

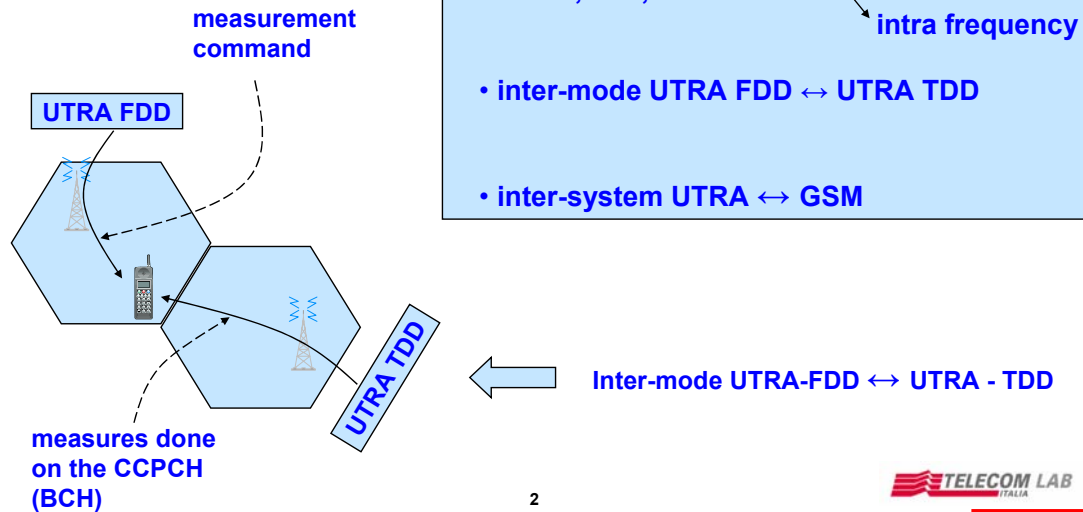


Handover

Politecnico di Torino
2005



Handover types



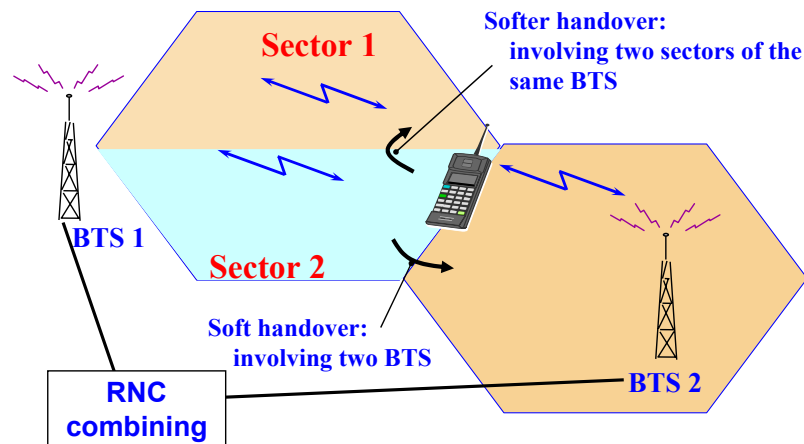
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The handover cases are depicted in the figure. The handover *arising between* UTRA FDD and UTRA TDD is performed by means of a command sent by the network (UTRA) to the mobile. From that moment on, the MS searches for the *Common Control Physical Channel* transmitted by the UTRA TTD along the 10ms frame (twice per frame).

Once the CCPCH is received, the procedure is started.

Softer and soft handover



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The intra-mode handover (the one arising within the same system) is started on the basis of the measures of E_C/N_0 performed on the pilot channel CPICH. The following parameters are measured:

- the power of the signal (*received signal code power*) measured after the *de-spreading over the pilot symbols*
- the overall received power measured over the wideband channel (*received signal strength indicator*).

