# Chapter 8.5
# The Next Generation CDMA Technology for Futuristic Wireless Communications:
## Why Complementary Codes?

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## ABSTRACT

*This chapter addresses the issues on the architecture of next generation CDMA (NG-CDMA) systems, which should offer a much better performance in terms of its capacity and transmission rate, etc., than that possible in all current 2-3G systems based on CDMA technology. The ultimate goal is to engineer a CDMA system, whose performance will no longer be interference-limited, for its application in futuristic wireless communications. To achieve this, many challenging issues should be tackled, such as innovated design approaches for CDMA codes, multi-dimensional spreading techniques, suitable CDMA signaling format for high-speed bursty traffic, and so forth. This chapter will review the author's ongoing research activities on the NG-CDMA technology, which can offer a performance never inferior to that of orthogonal frequency division multiple access (OFDMA) technology. In particular, the author will briefly introduce a new CDMA code design method, called Real Environment Adapted Linearization (REAL) approach, which can be used to generate CDMA code sets with inherent immunity against multipath interference and multiple access interference for both uplink and downlink transmissions. The chapter will also illustrate that an interference-free CDMA can only be made possible with the application of orthogonal complementary codes (OCCs). The use of traditional CDMA codes, such as Gold, Kasami, Walsh-Hadamard and OVSF codes, all working on an one-code-per-channel basis, will never help in this sense. Several other topics related to the NG-CDMA technology will also be addressed, such as system performance issues, other properties of the NG-CDMA technology, and so on.*


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## INTRODUCTION

This chapter addresses the issues on the development of NG-CDMA technologies and contains the information on the subjects from both open literature and our own research activities in last fifteen years.

When we initially started to work on the research project on the NG-CDMA technology in 2003, the CDMA technology reached its climax of popularity and everybody was talking about CDMA, and its applications could be found then in various wireless and wired communication systems, virtually everywhere. It seemed to me at that time that CDMA technology will stay in its leading position for a long time. However, recently CDMA technology has faced a serious challenge from other multiple access technologies, in particular from orthogonal frequency division multiple access (OFDMA) technology, and many people have turned away from CDMA to OFDMA.

There are many reasons that CDMA technology has become less popular than it was a few years ago. One of the most plausible reasons is that, as quoted from some people's opinion, the concept of CDMA technology was developed more than ten years ago and it suits well only for slow-speed and continuous-time signal transmissions, which are relevant to voice-centric services, as carried by most 2G mobile cellular systems, such as IS-95, etc. Now, we are talking about high-speed burst-type traffic (such as 4G wireless applications) in the wireless channels, and thus CDMA technology is not suitable. For almost the same reason, the OFDMA technology came into the stage and seems to be a strong candidate to replace CDMA as the prime multiple access technology for futuristic wireless applications, such as exactly what 3GPP Long Term Evolution (LTE) and WiMax systems (Lu, Qian, Chen, & Fu, 2008) are doing.

However, behind the explanation on why CDMA technology can not continue taking the lead we have sensed some unrevealed truth, which might also be the cause that has made the CDMA technology lag behind. Let us take a look at the mobile cellular communication technologies, which have gone through 2G and 3G since the first commercial CDMA cellular systems was launched more than ten years ago. In Taiwan, as well as in many other regions or countries, we have actually entered 3.5G era with High Speed Downlink Packet Access (HSDPA) being put in place by several mobile service providers. On the other hand, the CDMA technology stays in the same place (with almost the same core technologies being used in both 2G and 3G systems) and we have not seen any substantial technological advancement related to CDMA so far. Therefore, it is natural and understandable that people have turned to some other better multiple access technologies to replace CDMA, if the current CDMA technology itself does not advance as fast as expected.

The technical requirements of future Gigabit wireless systems will be very much different from the current 2-3G mobile cellular systems in terms of their applications and working conditions. The current 2-3G systems were developed basically for slow speed transmission in continuous traffic, the major part of which is dedicated for the voice-centric services. The prime traffic in the current 2-3G systems is still in circuit-switching mode. On the other hand, the future Gigabit wireless systems are expected to run on an all-IP wireless platform with a transmission speed at Gigabit per second. Also, the packet switching data streams will be the major part of the traffic. Therefore, the technical requirements and thus the design methodologies should be necessarily innovated to address all the problems existing in the current 2-3G systems.

The appreciation of CDMA technologies in 2-3G systems was due partly to the fact that they could provide on the average a relatively high bandwidth efficiency than that possible by using other multiple access techniques, such as FDMA and TDMA. Unfortunately, the improvement on the bandwidth efficiency achieved in the 2-3G

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