8.1 Introduction

The purpose of any communication system is to reliably transfer information between the source and destination. As a signal propagates through a wireless channel, it experiences random fluctuations in time, due to changes in reflections and attenuations. Thus, the channel characteristic of the channels change randomly with time. The average signal strength received by an antenna element over a local area in the propagation environment can be quite large, but during some time intervals it is not uncommon for the instantaneous signal level in a multipath environment to fall 30 dB or more below its mean level.

A substantial decrease in Signal to Noise Ratio (SNR) occurs in a flat fading channel when all arriving multipath components add destructively at the receiver antenna. In this case, the receiver is essentially experiencing in a deep fade or signal null. To cope with these results, during these time periods the receiver requires an alternate signal path to the transmitted signal with a sufficiently large SNR in order to reliably decipher the desired signal. Accordingly, diversity is achieved by using the information on the different branches available to the
receiver in order to increase the SNR at the decoding stage. The additional branches increase the probability that at least one branch, or the combined branch outputs, produce a sufficiently high SNR to permit reliable decoding of the useful message at the receiver.

There are several domains to produce additional diversity branches; the main ones are antenna, time, and frequency domains. Space or site diversity refers to the method of transmission or reception, or both, in which the effects of fading are minimized by the simultaneous use of two or more physically separated antennas (or sites). Antenna diversity requires multiple antennas at the receiver and is therefore usually bulkier. However, operating at high frequency bands allows for the size reduction of antenna elements, and it becomes feasible to have multiple antennas not only at the base stations, but also on the mobile handset. Time diversity takes advantage of the dynamics of the channel; at some point in time the received signal might be in a deep fade, while at a later time the channel has changed significantly such that the received SNR is at an acceptable value. Frequency diversity is implemented by transmitting information on more than one carrier frequency. The rationale behind this technique is that frequencies separated by more than the coherence bandwidth of the channel are uncorrelated and thus do not experience the same fade.

Generally, this chapter focuses on all diversity domains and mitigation techniques in general against the blockage/multipath and atmospheric effects for satellite communication systems. More specifically, the satellite diversity concept is introduced and some results are presented for Code Division Multiple Access (CDMA) based systems. Furthermore, several other issues of the diversity concept applied in satellite communication systems, as Multiple-Input Multiple-Output (MIMO) and space time coding, Power Control (PC), Adaptive Coding and Modulation (ACM), are analyzed. Concerning the blockage/multipath mitigation, recent results for joint fading mitigation, Intermediate Module Repeater (IMR) multipath diversity and combining techniques are presented.

**8.2 Diversity domains and mitigation techniques**

Various methods exist to counteract propagation effects exploiting diversity domains with of the satellite communications systems. The design of these methods has to take into account operating frequency bands, performance objectives of the system, and geometry of the network (system architecture, multiple access schemes, etc). In particular, here the focus is on:

- **Satellite, Site and Frequency Diversity**: the objective is to re-route information in the network in order to avoid impairments due to an atmospheric perturbation