8.6.3 Soft Handover

A user may simultaneously be connected to multiple BS's in CDMA based systems (soft handover). Since soft handover affects the amount of power transmitted by each BS to a certain user, it is necessary to determine whether the UE is served by a single BS or multiple BS's. The actual determination of the soft handover state of a user and the corresponding channel power requirements may get complicated. Hence, a simplified soft handover algorithm is presented next, which captures the essence of soft handover effects while avoiding implementation of complex algorithms.

Base stations that are connected to a user are included in the "active set" of that user. A base station is initially selected to be in the "active set" based on the strength of its pilot signal versus the interference background. Each base station broadcasts a certain fixed percentage of its maximum power on the pilot channel. The interference background consists of the non-orthogonal energy received on the other channels of the base stations within the active set and the total broadcast power of the base stations that are not in the active set. The BS selection criterion, "pilot Ec/Io" is then defined as

$$\left(\frac{E_c}{I_0}\right)_i = \frac{pilot\_frac \times P_{Max,i}/W}{FN_0 + \sum_{allj} P_j/W + I_{ext}/W} \quad \textit{(Eq. 34)}$$

with the following definitions:

- *Ec* is the chip energy received from ith BS;
- *Io* is the spectral density of total received interference;
- *pilot_frac* is the fraction of BS power allocated to pilot;
- $P_{max,}I$ is the maximum receivable power from ith BS (max BS transmit power*path loss);
- *W* is the system bandwidth;
- *Pj* is the total received power from jth BS;
- *F* is the mobile station noise figure;
- *N0* is the thermal noise power density;
- I_{ext} is the external interference (out of system).

Based on this selection criterion, the following simplified soft handover algorithm can be employed to assign soft handover states to each user:

For each user:

1. Add the BS with the strongest corresponding Ec/Io to the active set;

2. Add the BS with the second strongest corresponding Ec/Io to the active set if its Ec/Io is within 4 dB of the strongest Ec/Io.

Then the soft handover state of a user becomes the number of BS’s in its active set, which is either one or two. Note that in actual systems, the active set of a user may have more than 2 BS’s. However, in order to develop a unified methodology that can simulate various implementations of CDMA based systems and to avoid overwhelming complexity, this simplified approach is suggested. Several standards (including UMTS) present similar methodologies for simulations.

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