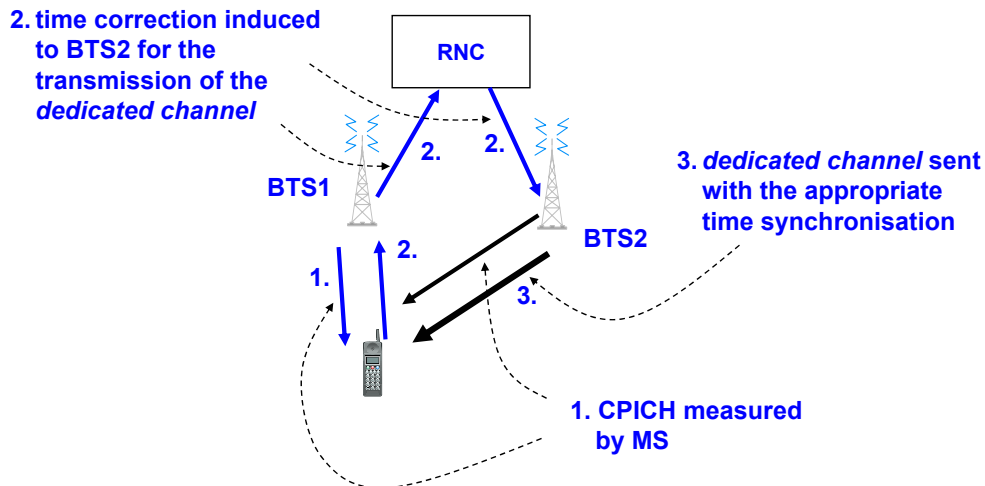
The MS calculates then the rates E_C/N_0 and sends them to the RNC through a level 3 procedure. (see section 4.4).

The *softer handover* takes place when the MS is located in the edge coverage zone arising between two contiguous sectors of the same base station. In this case the station receives the same signal generated by the MS on the up link and it elaborates the signal in the same way adopted for the multiple path arising within the same sector. During the *softer handover* a single closed loop for the power control is maintained.

On the down link, the two sectors send to the MS the same signal but they use two different scrambling codes, hence the MS can *macroscopic* path diversity. MS must then generate both codes to perform the *de-spreading*.

In the *soft handover* eventuality, the mobile is dwelling in a coverage-overlapping zone generate by two stations belonging to two different base stations. On the down link the transmission and combining function are similar to those described for the softer handover. On the up link, conversely, the combining is performed by the RNC and it takes place on a frame-basis (the best frame is chosen). The choice of the best frame is done according to the interleaving depth (fro 10 to 80 ms).

Synchronisation for soft handover



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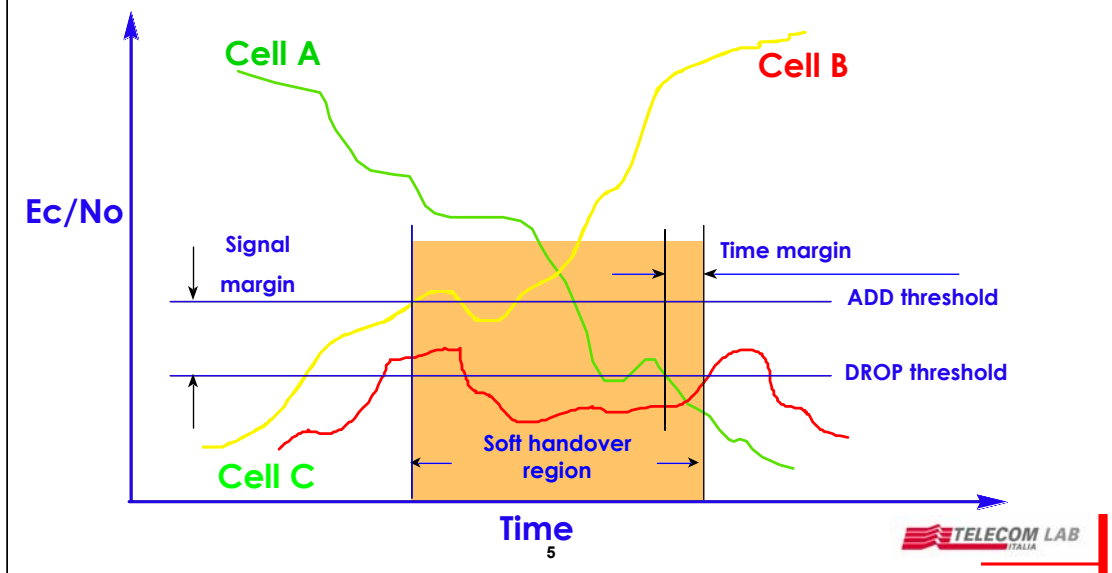
The *soft handover* generates some problems whenever the base stations involved are not synchronous. In this case, the station that is being included in the active set must arrange the transmission time of the *dedicated channel* belonging to that specific connection in such a way that the MS can perform the *despreading* functions.

