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Title: Principles for the definition of adjacent channel performance of UTRA

1.0 Introduction

In SMG 2 L1 Expert Group, it has been accepted that the adjacent channel performance of UTRA is a major contributing factor to the overall capacity and quality of UMTS networks. However, no conclusion was reached on the values of adjacent parameters to achieve a high level of quality (in particular, “outage” over a low proportion of the area served) and optimum capacity.

This paper proposes some principles for the selection of these parameters; an annex gives an overview of the discussions in L1 group, focussing on adjacent channel power (ACP).

2.0 Adjacent channel parameters

There are four adjacent channel parameters which have a major impact on quality and quality:

Transmitter Adjacent Channel Power (ACP)
This is the ratio of power in the wanted channel to the adjacent channel, and is largely due to non-linearity in the transmitter power amplifier.

Receiver Adjacent Channel Selectivity (ACS)
This is the rejection of the receiver of a signal in the adjacent channel to the wanted channel, and is determined by IF and baseband (digital) filtering.

Receiver Non-linearity
Receiver non-linearity can cause intermodulation products (IIP3) in the wanted channel from strong signals in adjacent channels. However, it has been shown that this need not be a limiting factor in most cases, for the state of current technology.

Channel spacing
The optimum channel spacing is determined by the above three parameters. If it is too small these factors reduce capacity and quality; if it is too large, the number of channels is reduced (and the system capacity is reduced by more than the increase in the capacity per channel). There are some constraints on channel spacing for regulatory reasons (eg, the requirement to support one channel in 2 X 5MHz and to support 2X 12 channels plus some guard bands in 2 X 60MHz). These are largely regulatory issues, and are not considered further in this paper.

3.0 Principles for the definition of adjacent channel performance

The following principles are proposed for the optimisation of the adjacent channel parameters of UTRA:

3.1 The uplink and downlink parameters should be considered separately.

It is widely believed that 3G traffic will be asymmetric with (on average) more traffic in the downlink than the uplink direction. It is therefore more important to optimise the capacity in the downlink.

3.2 The values should consider the likely changes in technology and their effect on system performance.

UMTS basestations will probably be first installed in areas where the demand for UMTS is anticipated to be greatest; these are the areas where the capacity of the network will eventually need to be greatest. Therefore the ACP performance of the early UMTS basestations is likely to have an effect on the maximum capacity of a network for many years.

On the other hand, the early UMTS terminal will be rapidly out-numbered by later terminals and will be typically replaced within a few years. The ACS performance of terminals is largely determined by an IF filter (usually a SAW), the A/D convertor and digital baseband filtering. These are all areas where there are rapid technology advances. The effect of ACS on system performance is the cumulative effect of all terminals; therefore if the performance of terminals is improved, the effect will be seen progressively as they are introduced (ie, it will not be necessary to wait for the last “old terminal” to be withdrawn before seeing the benefits of improved terminals).

Therefore, it would be unwise to reduce the requirement for basestation ACP because of short term limitations in the ACS performance of terminals.

3.3 Where possible, some safety margin should be allowed

Experience of “real” cellular networks (eg non-ideal basestation location, real terrain, non-ideal power control) has shown that the degradation in network performance from adjacent channel effects is often greater than for the ideal case, which is normally simulated.

Annex

Considerations for evaluation of the UTRA Adjacent Channel Power Requirements

1.0 Introduction

Studies of the impact of ACP on system performance of UTRA already presented to the SMG 2 L1 Expert Group (Tdocs SMG 2 L1 541/98, 653/98 and 654/98) have revealed that an appropriate level of ACP will be crucial to prevent large areas of total UMTS service outage, which will be quite unacceptable to both UMTS operators and users.

This annex gives an overview of previous work, stressing the importance of likely technical scenarios and relevant commercial considerations, in order to define an ACP value that will best suit UMTS operators' and users' needs.

4.0 Downlink outage mechanisms

The selectivity of the terminal receive chain is a measure of its ability to suppress unwanted adjacent channel signals. Previous contributions[1] have already demonstrated that system capacity is unaffected by the receive filter selectivity providing it is significantly better than the basestation ACP performance. If a mobile receive filter with selectivity equal to or poorer than the basestation ACP performance is used, then capacity will be reduced. Only under such conditions are both ACP and ACS contributing to the interference observed at the demodulator.

The main system-related causes of outage are related to the following three parameters:
- ACP
- receiver selectivity
- intermodulation products (IIP3).

These have been described in a previous contribution,[2] and their inter-relationship is shown in Figure 1. This shows, for a typical scenario, the effect of different performance values of ACP, mobile selectivity and mobile receiver IIP3 on the distance from an un-coordinated basestation over which there is outage. This shows that receiver intermodulation is not a limiting factor unless the performance of receiver selectivity and basestation ACP are both very good. On the other hand, an inadequate performance in either of these parameters would seriously degrade the distance over which outage occurs.

[1] Tdoc 045/99 SMG2 UMTS L1 'A balanced approach to evaluating UTRA Tx adjacent channel protection and Rx adjacent channel selectivity requirements'.
[2] Tdoc 653/98 SMG2 UMTS L1 'Balancing basestation and terminal performance requirements to minimise service outage'.

