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Introduction

The world's first cellular network (i.e., Advanced Mobile Phone System, AMPS) was put into service in the early 1980s, and it was built based on analog radio transmission technologies. Within few years of launching the services, the cellular network began to hit a capacity ceiling as millions of new subscribers signed up for mobile voice services, demanding more and more airtime. Dropped calls and network busy signals became commonplace in many areas covered by mobile cellular networks.

To accommodate more traffic within a limited amount of radio spectrum, the industry developed a new set of digital wireless technologies called time division multiple access (TDMA). DAMPS (Digital AMPS) and GSM (Global System for Mobile) then came onto the stage. DAMPS and GSM use a time-sharing protocol to provide three to four times more capacity than the analog systems (for instance, AMPS systems). But just as DAMPS was being standardized in North America, an even better solution was found, and that is CDMA technology.

The most important milestone in the application of CDMA technologies is the time when Qualcomm successfully developed the first CDMA-based civilian mobile cellular communication standard in the 1990s, which is commonly called IS-95. In fact, the first CDMA network was commercially launched in 1995, and provided roughly ten times more capacity than analog networks, more than TDMA-based DAMPS or GSM. Since then, CDMA-based mobile cellular has become the fastest growing of all wireless technologies, with over 100 million subscribers worldwide today. In addition to supporting more traffic, CDMA-based mobile cellular systems bring many other benefits to carriers and consumers, including better voice quality, broader coverage, lower average power emission, stronger security, and smoother/easier evolutionary upgrading of the networks.

Since then, it has been successfully demonstrated in theory as well as in practice that a CDMA system based on the direct sequence (DS) spreading technique can in fact offer a higher bandwidth efficiency than its predecessors, such as the frequency division multiple access (FDMA) and TDMA techniques, in addition to many other extremely useful technical features, such as low probability of interception, privacy, good protection against multipath interference, attractive overlay operation with existing radio systems, etc., as to be discussed in Chapter 2. Today, DS-based CDMA technology has become one of the prime multiple access radio technologies for many wireless networks and mobile cellular standards, such as cdma2000, W-CDMA, and TD-SCDMA. CDMA technology reached its climax at the beginning of this century. As a direct beneficiary of the great success of CDMA technology, Qualcomm has enjoyed a huge amount of licensing incomes from the applications of the technology even from many other companies in the same industry.

Then, it has been commonly known that the use of CDMA technology has become a very expensive business exercise, and it is to a company's best interest not to use any CDMA-related

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technologies such that the company could effectively reduce the cost of the development process of any wireless communication products. Under such circumstances, the technological evolution of CDMA itself has been affected and most companies in the industry do not want to touch CDMA any more. The investment from the telecommunication industry in CDMA-related technologies has substantially shrunk, especially after the 3G mobile cellular standardization process came to an end. Instead, they would very much like to find some other competing technology which can offer equally good performance for wireless applications. Orthogonal frequency division multiplex (OFDM) or orthogonal frequency division multiple access (OFDMA) technology came to the stage partly because of this reason.

Since the first release of the IS-95A standard in 1995,[1] more than ten years have passed, during which mobile cellular standards have gone through at least two generations, from 2G to 3G, both of which have been widely deployed throughout the world. As a matter of fact, 3.5G technologies have also been put into service in many countries in the world. For instance, several mobile cellular service operators in Taiwan have started to provide their subscribers with 3.5G technology based on the High-Speed Downlink Packet Access (HSDPA) technique,[2] which was developed by 3GPP, to offer high-speed data access for mobile users, especially those who often need to use their notebooks or laptops on the move.

