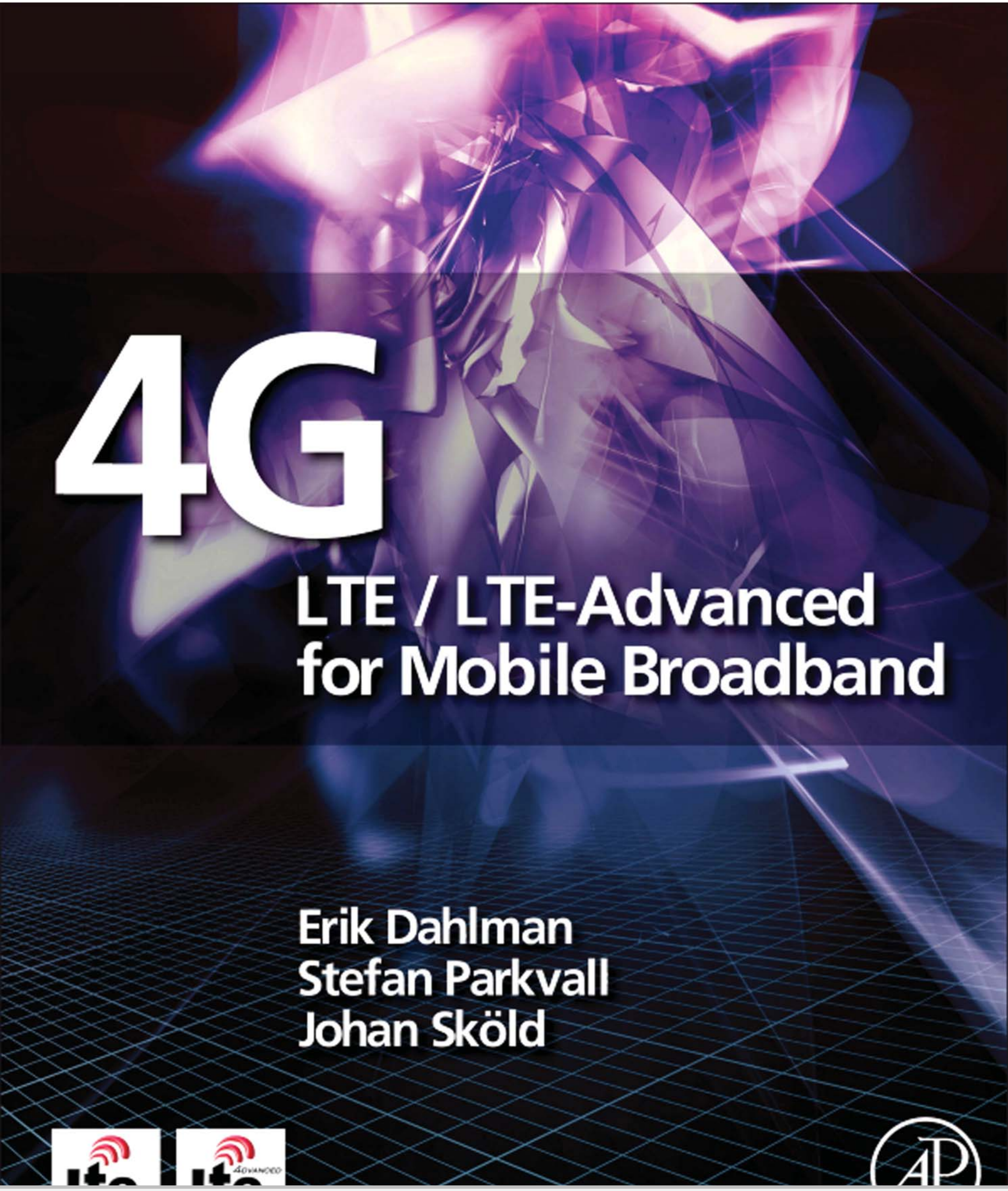

4G

LTE / LTE-Advanced for Mobile Broadband

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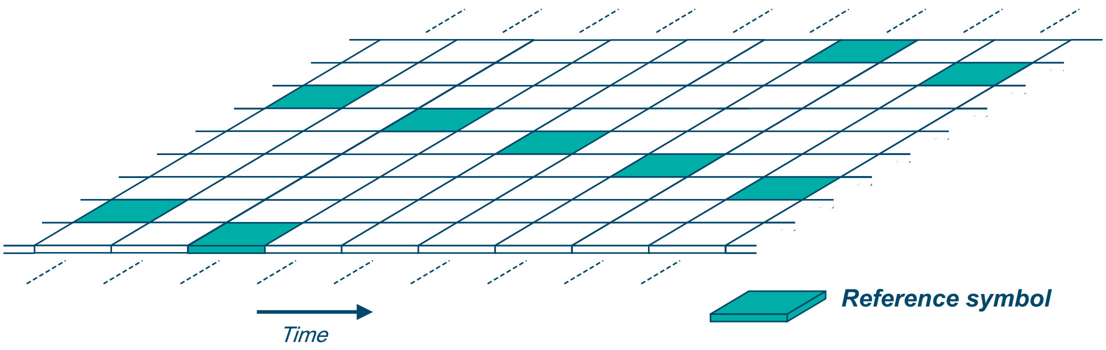

FIGURE 3.12

Time–frequency grid with known reference symbols.

