Mobile Radio Propagation: Small-Scale Propagation Modeling

We have seen in the last lecture that reflections from large objects (such as a building or the ground), diffraction on the edges of large objects (such as mountains) or scattering cause relatively slow variations in the received signal power (variations that occur as a result of movements in the environment in the range of 1m – 10m). There are other mechanisms that cause very rapid changes in the received signal power that result from very small movements in the range of (1cm to 10cm). These cause small-scale fading in the transmission channel since small movements result in rapid changes.

The following are the main causes of small-scale fading in a wireless channel:

a) Multipath Reception

Receiving a signal via several paths that have different lengths and hence different propagation delays causes fast and very rapid power fluctuation in the received signal known as multipath fading. In fact, since different paths have different lengths, multipath transmission causes signals to be smeared (spread out) which results in inter-symbol interference (ISI). The larger the difference in path lengths between the shortest and longest paths (with significant magnitudes), the more signal smearing our received signal suffers from.

b) Speed of Mobile

A stationary mobile phone in a stationary environment does not suffer from fading. Once the mobile phone moves, multipath fading with fluctuating amplitude occurs. The speed of the fades (or the speed at which fades arrive) is a directly related to the speed of movement of the mobile phone.

c) Speed of Surrounding Objects

As the speed of the mobile phone significantly influences the power of the received signal of the mobile phone or tower over small mobile movement distances, the power of the received signal is also significantly influenced by the movement of surrounding objects in cases where the mobile phone is stationary or worse when it is moving. The situation is even worse when a line of site components of the received signal does not exist and the components received by the mobile phone or cellular tower are all resulting from reflections, scattering, and diffraction. If the speed of motion of the surrounding objects is slower then the speed of motion of the mobile, the movement of the surrounding objects can be ignored, otherwise their movement has to be taken in consideration.

d) Transmission Bandwidth

If we look at the effect of multipath fading in frequency domain, we see that its effect is localized in frequency. This means that signals with large bandwidth are affected by multipath fading less severly than signals with narrow bandwidths. Therefore, Wideband CDMA (which has channel bandwidth of 5 MHz), for example, is less affected by multipath fading then CDMA (which has channel bandwidth 1.25 MHz).