In contrast to the fact that mobile cellular has advanced to its 3.5G technology, it is very sad to see that CDMA technology itself has stayed virtually at the same place, or in its first generation based on the same core techniques, such as direct-sequence spreading, application of unitary spreading codes (which work on a one-code-per-user basis), closed-loop and open-loop power-control, etc., with a strictly interference-limited performance. The sluggishness in CDMA technological evolution has given us a lesson, which teaches us how to create the best environment possible for a technology to continue its evolution without being stopped by unnecessary barriers on its evolutionary path. Technically speaking, we all know that CDMA technology is a powerful and promising technology, which should be paid enough attention for its further advancement. Economically speaking, however, due to the problems with transfer of intellectual property rights (IPR) and associated huge licensing fees, many people have turned away from CDMA to search for some other cheaper and better replacement technologies (such as OFDMA, etc.) for next generation wireless applications. Politically speaking, technology is only technology, which always has its pros and cons, but the most important concern for a company or a country/region is that home-grown technologies/standards should never rely heavily on others' IPRs. Under this rationale, the technological evolution of CDMA has been effectively handicapped, without being given an opportunity to evolve into its next generation.

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[1] Interim Standard 95 (IS-95) is the first CDMA-based digital cellular standard pioneered by Qualcomm. The brand name for IS-95 now is cdmaOne. IS-95 is also known as TIA-EIA-95. cdmaOne's technical history is reflective of both its birth as a Qualcomm internal project, and the world of then-unproven competing digital cellular standards under which it was developed. The term IS-95 generically applies to the earlier set of protocol revisions, namely P_REV's one through five. P_REV=1 was developed under an ANSI standards process with documentation reference J-STD-008. J-STD-008, published in 1995, was only defined for the then-new North American PCS band (Band Class 1, 1900 MHz). The term IS-95 properly refers to P_REV=1, developed under the Telecommunications Industry Association (TIA) standards process, for the North American cellular band (Band Class 0, 800 MHz) within roughly the same time frame. IS-95 offered interoperation (including handoff) with the analog cellular network. For digital operation, IS-95 and J-STD-008 have most technical details in common. The immature style and structure of both documents are highly reflective of the 'standardizing' of Qualcomm's internal project.

[2] HSDPA is a mobile telephony protocol, a 3.5G technology, which provides a smooth evolutionary path for UMTS-based 3G networks allowing for higher data transfer speeds. Current HSDPA deployments support 1.8 MBit/s or 3.6 MBit/s in downlink. Further steps to 7.2 MBit/s and beyond are planned for the future. As an evolution of the W-CDMA standard, HSDPA achieves the increase in the data transfer speeds by defining a new W-CDMA channel: a high-speed downlink shared channel (HS-DSCH) that operates in a different way from all existing W-CDMA channels and is used for downlink communications to the mobile.

Also, in such a circumstance (in which all people try to avoid using CDMA as much as possible in order not to be liable for license fee charges), people have turned to other replacement air-link architecture to develop their own Beyond 3G wireless systems. This has been reflected in most Beyond 3G wireless applications developed recently. One of the most important standardization efforts in this respect should be long-term evolution (LTE) and evolved UTRAN (E-UTRAN) technology proposed by 3GPP [1]. Very likely, this proposed 4G standard will use single-carrier FDMA for its uplink channel technique and OFDMA for its downlink channel air-link scheme, without using CDMA technology. The reasons for its reluctance to use CDMA technology are very complex, but one of them for sure is just to avoid possible IPR conflicts with the company which owns most CDMA IPRs.

Now, the question is, at least from the technical point of view, whether or not CDMA-based technology is inferior to OFDMA. The answer may not be obvious. It is noted that, although many wireless products on the market (mostly developed for WLANs and digital broadcasting applications) have been using OFDM or its related techniques, the OFDMA and OFDM technologies have not been fully tested and widely deployed in a relative large system/network such as mobile cellular applications. Therefore, the robustness of OFDMA and OFDM technologies for their applications in a mobile cellular communication system to cover large areas is still an unclarified concern to many people, especially its operation under severe weather conditions.

