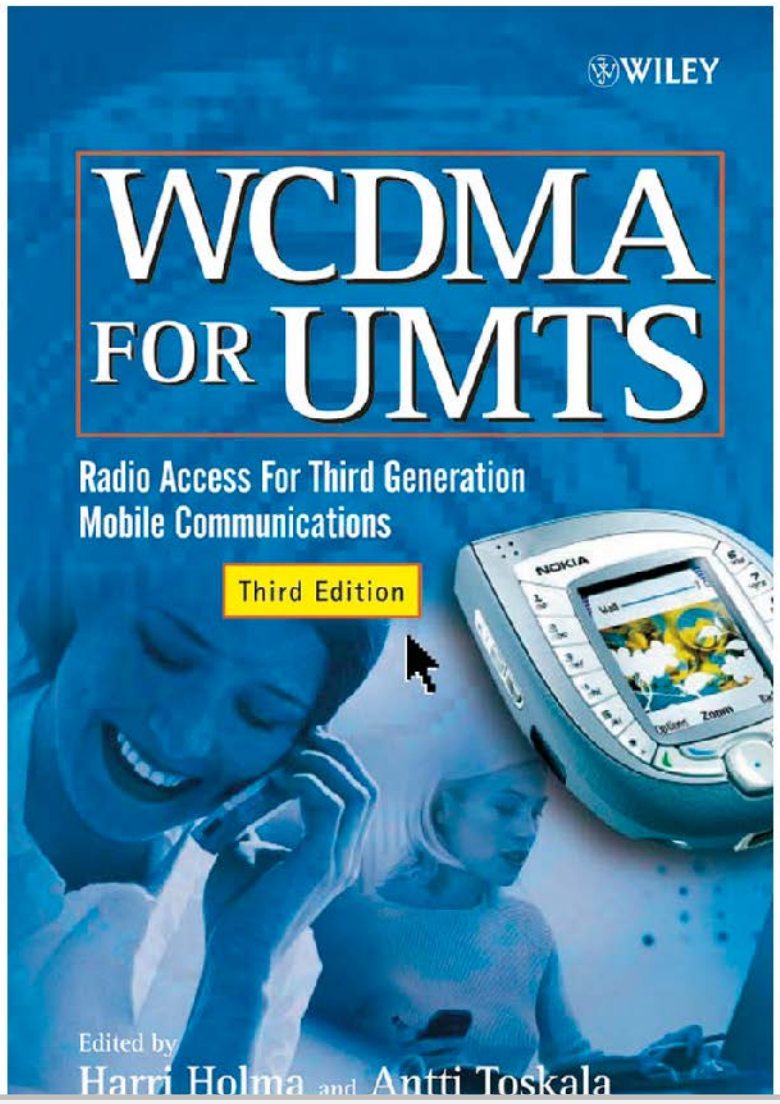

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WCDMA FOR UMTS

Radio Access for Third Generation Mobile Communications

Third Edition

Edited by

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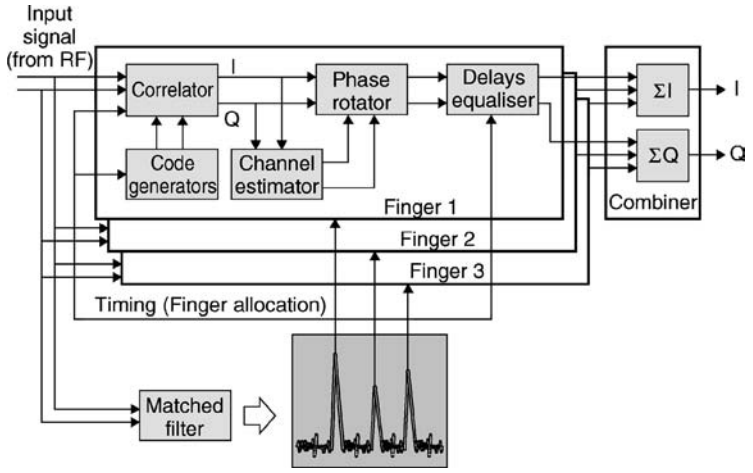

Figure 3.7. Block diagram of the CDMA Rake receiver

estimator uses the pilot symbols for estimating the channel state which will then be removed by the phase rotator from the received symbols. The delay is compensated for the difference in the arrival times of the symbols in each finger. The Rake combiner then sums the channel-compensated symbols, thereby providing multipath diversity against fading. Also shown is a matched filter used for determining and updating the current multipath delay profile of the channel. This measured and possibly averaged multipath delay profile is then used to assign the Rake fingers to the largest peaks.

