

Multi-Carrier Systems



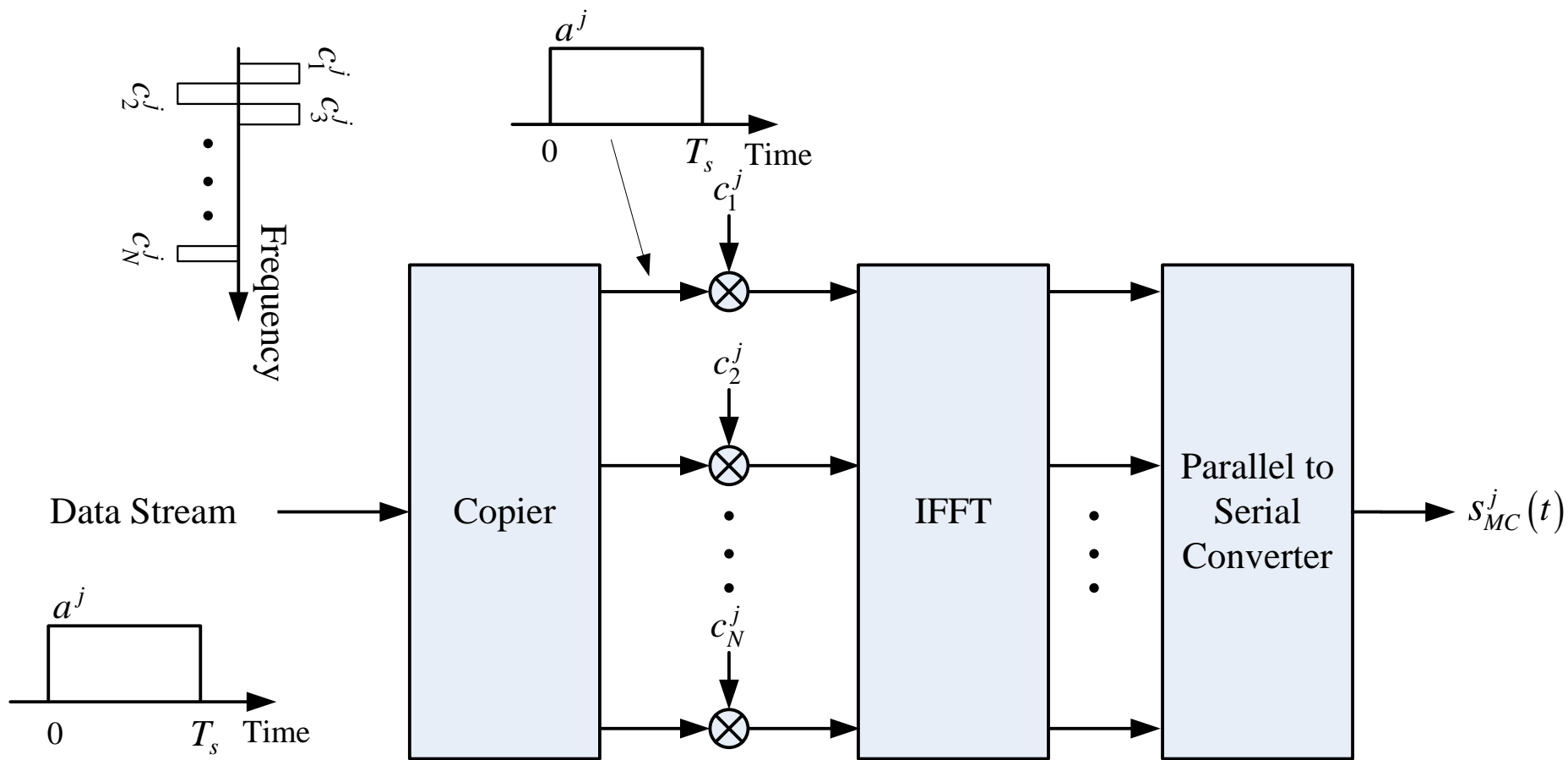
- ✿ Multi-Carrier System Models
 - ✿ MC-CDMA
 - ✿ MC-DS-CDMA

