Chapter VIII
OFDM Transmission Technique:
A Strong Candidate for the Next Generation Mobile Communications

Hermann Rohling
Hamburg University of Technology, Germany

ABSTRACT

The orthogonal frequency division multiplexing (OFDM) transmission technique can efficiently deal with multi-path propagation effects especially in broadband radio channels. It also has a high degree of system flexibility in multiple access schemes by combining the conventional TDMA, FDMA, and CDMA approaches with the OFDM modulation procedure, which is especially important in the uplink of a multi-user system. In OFDM-FDMA schemes carrier synchronization and the resulting sub-carrier orthogonality plays an important role to avoid any multiple access interferences (MAI) in the base station receiver. An additional technical challenge in system design is the required amplifier linearity to avoid any non-linear effects caused by a large peak-to-average ratio (PAR) of an OFDM signal. The OFDM transmission technique is used for the time being in some broadcast applications (DVB-T, DAB, DRM) and wireless local loop (WLL) standards (HIPERLAN/2, IEEE 802.11a) but OFDM has not been used so far in cellular communication networks. The general idea of the OFDM scheme is to split the total bandwidth into many narrowband sub-channels which are equidistantly distributed on the frequency axis. The sub-channel spectra overlap each other but the sub-carriers are still orthogonal in the receiver and can therefore be separated by a Fourier transformation. The system flexibility and use of sub-carrier specific adaptive modulation schemes in frequency selective radio channels are some advantages which make the OFDM transmission technique a strong and technically attractive candidate for the next generation of mobile communications. The objective of this chapter is to describe an OFDM-based system concept for the fourth generation (4G) of mobile communications and to discuss all technical details when establishing a cellular network which requires synchronization in time and frequency domain with sufficient accuracy. In this cellular environment a flexible frequency division multiple access scheme

based on OFDM-FDMA is developed and a radio resource management (RRM) employing dynamic channel allocation (DCA) techniques is used. A purely decentralized and self-organized synchronization technique using specific test signals and RRM techniques based on co-channel interference (CCI) measurements has been developed and will be described in this chapter.

INTRODUCTION

In the evolution of mobile communication systems approximately a 10-year periodicity can be observed between consecutive system generations. Research work for the current 2nd generation of mobile communication systems (GSM) started in Europe in the early 1980s, and the complete system was ready for market in 1990. At that time the first research activities had already been started for the 3rd generation (3G) of mobile communication systems (UMTS, IMT-2000) and the transition from the current second generation (GSM) to the new 3G systems will be observed this year. Compared to today's GSM networks, these new UMTS systems will provide much higher data rates, typically in the range of 64 to 384 kbps, while the peak data rate for low mobility or indoor applications will be 2 Mbps.

The current pace, which can be observed in the mobile communications market, already shows that the 3G systems will not be the ultimate system solution. Consequently, general requirements for a 4G system have to be considered which will mainly be derived from the types of service a user will require in future applications. Generally, it is expected that data services instead of pure voice services will play a predominant role, in particular due to a demand for mobile IP applications. Variable and especially high data rates (20 Mbps and more) will be requested, which should also be available at high mobility in general or high vehicle speeds in particular (see Figure 1). Moreover, asymmetrical data services between up- and downlink are assumed and should be supported by 4G systems in such a scenario where the downlink carries most of the traffic and needs the higher data rate compared with the uplink.

Figure 1. General requirements for 4G mobile communication systems