Beyond the synchronisation problems, the mobile measures the E_c/N_0 values over a set of cells named *neighbouring set*. The set of cells not yet included in the active set but received by the MS with an adequate level of E_c/N_0 (potentially able to be inserted) is named *candidate set*.

The insertion/extraction of a cell into/from the active set obeys a smoothing mechanism based on margins. The level 3 messages driving the entire macrodiversity process are described in section 4.4. In function of the E_c/N_0 levels, the network can activate insertion/extraction commands, including commands for multiple insertions or extractions.

The macro diversity mechanism includes also time margins.

Macrodiversity - active set



The macro diversity state implies that the same information is transmitted by making use of several codes.

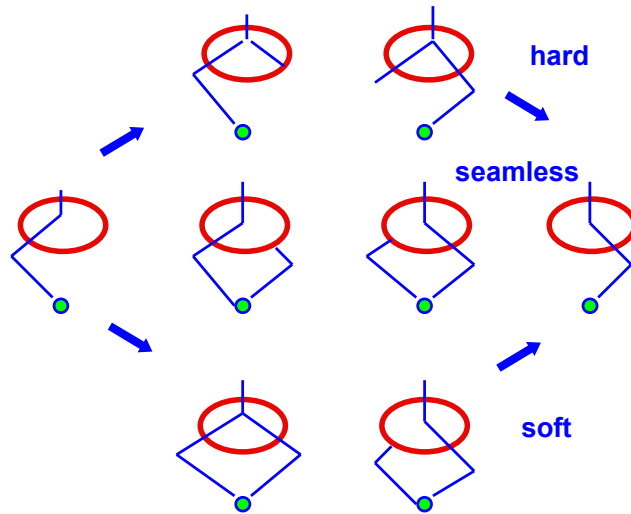
The figure represents a typical macro diversity sequence, showing the inclusion/extraction into/from the active set. The process is driven by the MS movements and by the dynamics of the received levels.

Each path is routed independently in by the network, at least until it remains within the access part of UMTS: a single connection remains in progress through a multiplicity of *equivalent* bearers until the macro diversity condition holds.

The mechanism fulfils implicitly the handover requirements on the connection continuity for the circuit-switched connections. In addition, it allows to release the stringent time constraints imposed by the hard-handover scheme adopted by the GSM.

