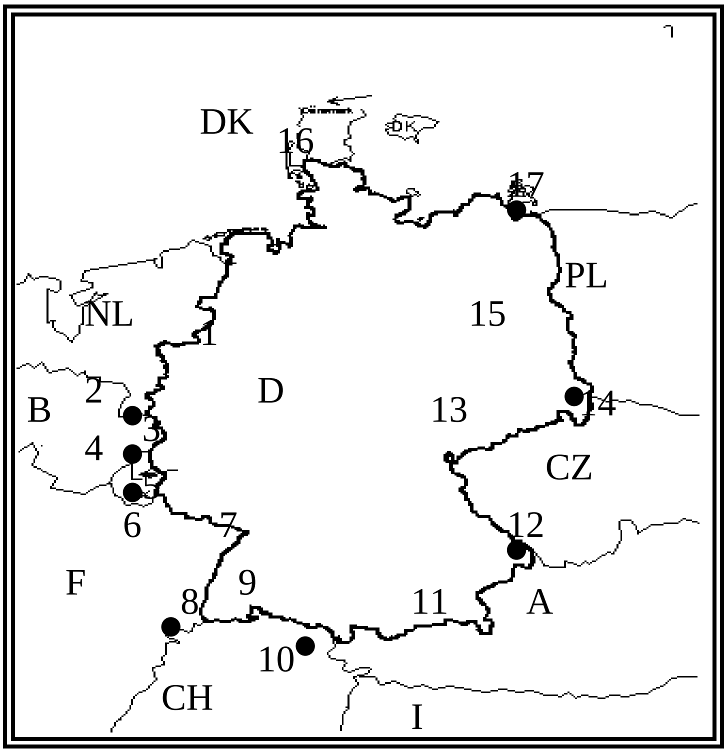

Figure 1: Cross-border code coordination (see Table 1)

Case no	Code group	1	2	3	4	5	6
(see Figure 1)	Country\codes	0-85	86-170	171-255	256-340	341-425	426-511
1	D/HOL	D	HOL	D	HOL	D	HOL
2	D/HOL/BEL	D	HOL	BEL	HOL	D	BEL
3	D/BEL	D	D	BEL	BEL	D	BEL
4	D/BEL/LUX	D	LUX	BEL	BEL	D	LUX
5	D/LUX	D	LUX	D	LUX	D	LUX
6	D/LUX/F	D	LUX	F	LUX	D	F
7	D/F	D	D	F	F	D	F
8	D/F/SUI	D	SUI	F	F	D	SUI
9	D/SUI	D	SUI	D	SUI	D	SUI
10	D/SUI/AUT	D	SUI	AUT	SUI	D	AUT
11	D/AUT	D	D	AUT	AUT	D	AUT
12	D/AUT/CZE	D	CZE	AUT	AUT	D	CZE
13	D/CZE	D	CZE	D	CZE	D	CZE
14	D/CZE/POL	D	CZE	POL	CZE	D	POL
15	D/POL	D	D	POL	POL	D	POL
17	D/POL/DNK	D	DNK	POL	POL	D	DNK
16	D/DNK	D	DNK	D	DNK	D	DNK

Table 2: Allocation of code groups in the case of efficient code allocation

4. Summary

- Various studies show that frequency coordination for UTRA networks is not sensible or spectrum efficient. Frequency channel allocation would mean that not every network operator in a border area would be assigned a preferential frequency. Frequency channel allocation is therefore not suitable and can be excluded because of a number of disadvantages.

- The planning of UTRA networks in border areas does not differ considerably from an operator's planning for co-frequency cells. Decoupling through cell-specific codes and the definition of field strength limits on the cell border seems to be a suitable and spectrum efficient method for cross-border coordination.

- The limits for operators on the border calculated using values derived from literature and ETSI STC SMG2 documents are shown in section 2 (page 3). In order to prevent a distant high-power transmitter with a corresponding interference range from generating the calculated field strength, the field strength must be lower than the minimum wanted field strength $F_{min\,MS}$ at a distance of 6 km (range of a base station in the case of voice traffic in a car in motion) beyond the border.

- The [512] cell-specific codes offer a very flexible distribution of channel capacity in the border areas. The division of the codes into 6 groups (section 3.1) ensures the uninterrupted provision of codes along the border of a country. However, the number of codes available to each country is 50% and 33% of the maximum number in the case of bilateral and trilateral coordination respectively.
  This is therefore a very efficient solution in terms of the use of the codes.

- The results of this study can be applied to other broadband IMT2000 systems using FDD CDMA but not to narrowband systems such as PHS or DECT.

- [TDD CDMA systems can only be operated without interference if there is coordination between the operators of adjacent networks on the basis of cell codes and upper field strength limits.]

- This method also guarantees statistically equal opportunities for adjacent radio networks even if they are not set up at the same time.