I would like to share the experience of using OFDM-based DVB-T services at my home in Taiwan. In fact, the DVB-T standard is an European standard developed for digital television broadcasting services and it can be effectively viewed as an analogy to the downlink channel transmission in a mobile cellular system, although there are still some differences between the two. Nevertheless, the DVB-T standard basically uses 4096 point IFFT/FFT as a major signal multiplex scheme to encode baseband television signals into frames before sending them into channels via amplitude modulation, which is quite similar to the technique used in downlink channels of a cellular system. Of course, the OFDMA signaling format used in downlink channels in a mobile cellular system may adopt much more signal protective schemes against channel impairment factors, such as multipath and Doppler effects.

Since I installed a set-top box for DVB-T services at my home, I have been enjoying free high-quality digital TV channels from the service providers, but only under good weather conditions. As the signal reception quality in the DVB-T is much more susceptible to weather conditions than a traditional analog TV tuner, I have to retain my old analog TV set in case no signal is available from my DVB-T set-top box, especially in the summer seasons when we usually have a lot of thunder storms with very heavy rain in Taiwan. The susceptibility to severe weather conditions of the DVB-T set-top box has much to do with the amplitude modulation (AM) used in all OFDM- or OFDMA-based air-link technologies. It is a well-known fact that AM is extremely sensitive to noise and interference because it carries information on its carrier's amplitude. In addition, there is no processing gain available in those OFDM- or OFDMA-based schemes and thus it is impossible to gain any extra protection from spectrum expansion. On the other hand, a CDMA technology can offer numerous operational advantages which OFDM- or OFDMA-based schemes lack.

Obviously, the main objective of this book is not to compare the operational advantages of CDMA and OFDMA technologies. Instead, this book wants to convey a clear and strong signal that CDMA is not a legacy technology. It is not true that CDMA has inherent problems impossible to be overcome by itself and thus has to be replaced by some other emerging technology like OFDMA. In fact, CDMA is still a viable and strong candidate for wide application in Beyond 3G wireless systems. CDMA technology should not be considered as a technology owned by only very few companies and others should be afraid of using it due to the IPR issues. The IPRs should be used to encourage more research initiatives and free competition, instead of building up high barriers to slow down technological evolution of the technology.

The motivation for writing this book is to encourage more initiatives to push CDMA technology to its second and third generations, just like mobile cellular technologies. Since its concept was first implemented in the IS-95 standard, CDMA technology unfortunately has basically stayed at the same place. The identical core CDMA technologies have been repeatedly used in 2G and 3G mobile cellular systems. We would like to call it ‘the first generation CDMA technology,’ which should be innovated and evolved into next generation. What, then, is the next generation CDMA technology (which is the focus of this book)?

I have been working on CDMA technology since my PhD research carried out in the Telecommunications Laboratory, University of Oulu, Finland, in 1988,[3] which was the time when CDMA technology was just being brought forward for discussions on its possible applications in commercial mobile cellular systems. The first generation CDMA technology can be characterized by the following key techniques:

- Unitary spreading codes/sequences, which work on a one-code-per-user basis and have been used by all currently existing CDMA-based mobile cellular systems, such as IS-95, cdma2000, W-CDMA, and TD-SCDMA. Those codes/sequences include Gold codes, Kasami codes, m-sequences, Walsh-Hadamard sequences, and orthogonal variable spreading factor (OVSF) codes.

- Direct sequence (DS) spreading modulation, which is used to spread the bandwidth of the original data information into wideband signal by covering a complete spreading code/sequence onto a bit duration.[4]

- Precision power control technique, in which both open-loop and closed-loop power control will be used to adjust mobile transmission power level such that all signals from different mobiles will reach roughly the same level viewed at a base station receiver. Power control is a must for all current CDMA systems to operate successfully due to the near-far effect in a CDMA system based on traditional unitary codes.