Handover modes

Handover Functions
basic feature
for the RAN
architecture



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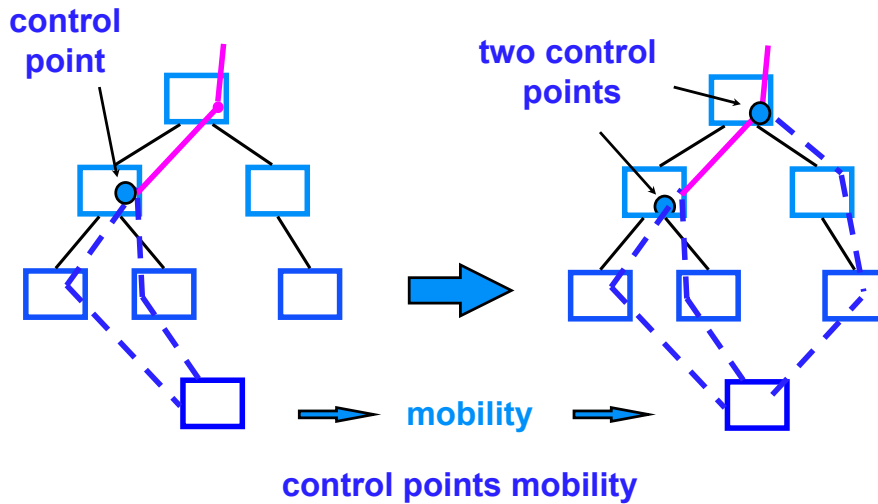
The handover modes are sketched in the figure.

The *hard handover* is typically used in second generation systems like the GSM. It implies a time interruption on the air between the two paths.

The *seamless* handover duplicates the network resources before the *new* path is established. This solution is often used in systems adopting the dynamic channel allocation for the radio resources.

The *soft handover* mechanism is instead that used in the W-CDMA systems. It impacts on the network features significantly.

The macrodiversity control



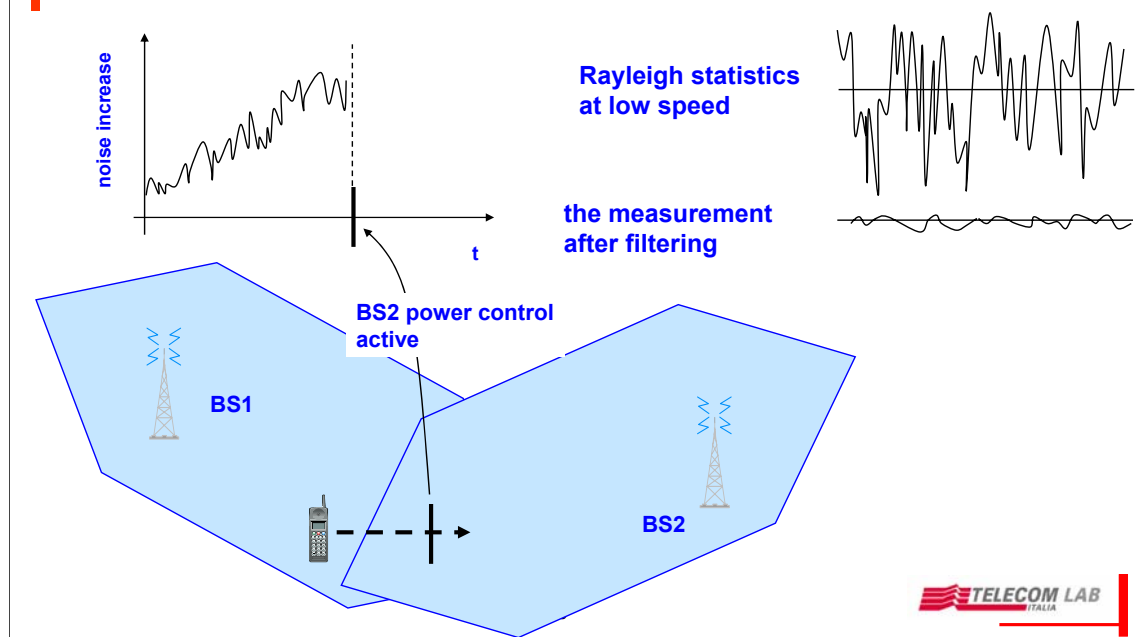
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In particular, thanks to the macro diversity, the network is forced to duplicate dynamically the paths (the same connection) within the fixed access segment. This implies that *combining* and *multicasting* points are defined dynamically along the connection.