- ✿ Combining Schemes
 - ✿ Equal Gain Combining (EGC)
 - ✿ Maximum Ratio Combining (MRC)
 - ✿ Orthogonality Restoring Combining (ORC)

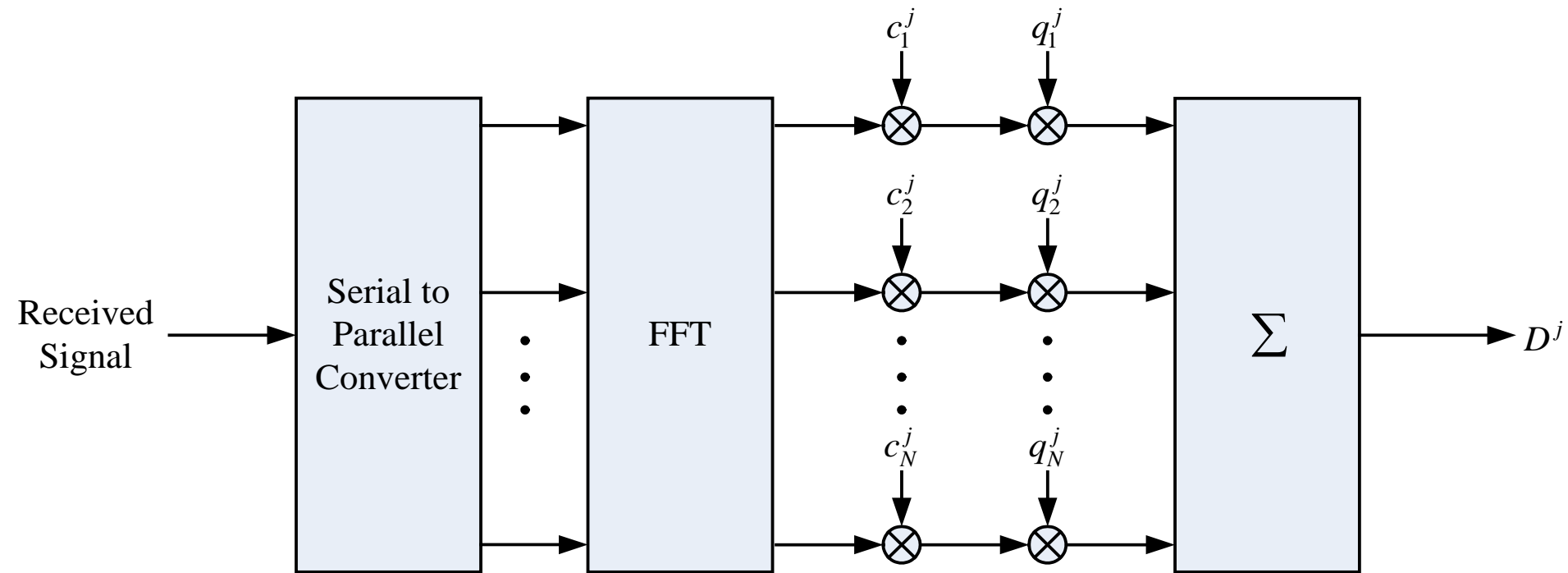
MC-CDMA



MC-CDMA Transmitter



MC-CDMA Receiver



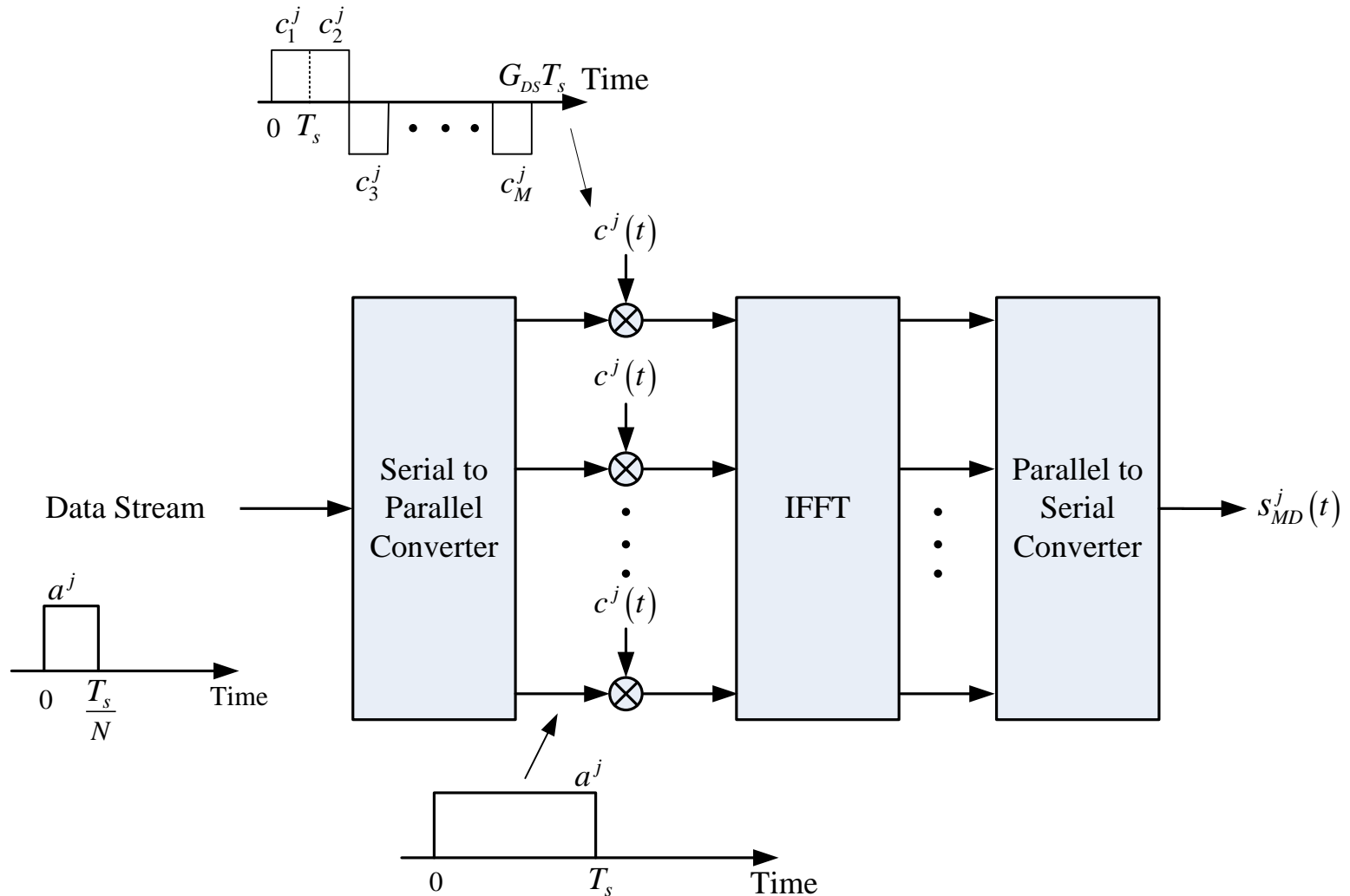
MC-CDMA

- ✿ The MC-CDMA transmitter spreads the original data stream over different subcarriers using a given spreading code in the frequency domain.
- ✿ We can use the Hadamard Walsh codes as the given spreading code.
- ✿ The capability of suppressing multiuser interference is determined by the cross-correlation characteristic of the spreading codes.
- ✿ Therefore, the capability of distinguishing one component from other components in the composite received signal is determined by the auto-correlation characteristic of the spreading codes.