- RAKE receiver, which has been used in all traditional CDMA systems to overcome multipath-induced inter-symbol interference (ISI) or simply multipath interference (MI). A RAKE receiver consists of several ‘fingers,’ each of which is made up of a correlator or code-matched filter to capture a particular multipath return. All captured multipath returns will then be coherently or non-coherently combined to form a strengthened decision variable. Therefore, RAKE receiver is one of the most important components in first generation CDMA technology.

- Multi-user detection (MUD) schemes, which are useful to detect multi-user signals through signal decorrelation processes carried out in a CDMA receiver. The commonly used MUD schemes include decorrelating detection (DD), minimum mean squared error (MMSE) detector, parallel interference cancelation (PIC) detector, and serial interference cancelation (SIC) detector.

- Multi-carrier parallel transmission, which consists of a serial-to-parallel converter, followed by a multi-carrier modulator. A multi-carrier modem can split up a wideband data signal stream into several narrowband sub-streams, each of which carries part of the original data stream and occupies a much narrower bandwidth than the original signal. In multi-carrier transmissions, each of the sub-streams is less likely to suffer frequency selective fading than the original wideband data stream. Even if a sub-stream falls into a fading null, the errors can be recovered by using some proper interleaving and error-correcting coding schemes.

With the help of all aforementioned techniques, a communication system based on the first generation CDMA technology can offer bandwidth efficiency and detection efficiency better than the one based

[3]Therefore, it has been widely believed that the initial concept of CDMA cellular was conceived also in November 1988.

[4]In this book, we consider only short-code spreading modulations, in which one spreading code will cover a complete bit duration. We do not consider the long-code scrambling operation, in which a very long spreading sequence is used to cover many bits.

on FDMA and TDMA technologies. However, the performance of a communication system based on the first generation CDMA technology can only offer a strictly interference-limited capacity, meaning that the capacity of a mobile cellular system based on the IS-95 standard, for example, can only support a number of users far less than the processing gain of the spreading codes used by the system.

Many problems of a communication system based on the first generation CDMA technology in fact stem from the unitary spreading codes/sequences. Those unitary codes include many famous user-separation codes, such as Gold codes, Kasami codes, m-sequences, Walsh-Hadamard codes, and OVSF codes, all of which work on a one-code-per-user basis. They were proposed a relatively long time ago by researchers working in information theory. The problem is that people working in information theory then might not have had sufficient knowledge on wireless channels, in which many impairing factors exist, such as external interferences, multipath propagation, Doppler effect, etc. All of those spreading codes used in the first generation CDMA systems, such as IS-95, cdma2000, W-CDMA, and TD-SCDMA, were proposed much earlier than the time when the CDMA cellular concept was conceived. The most serious problem with these unitary spreading codes is that their correlation properties are far from ideal. Here, what we mean in terms of correlation properties stands for the auto-correlation function of a code and the cross-correlation function between any two codes in the same code family or set. In other words, the orthogonality of all those codes is bad in general, and some of them are not orthogonal at all when they are used in asynchronous transmission channels, such as uplink channels in a mobile cellular system. Unfortunately, both 2G and 3G mobile cellular systems based on the first generation CDMA technology have used these unitary codes for CDMA purposes. In this sense, their strictly interference-limited performance is inevitable.

To develop the next generation CDMA technologies, much innovation is required in spreading code design approaches. We have been working hard for years to search for new approaches to generate innovative spreading codes/sequences. Many interesting results have been obtained and will be presented in this book. Those results include many promising spreading codes/sequences, which possess much better correlation properties than all existing unitary codes. Those proposed codes include super complementary codes, generalized pair-wise complementary codes, column-wise complementary codes, optical complementary codes, etc. Among them, the super and column-wise complementary codes are perfectly orthogonal codes in the sense that they offer zero cross-correlation functions between any two codes for any relative shift in both synchronous and asynchronous transmission channels. With this desirable property, a CDMA system can achieve multiple access interference (MAI) free operation for both uplink and downlink transmissions. In addition, the super and column-wise complementary codes can offer an ideal auto-correlation property such that their auto-correlation functions will be zero for all relative shifts except zero shift in both synchronous and asynchronous transmission modes. The ideal auto-correlation in the super and column-wise complementary codes ensures multipath interference-free operation in both uplink and downlink channels. The joint effect of ideal cross-correlation functions and ideal auto-correlation functions makes a CDMA system using them virtually interference-free, making our dream come true: to make a truly noise-limited CDMA system!