Different *combining* levels are defined in function of the network topology. The information allowing for the combining features to be performed, are either associated to the single bit (*soft info*) or to a frame-related block of data. The former kind of combining is performed whenever the macro diversity arises at the B-node level, the latter is performed at the RNC level.

Some limits in measuring E_c/N_0

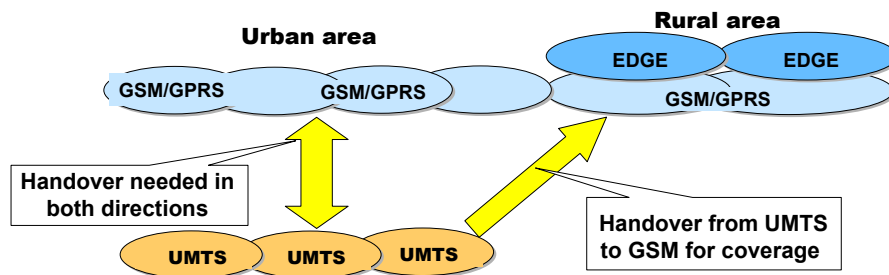


The measure of the E_c/N_0 shown by the CPICH is performed through a filtering (several measures averaged over a time period). When the MS is moving at low speed, the *fast fading* effect is the prevailing one (Rayleigh distribution). To avoid that the inclusion/exclusion events take place too frequently, long measurement periods may be adopted. This choice threatens the handover promptness.

A dual situation happens with an high speed of the mobile. Here, also short measurement periods supply meaningful values of E_c/N_0 , hence the handover promptness is ensured.

On the other hand, delaying the inclusion of a station into the active set may be dangerous. In fact, the candidate station is able to reduce the excessive transmission power of the MS just after the inclusion is performed. The higher are the mobile speed and the transmission power, the worse the effect.

Intra-system handover – requirements



- Service continuity
- Coverage completeness
- Optimisation of the resource usage

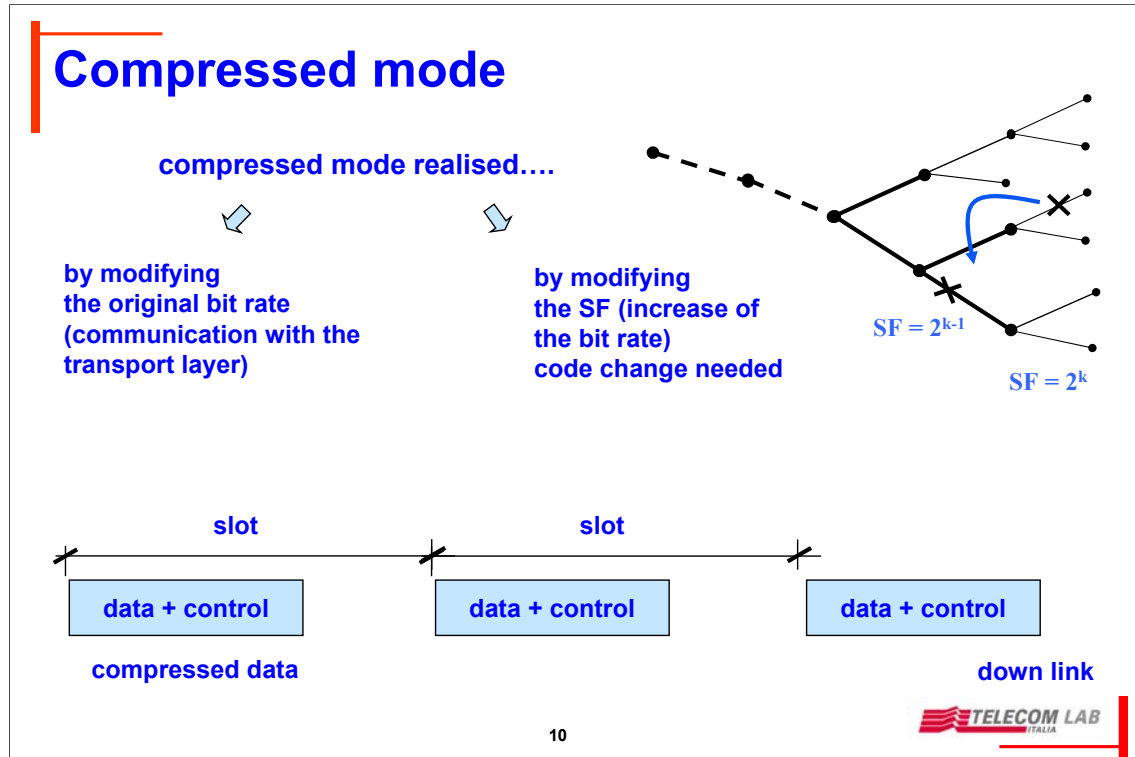
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The UMTS mobile terminal receives and transmits over the same couple of (wideband) frequencies all along the active communication.