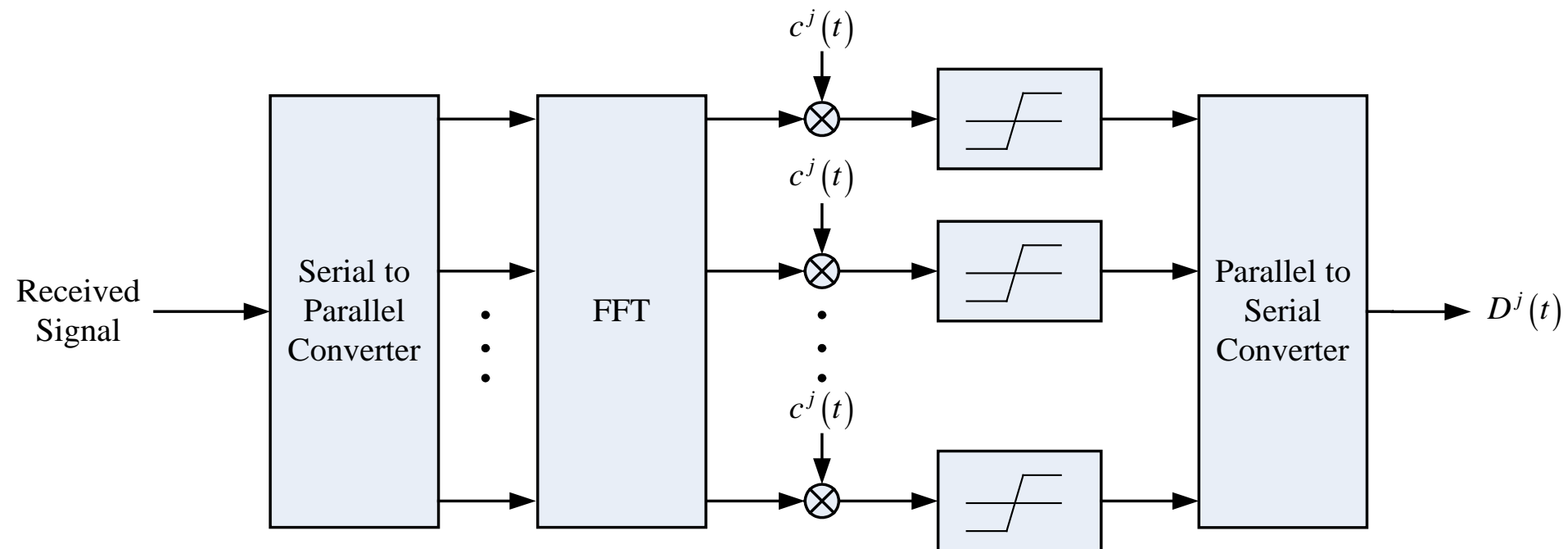
MC-DS-CDMA



MC-DS-CDMA Transmitter



MC-DS-CDMA Receiver



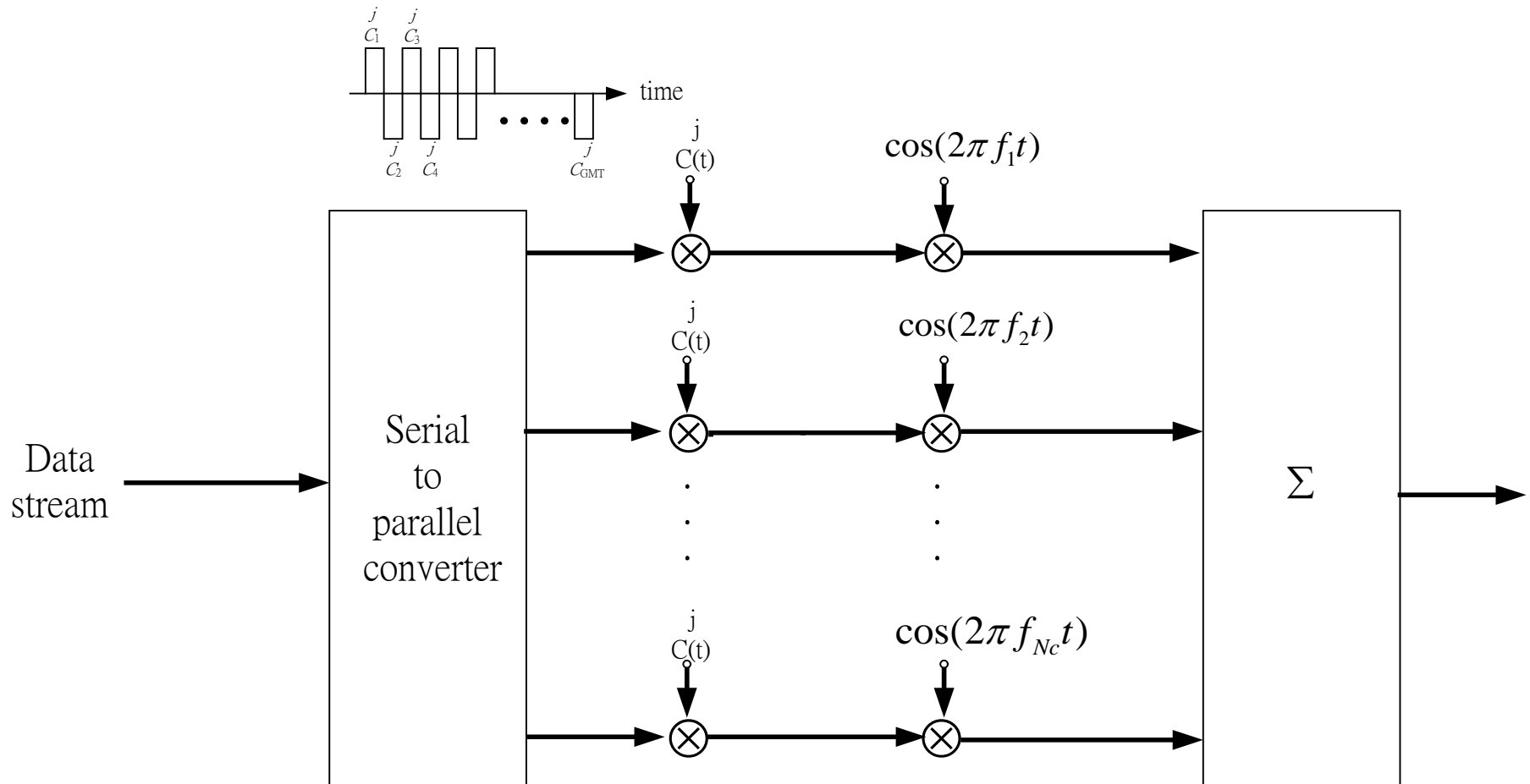
MC-DS-CDMA

- ✿ The Multicarrier DS-SS transmitter spreads the **Serial-to-Parallel converted data streams** using a given spreading code in the **time domain** so that the resulting spectrum of each subcarrier can satisfy the orthogonality condition with the minimum frequency separation.