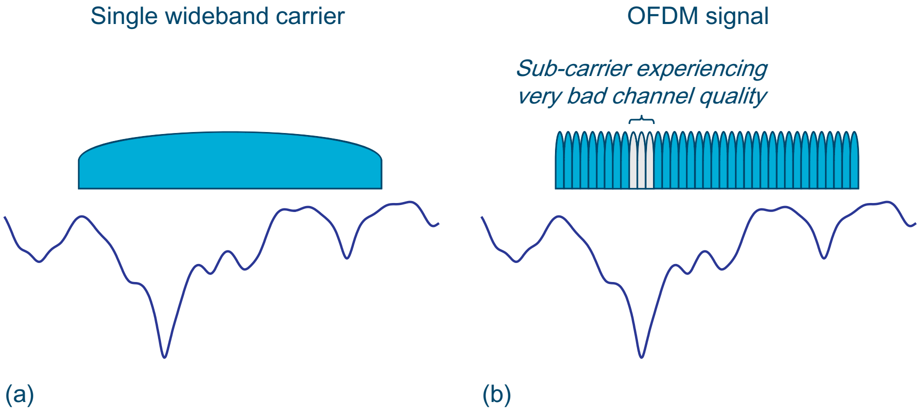

FIGURE 3.13

(a) Transmission of single wideband carrier. (b) OFDM transmission over a frequency-selective channel.

3.7 FREQUENCY DIVERSITY WITH OFDM: IMPORTANCE OF CHANNEL CODING

As discussed in Section 2.3 in the previous chapter, a radio channel is always subject to some degree of frequency selectivity, implying that the channel quality will vary in the frequency domain. In the case of a single wideband carrier, such as a WCDMA carrier, each modulation symbol is transmitted over the entire signal bandwidth. Thus, in the case of the transmission of a single wideband carrier over a highly frequency-selective channel (see Figure 3.13a), each modulation symbol will be transmitted both over frequency bands with relatively good quality (relatively high signal strength) and frequency bands with low quality (low signal strength). Such transmission of information over multiple frequency bands with different instantaneous channel quality is also referred to as *frequency diversity*.

On the other hand, in the case of OFDM transmission each modulation symbol is mainly confined to a relatively narrow bandwidth. Thus, for OFDM transmission over a frequency-selective channel, certain modulation symbols may be fully confined to a frequency band with very low instantaneous

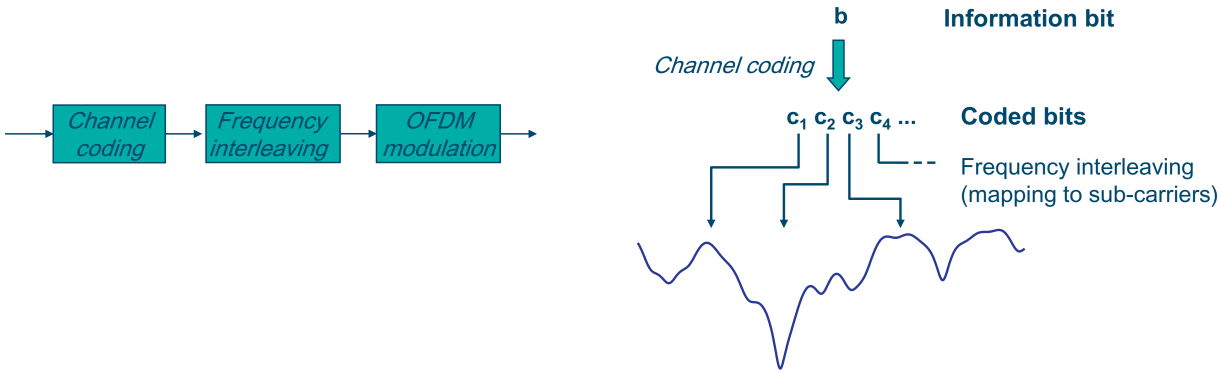

FIGURE 3.14

Channel coding in combination with frequency-domain interleaving to provide frequency diversity in the case of OFDM transmission.

signal strength, as illustrated in Figure 3.13b. Thus, the individual modulation symbols will typically not experience any substantial frequency diversity even if the channel is highly frequency selective over the overall OFDM transmission bandwidth. As a consequence, the basic error-rate performance of OFDM transmission over a frequency-selective channel is relatively poor and especially much worse than the basic error rate in the case of a single wideband carrier.

However, in practice channel coding is used in most cases of digital communication and especially in mobile communication. Channel coding implies that each bit of information to be transmitted is spread over several, often very many, code bits. If these coded bits are then, via modulation symbols, mapped to a set of OFDM subcarriers that are well distributed over the overall transmission bandwidth of the OFDM signal, as illustrated in Figure 3.14, each information bit will experience frequency diversity in the case of transmission over a radio channel that is frequency selective over the transmission bandwidth, despite the fact that the subcarriers, and thus also the code bits, will not experience any frequency diversity. Distributing the code bits in the frequency domain, as illustrated in Figure 3.14, is sometimes referred to as *frequency interleaving*. This is similar to the use of time-domain interleaving to benefit from channel coding in the case of fading that varies in time.

Thus, in contrast to the transmission of a single wideband carrier, channel coding (combined with frequency interleaving) is an essential component in order for OFDM transmission to be able to benefit from frequency diversity on a frequency-selective channel. As channel coding is typically used in most cases of mobile communication this is not a very serious drawback, especially taking into account that a significant part of the available frequency diversity can be captured already with a relatively high code rate.

3.8 SELECTION OF BASIC OFDM PARAMETERS

If OFDM is to be used as the transmission scheme in a mobile-communication system, the following basic OFDM parameters need to be decided upon:

- The subcarrier spacing Δf.
- The number of subcarriers N_c, which, together with the subcarrier spacing, determines the overall transmission bandwidth of the OFDM signal.