But the handover towards the GSM has to be guaranteed, as well as towards other UMTS channels (5MHz channels).

This requirement derives from the need of ensuring:

- the service continuity
- the coverage completeness
- an efficient use of the radio resources.



When the active MS has to perform measures over a different frequency (with respect to the one it is using) a *compress mode* is adopted on both the Tx and Rx sides.

Of course this is needed if the MS has a single radio chain.

Typically, the *compressed mode* is realised on the *down link* through:

- the reduction of the *bit rate* of the connection (if allowed by the connection requirements)
- the *bit rate* increase through the change of the spreading code (reduction of the spreading factor).

In both cases, a time width is recovered to perform the measures, thanks to the *discontinuous transmission* scheme adopted on the *down link*.

The *compressed mode* worsens the radio conditions of the call in progress.

The compression may be used on both the up and down links. It is necessary on the up link whenever the measurements done on both the systems are to be transmitted simultaneously.

The procedure takes place at level 3.

Load estimate on the up link based on the received power measurement

$$\text{load factor on the down link} = \frac{\text{effective interference caused by the real traffic}}{\text{total received interference}}$$

$$I_{tot} = I_{tot}^{inter} + I_{tot}^{intra} + P_N$$

$$\eta_{UL} = \frac{I_{tot}^{inter} + I_{tot}^{intra}}{I_{tot}^{inter} + I_{tot}^{intra} + P_N} = 1 - \frac{P_N}{I_{tot}}$$

$$\text{noise rise} = \frac{I}{1 - \eta_{UL}}$$

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The load estimate on the *up* and *down* link are essential to realise an effective control of the radio resources in relation to the cell availability.

The figure represents the criteria adopted to calculate the loading factor on the up link. The evaluation is based on the measure of the received power.

The noise power of the receiver P_N and the total interference power can be easily evaluated by the receiver (the latter includes the interference generated by the calls in progress in the cell and in the interfering cells).

These two parameters are used to calculate the *up link* loading factor.

The *noise rise* is defined as the ratio between the overall wideband power received by the station and the noise power. It can be expressed as a function of the loading factor.

Load estimate on the up link based on the throughput measurement

Starting from

$$(E_b / N_0)_i = \frac{W}{v_i \cdot R_i} \cdot \frac{P_i}{I_{tot} - P_i}$$

for the i-th user

....considering the contribution of the N users

and filtering the interference due to neighbouring cells

$$\eta_{UL} = (f + 1) \cdot \sum_{i=1}^N \frac{1}{1 + \frac{W}{(E_b / N_0)_i \cdot v_i \cdot R_i}}$$

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An alternative approach consists in evaluating the effective *throughput* the cell is carrying in a given instant.