On the other hand, the generalized pair-wise complementary code is not a perfectly orthogonal spreading code. However, each user is only assigned a pair of codes for CDMA and thus the CDMA transceiver can be made much simpler, being able to be implemented using a single carrier modem with the help of two orthogonal carriers, i.e., $\sin \omega_c t$ and $\cos \omega_c t$. In addition, the correlation properties of the generalized pair-wise complementary codes are much better than those of all traditional unitary spreading codes, helping to effectively improve the overall performance of a CDMA system using generalized pair-wise complementary codes.

The optical complementary codes were developed by us for their applications in next generation optical CDMA systems. The design approach of the optical complementary codes is based on the ideal auto-correlation function (with the auto-correlation functions for any relative shifts being zero except for the zero shift) and minimized cross-correlation function ($\lambda_c = 1$). In this way, an optical

CDMA system using the resultant optical complementary codes offers a performance much better than all existing optical CDMA systems.

In particular, Chapter 6 of this book will introduce a unique joint code and system design approach, which is called the real environment adaptation linearization (REAL) approach and is used to design spreading codes/sequences by taking into account almost all real operational conditions in a wireless communication system, such as multipath propagation, random signs in continuous bit stream, bursty traffic, etc. Thus, the obtained spreading codes/sequences can inherently address almost all of those impairing factors without using other external auxiliary sub-systems to overcome those impairments. This revolutionary approach also gives us two important conclusions. First, it proves that an interference-free CDMA is possible if and only if orthogonal complementary codes are used. Second, the maximal number of users supportable in such an interference-free CDMA is equal to the flock size of the orthogonal complementary codes. This is the first time that the existence of an interference-free CDMA and its close relationship with the orthogonal complementary codes has been shown in the literature. The conclusions made from the REAL approach are significant and have laid the foundation for development of the next generation CDMA technologies.

This book will also introduce a type of very interesting orthogonal complementary code in Chapter 6, called column-wise complementary codes because they can be constructed based on their column-wise correlation properties. Based on this particular code-construction process, we are allowed to view their unique characteristics from their orthogonality formulation process, such that we can find many interesting applications for them. More specifically, it is seen from the column-wise complementary codes that some of them can establish their orthogonality based on either time-domain correlation or frequency-domain correlation or both. For example, if the orthogonality of a column-wise complementary code set is established purely on the frequency-domain correlation, we can apply the code set in those applications where time-selective fading is a serious problem, such as in vehicle-to-vehicle (V2V) communications, high-speed railway communications, etc. In this way, CDMA systems based on column-wise codes can offer robust performance even under a very large Doppler spread. On the other hand, if the orthogonality of a column-wise complementary code set is based mainly on the time-domain correlation, the codes can be used in those applications where frequency-selective fading is a big problem. Therefore, the next generation CDMA technologies can be tailor-made for different applications by carefully choosing the appropriate column-wise complementary spreading code sets.

In addition to the spreading codes/sequences, spreading modulation is another important issue which should be addressed sufficiently in development of next generation CDMA technologies. Almost all communication systems based on the first generation CDMA technology use DS spreading modulation to spread the original data signal bandwidth and implant signatures for different users.[5] The DS spreading modulation scheme offers a relatively low spectral efficiency and rigid bandwidth spreading mechanism, such that it is very difficult to support quality-of-service (QoS) sensitive variable rate transmissions. We will introduce a parameter, called spreading efficiency (SE), in particular to measure the bandwidth efficiency of a spreading modulation scheme. The SE is measured by the number of bits of information carried by each chip. Therefore, the SE for a traditional DS spreading modulation scheme is merely $\frac{1}{N}$ bits per chip, if the spreading code length is N and every bit is spread by a complete spreading code with N chips. Obviously, there is much room left for improvement.