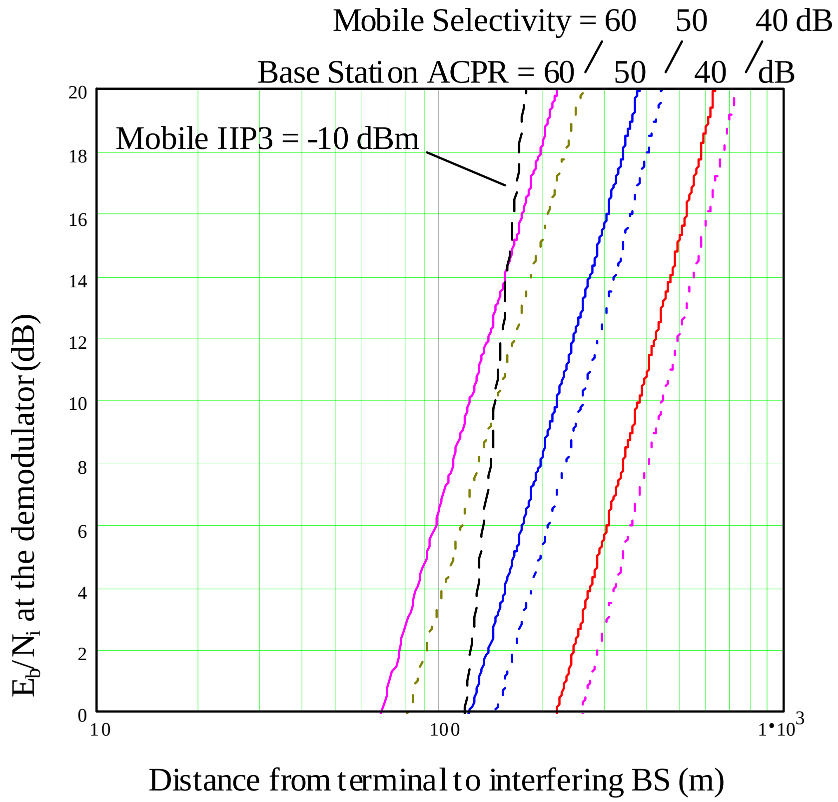

Figure 1: Effect of interference mechanisms on demodulator E_b/N_i

5.0 Discussion

UTRA is intended to support a wide range of services from voice to data of at least 144 kbps in urban cells; it will be important to ensure uniformity between services. It has already been pointed out[3] that inadequate specification of BS ACP can lead to rapid power fluctuations in the situation, where both voice and data users are supported with equivalent levels of geographic mobility. This will result in potentially catastrophic effects on capacity. In order to overcome such difficulties, it was shown that an ACP of 50dB reduces the power budget overhead required to support LCD144 services from 45% (ACP = 40 dB) to 9% (ACP = 50dB).

In a later paper, it was shown[4] that outages occur due to in-band interference caused by BS ACP interference or intermodulation products in the receiver. A cumulative IIP3 = -10 dBm is feasible with existing commercial technology; in such a case, ACP dominates. An ACP = 40 dB would lead to significantly increased outage probabilities[5] around cell peripheries. In

[3] Tdoc 541/98 SMG2 UMTS L1 'Relationship between ACP and outage for voice and data services'.
[4] Tdoc 653/98 SMG2 UMTS L1 'Balancing basestation and terminal performance requirements to minimise service outage'.
[5] Tdoc 654/98 SMG2 UMTS L1 'The geographic distribution of capacity loss due to basestation ACPR performance'.

order to maintain a capacity loss of less than 2% at cell peripheries, a stringent BS ACP = 60dB is required.

Before finalizing the BS ACP value for UTRA, it will be important to consider a number of factors:

- the impact of ACP on capacity is more significant in DS-CDMA based systems than in GSM, due to the inherent single frequency re-use;
- outage and capacity are two different things; a poorly specified ACP value will lead to significant outage areas where service cannot be established; required service coverage cannot be clearly defined through study of capacity impacts alone;
- it is commonly accepted that UTRA traffic demand will be most significant in the downlink; simulation scenarios should therefore take this into account;
- achievable ACS values will improve significantly by the time of UTRA deployment, as receiver digital baseband technology will follow the aggressive performance improvements typical with digital circuits; linear phase characteristics are readily achievable with digital filtering and consequently, group delay will not be introduced;
- BTS ACP and mobile IIP3 are both outage mechanisms which are caused by non-idealities in analogue signal processing, in the basestation transmitter and mobile receiver respectively; as these are analog domain issues, it is unlikely that their performance will improve at the same rate as performance issues governed by digital processing technology;
- initial UMTS infrastructure roll-out will follow from regional estimates of addressable market volumes (ie. capacity demands) and associated limited capital expenditures; it is therefore unlikely that multi-carrier handoff will alleviate capacity limitations, induced through a poorly specified ACP value, for some time; in addition, it is important to specify a BS ACP value which will not lead to unnecessary outages and reductions in capacity which could damage initial market perceptions and consequent take-up of UMTS services.

Consequently, UTRA performance will be characterised principally through the BS ACP and a value for this must be finalized.

Scenarios used in the determination of the ACP value must accommodate anticipated UTRA deployment conditions.