The relationship between $(E_b/N_0)_i$ the processing gain e the signal to interference ratio for a single active user i in the cell is:

$$(E_b / N_0)_i = \frac{W}{v_i \cdot R_i} \cdot \frac{P_i}{I_{tot} - P_i}$$

Where W is the used bandwidth, R_i the user bit rate, v_i the activity factor of the connection. I_{tot} is the overall power received by the station. The loading factor attributed to user i can be easily calculated as:

$$\eta_i^* = P_i / I_{tot} = \frac{1}{1 + \frac{W}{(E_b / N_0)_i \cdot R_i \cdot v_i}}$$

Summing-up the contributions of the N users, the cell loading factor η_{UL}^* is:

$$\eta_{UL}^* = \frac{\sum_{i=1}^N P_i}{I_{tot}} = \sum_{i=1}^N \eta_i$$

The final expression (figure) allow to separate the contribution of the contiguous cells through the parameter f (the ratio between the inter-cell and the intra-cell interference).

$$\eta_{UL} = \frac{\sum_{i=1}^N P_i}{(I_{tot}^{intra} + I_{tot}^{inter})} = \frac{\sum_{i=1}^N P_i}{I_{tot}^{intra} \cdot (1 + f)} = \eta_{UL}^* \cdot \frac{1}{(1 + f)}$$

Load estimate on the down link

$$\eta_{DL} = \frac{P_{tot}}{P_{max}}$$

Load estimated through
power measurement

Load estimated through
the throughput evaluation

$$\eta_{DL} = \sum_{i=1}^N \frac{(E_b / N_0)_i}{W / R_i} \cdot v_i ((1 - \alpha_i) + f_i)$$

i-th source bit rate

i-th source activity factor

orthogonality factor

inter-cell interference factor
(specific for the i-th source)

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A similar approach can be used for the *down link* (based either on the power or on the *throughput* estimate).

In the former case, the station calculates the ratio between the instantly emitted power and the maximum transmission power.

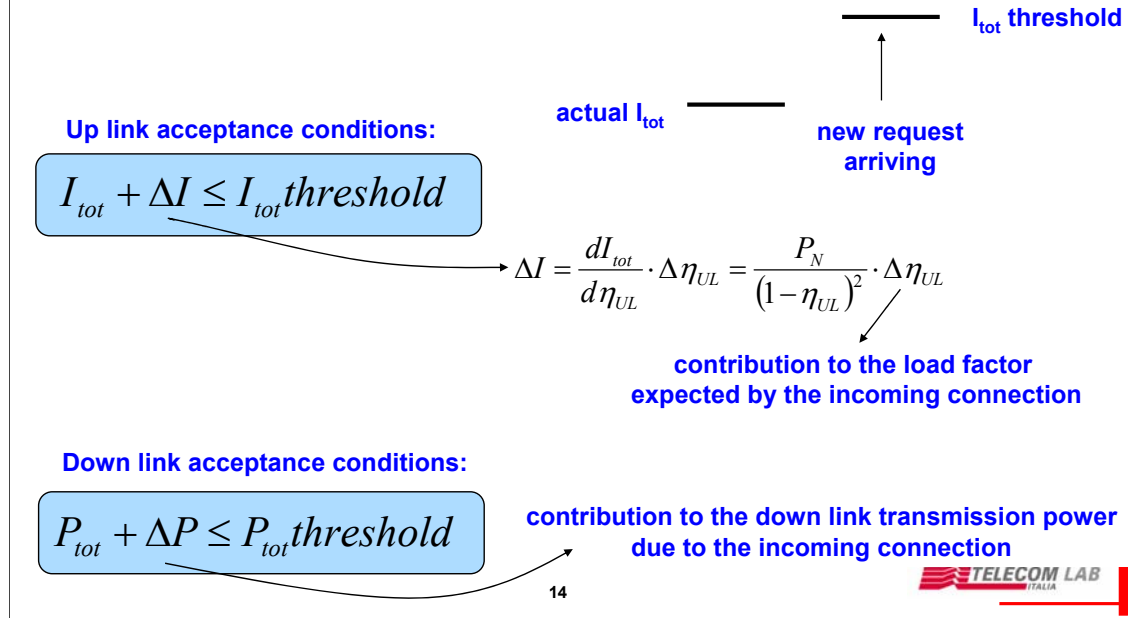
In the latter case, the loading factor is evaluated through an approach similar to that discussed for the *up link*.