In Chapter 7 of this book, an innovative spreading modulation scheme, namely offset stacking (OS) spreading modulation, will be proposed. The OS spreading modulation should work jointly with orthogonal complementary codes and it offers a very high spreading efficiency, which can be up to one bit per chip, thus being N times higher than that of the traditional DS spreading modulation scheme. In addition, OS spreading offers a unique flexibility in adjustment of the data transmission rate through the change of relative offset chips between two consecutive bits. Therefore, OS spreading is in particular suitable for high-speed multimedia signal transmissions with variable QoS requirements.

[5] In this book, we will concentrate on DS spreading modulation and will not discuss other traditional spreading modulation schemes, such as frequency hopping (FH) and time hopping (TH).

It is also noted that OS spreading modulation is a general spreading modulation scheme, and DS spreading is only a special case of OS spreading with its relative offset chips being equal to the code length N. In this sense, study of OS spreading is theoretically important as it can help us to understand much better (in a much wider scope) how to optimize the performance of a spreading modulation scheme in terms of bandwidth efficiency and transmission flexibility.

Recently, space-time (S-T) coding techniques have been widely applied to various wireless communication systems. The MIMO technology based on S-T coding schemes will certainly play an extremely important role in future wireless communication systems, because it can help to increase the data transmission rate and improve the signal detection efficiency without consumption of scarce bandwidth and time resources. Several important S-T coding schemes have been proposed in the literature, such as space-time block coding (STBC), space-time trellis coding (STTC), and space-time differential coding (STDC), all of which have been found useful applications in many wireless systems. In Chapter 8, we will introduce a new S-T coding scheme, called space-time complementary coding (STCC), which operates based on the application of orthogonal complementary codes. A CDMA communication system based on the STCC scheme can enjoy both interference-free operation and full spatial diversity gain, such that the overall performance can be substantially improved. In fact, in Chapter 8, we will introduce two different types of STCC CC-CDMA systems, one being STCC DS/CC-CDMA and the other being STCC OS/CC-CDMA using generalized pair-wise complementary codes. We will also compare their performance with traditional S-T coded CDMA systems, such as STBC CDMA.

Another important ingredient of next generation CDMA technologies will be multi-dimensional spreading techniques, which will also be discussed in Chapter 5. As a matter of fact, all CDMA schemes proposed in this book are based largely on various complementary codes. Each user in a complementary-code-based CDMA system is assigned a flock of M element codes as its signature code, and all M element codes should be sent via different channels (either frequencies or time slots) in parallel (via frequency division multiplex) or in serial (via time division multiplex) to a receiver. If we use M sub-carriers to send M element codes, two-dimensional spreading takes place at a transmitter. Now, we have two dimensions to spread original data information, one being in the time domain through N different chips in each element code, and the other being in the frequency domain via M different sub-carriers. The vast number of different orthogonal complementary codes generated in this book allows us to choose many different orthogonal complementary code sets with different combinations of their element code length N and their flock size M, to form different $N \times M$ rectangular-shaped code matrices according to different applications. In some applications, we should reduce the spreading dimension in the frequency domain M (to avoid frequency-selective fading), while in others we should shorten the spreading dimension in the time domain N (to avoid time-selective fading), while still keeping their product $N \times M$ unchanged for a fixed processing gain. Therefore, two-dimensional spreading offers us a much greater degree of freedom in design of a wireless system based on next generation CDMA technology for a particular application. Furthermore, we can also add the third dimension (or the space domain) to the two-dimensional spreading schemes, forming three-dimensional spreading techniques, which can be another important enabling technology to implement next generation CDMA technologies.