In typical implementations of the Rake receiver, processing at the chip rate (correlator, code generator, matched filter) is done in ASICs, whereas symbol-level processing (channel estimator, phase rotator, combiner) is implemented by a DSP. Although there are several differences between the WCDMA Rake receiver in the mobile and the base station, all the basic principles presented here are the same.

Finally, we note that multiple receive antennas can be accommodated in the same way as multiple paths received from a single antenna: by just adding additional Rake fingers to the antennas, we can then receive all the energy from multiple paths *and* antennas. From the Rake receiver's perspective, there is essentially no difference between these two forms of diversity reception.

3.5 Power Control

Tight and fast power control is perhaps the most important aspect in WCDMA, in particular on the uplink. Without it, a single overpowered mobile could block a whole cell. Figure 3.8 depicts the problem and the solution in the form of closed loop transmission power control.

Mobile stations MS1 and MS2 operate within the same frequency, separable at the base station only by their respective spreading codes. It may happen that MS1 at the cell edge suffers a path loss, say 70 dB above that of MS2 which is near the base station BS. If there were no mechanism for MS1 and MS2 to be power-controlled to the same level at the base station, MS2 could easily overpower MS1 and thus block a large part of the cell, giving rise to

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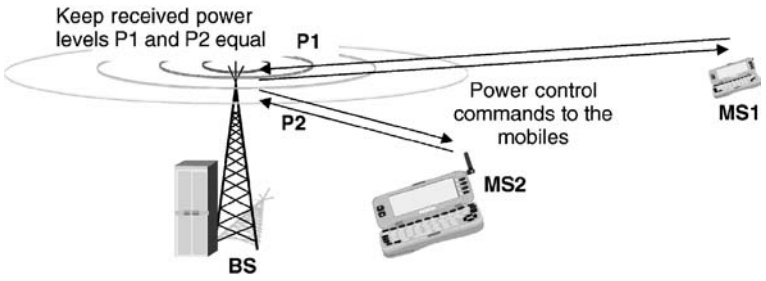

Figure 3.8. Closed loop power control in CDMA

the so-called near–far problem of CDMA. The optimum strategy in the sense of maximising capacity is to equalise the received power per bit of all mobile stations at all times.

While one can conceive open loop power control mechanisms that attempt to make a rough estimate of path loss by means of a downlink beacon signal, such a method would be far too inaccurate. The prime reason for this is that the fast fading is essentially uncorrelated between uplink and downlink, due to the large frequency separation of the uplink and downlink bands of the WCDMA FDD mode. Open loop power control is, however, used in WCDMA, but only to provide a coarse initial power setting of the mobile station at the beginning of a connection.

The solution to power control in WCDMA is fast closed loop power control, also shown in Figure 3.8. In closed loop power control in the uplink, the base station performs frequent estimates of the received Signal-to-Interference Ratio (SIR) and compares it to a target SIR. If the measured SIR is higher than the target SIR, the base station will command the mobile station to lower the power; if it is too low it will command the mobile station to increase its power. This measure–command–react cycle is executed at a rate of 1500 times per second (1.5 kHz) for each mobile station and thus operates faster than any significant change of path loss could possibly happen and, indeed, even faster than the speed of fast Rayleigh fading for low to moderate mobile speeds. Thus, closed loop power control will prevent any power imbalance among all the uplink signals received at the base station.

The same closed loop power control technique is also used on the downlink, though here the motivation is different: on the downlink there is no near–far problem due to the one-to-many scenario. All the signals within one cell originate from the one base station to all mobiles. It is, however, desirable to provide a marginal amount of additional power to mobile stations at the cell edge, as they suffer from increased other-cell interference. Also on the downlink a method of enhancing weak signals caused by Rayleigh fading with additional power is needed at low speeds when other error-correcting methods based on interleaving and error correcting codes do not yet work effectively.

Figure 3.9 shows how uplink closed loop power control works on a fading channel at low speed. Closed loop power control commands the mobile station to use a transmit power proportional to the inverse of the received power (or SIR). Provided the mobile station has enough headroom to ramp the power up, only very little residual fading is left and the channel becomes an essentially non-fading channel as seen from the base station receiver.

While this fading removal is highly desirable from the receiver point of view, it comes at the expense of increased average transmit power at the transmitting end. This means that a

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