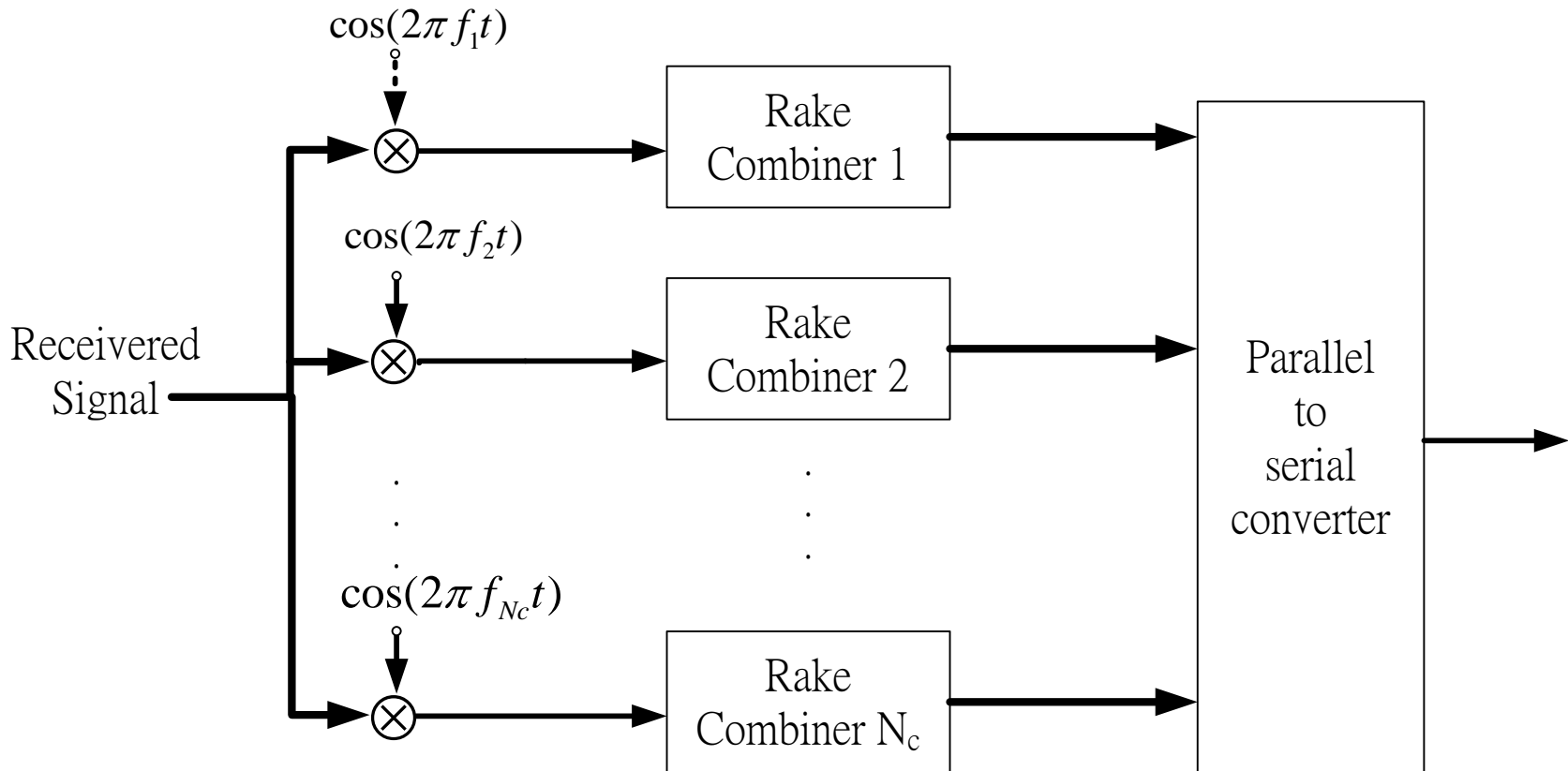
MT-CDMA



MT-CDMA Transmitter



MT-CDMA Receiver





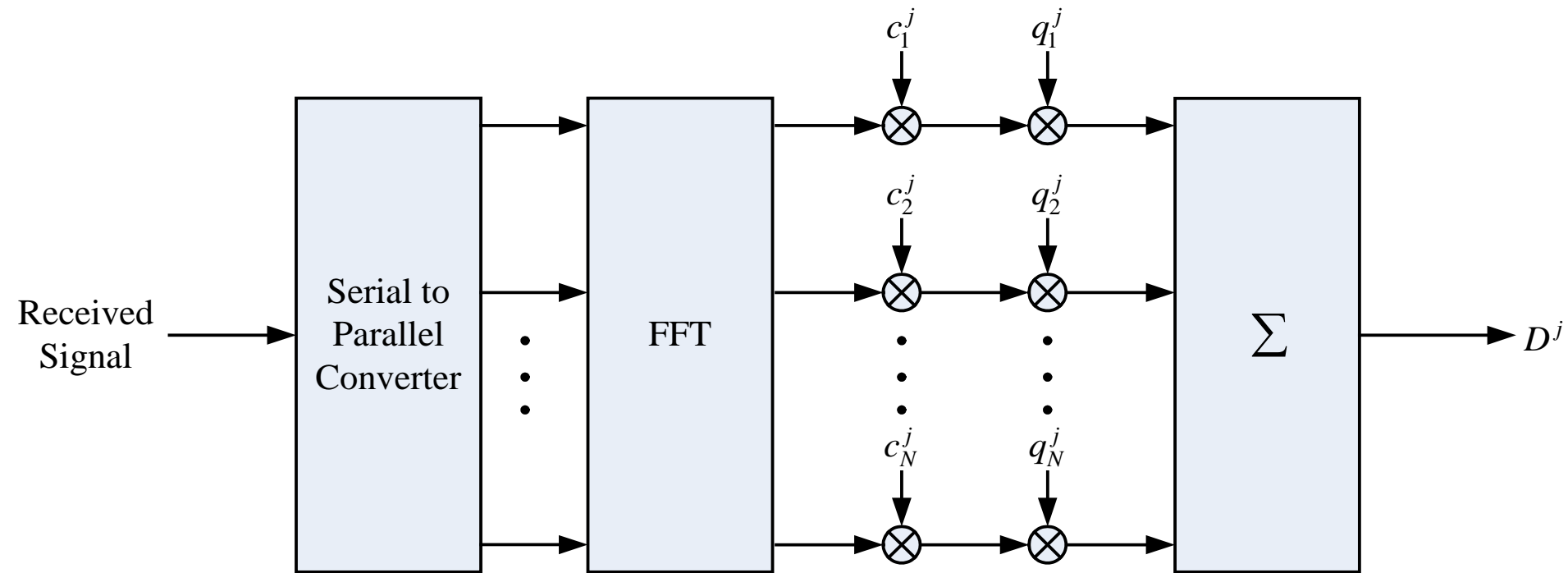
Combining Schemes

- ✿ Equal Gain Combining (EGC)
- ✿ Maximum Ratio Combining (MRC)
- ✿ Orthogonality Restoring Combining (ORC)

Combining Overview

- ✿ In an MC-CDMA receiver the received signal is combined, in a sense, in the frequency domain, therefore, the receiver can always employ all the received signal scattered in the frequency domain.
- ✿ Through a frequency selective fading channel, all the subcarriers have different amplitude level and different phase shift.
- ✿ In this section, we will introduce three different combining techniques.
 - ✿ Equal Gain Combining (EGC)
 - ✿ Maximum Ratio Combining (MRC)
 - ✿ Orthogonality Restoring Combining (ORC)

MC-CDMA Receiver



Combining

✿ Equal Gain Combining (EGC)

- ✿ The equal gain combining only compensates the channel phase shift.
- ✿ The gain for the EGC is given by $q_m^j = e^{-j\theta_m}$.

✿ Maximum Ratio Combining (MRC)

- ✿ The maximum ratio combining compensates the channel phase shift and given different weights to each subcarrier.
- ✿ The gain for the MRC is given by $q_m^j = A_m e^{-j\theta_m}$.
- ✿ In the case of one user, the maximum ratio combining method can maximum the SNR.

Combining

- ✿ Orthogonality Restoring Combining (ORC)
 - ✿ The orthogonality restoring combining compensates the channel phase shift and the channel amplitude fading.
 - ✿ The gain for the ORC is given by $q_m^j = \frac{1}{A_m} e^{-j\theta_m}$.
 - ✿ However, low level subcarriers tend to be multiplied by high gains, and the noise components are amplified at weaker subcarriers.
 - ✿ The noise amplification effect degrades the BER performance.