M-ary CDMA, which is covered in Chapter 9, may be yet another important part of next generation CDMA technologies. Very much different from a normal DS-CDMA system, an M-ary CDMA system uses multiple spreading codes at each user. Data information will be directly encoded in the patterns of sent codes from a particular user. For instance, if each user is assigned H codes, then there will be $3^H - 1$ patterns of sent codes and each pattern can be used to represent one of 2^m different symbols if H and m are selected as long as they satisfy the relation $3^H - 1 \geq 2^m$. Obviously, if so there must be many ways to choose 2^m from $3^H - 1$ patterns of sent codes such that each symbol consists of m bits. This gives us a nice optimization problem to maximize the mean Euclidean distances among 2^m different constellation points, which are selected from a collection of $3^H - 1$ constellation points. An M-ary CDMA system can offer much higher bandwidth efficiency than a traditional DS-CDMA system as it can carry *m* bits of information in every bit duration, while a conventional DS-CDMA system can carry strictly one bit only.

In Chapter 10, we will also discuss the issues on next generation optical CDMA systems based on optical complementary codes, which were proposed in our research recently. In contrast to a wireless system, an optical communication system is very different and carries many unique properties. In particular, an optical system will send binary data through '0' and '1', instead of '−1' and '+1' as is the case for a wireless system. Therefore, this peculiarity should also be reflected in the spreading code design process for an optical CDMA system. We will propose a new spreading code, namely optical complementary code (OCC), for its applications in next generation optical CDMA (OCDMA) systems. We will also carry out performance comparison among various OCDMA systems with different optical spreading codes, to verify the superiority of the proposed optical complementary codes.

At the end of this book, a few appendices are given to explain the derivations or proofs of several important equations or relations used in the book. In addition, we have listed commonly used complete complementary codes and super complementary codes in Appendices E and F, respectively.

Before the end of the introduction of this book, I would like also to give some information about several special issues or feature topics on the related research topics in some IEEE journals or magazines, for which I was/am the Guest Editor.

I, together with two other guest editors, edited a feature topic on 'Multiple Access Technologies for B3G Wireless Communications' [2] in *IEEE Communications Magazine*, which was published in February 2005. This feature topic covers various important issues on which type of multiple access technologies should be used in Beyond 3G wireless communications.

I was the lead Guest Editor of the special issue on 'The Next Generation CDMA Technologies' [3] of *IEEE Journal on Selected Areas in Communications*, which was published in the first Quarter of 2006. This special issue is the first of its kind and the call - for - papers received a great response from the community, clearly reflected in the number of submissions received for the issue. In this issue many interesting ideas have been brought forward, and in fact we received too many papers, making the acceptance ratio for this issue very low.

Another special issue for which I was the lead Guest Editor has just been published by *IEEE Vehicular Technology Magazine*, entitled 'Evolution of Air-Interface Technologies for 4G Wireless Communications' [4].

Very recently, I have proofread the guest editorial for a special issue on 'Evolution toward 4G Wireless Networking' [5] for *IEEE Network Magazine*, which appeared in January 2007. In this issue some up-layer issues on the 4G wireless networks have been covered.

Currently, I am in the process of reviews for all submissions for a special issue on 'Next Generation CDMA vs. OFDMA for 4G Wireless Applications' [6], for *IEEE Wireless Communications Magazine*, which will be published in June 2007. This issue will be another important special issue covering the topics explicitly on two contending multiple access technologies, CDMA and OFDMA. Therefore, I believe that it will offer many informative discussions and comparisons on the two major air-link technologies.

I am deeply fascinated by the research on the next generation CDMA technologies, and a great amount of research data has been obtained, which is very encouraging. Due to the limited page budget allowed in this book, I could not put all of them inside. Hopefully, I can publish them in another book or in the revision of this one. I hope that readers will find this book informative and useful. All are warmly welcome for any comments or suggestions on this book. Please feel free to contact me via email at `hshwchen@ieee.org`. Thank you very much!