A new parameter has to be introduced: the orthogonality coefficient α_i which includes the limits introduced by the multipath behaviour in the down link. The correction is a direct function of the radio obstacles on the Rx – Tx path.

The other important element is the interference factor f_i deriving for the mobile terminal from surrounding cells. It depends on the position of the mobile in the cell: for this reason it depends on the summation index.

For the down link loading factor, α and f are assigned mean values ranging from 0.4 – 0.9 for the former and values around 0.30 for the latter.

Call admission control through the power measurement



The control policies realised in the RNC are based on the loading factor estimates. They allow the network to accept just those connections (or packet sessions) leaving the overall load under given load thresholds. These thresholds are expressed respectively in terms of maximum admitted incremental power and loading factor on the *up* and *down* links.

Being:

$$I_{tot} = \frac{P_N}{1-\eta_{UL}}$$

The derivative of I_{tot} with respect to $(1-\eta_{UL})$ gives a good approximation of how the total interference level grows in function of η_{UL} . Once the load increment $\Delta\eta_{UL}$ due to the new call is calculated, the evaluation of ΔI_{tot} is straightforward

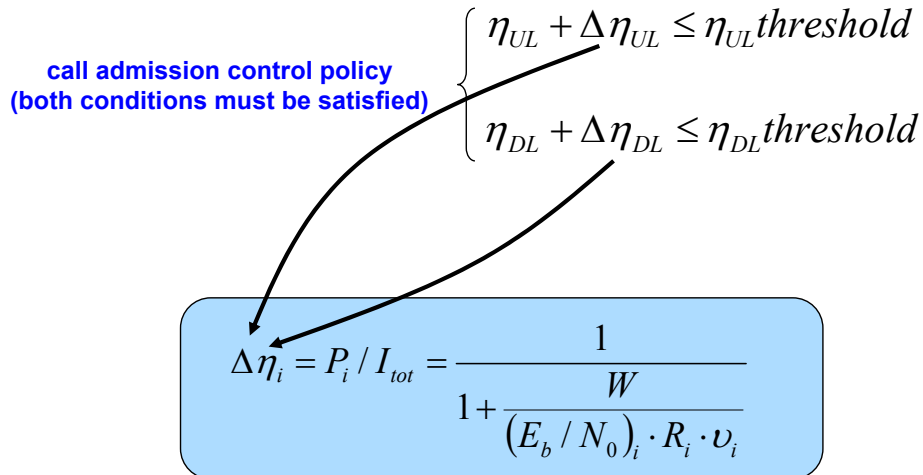
$\Delta\eta_{UL}$ is the loading factor due to the new call i , previously calculated:

$$\eta_i = P_i / I_{tot} = \frac{1}{1 + \frac{W}{(E_b / N_0)_i \cdot R_i \cdot \nu_i}}$$

A similar procedure can be adopted for the *down link*.

The thresholds are normally defined in the planning phase.

Call admission control throughput-based



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If the load evaluation for the *up* and *down links* has been performed through the *throughput* evaluation, the *admission control* policy is based on a fixed threshold assigned for this parameter.

The value of $\Delta\eta$ for the *up* and the *down link* is calculated through:

$$\Delta\eta_i = P_i / I_{tot} = \frac{1}{1 + \frac{W}{(E_b / N_0)_i \cdot R_i \cdot \nu_i}}$$

Already used in the previous considerations.