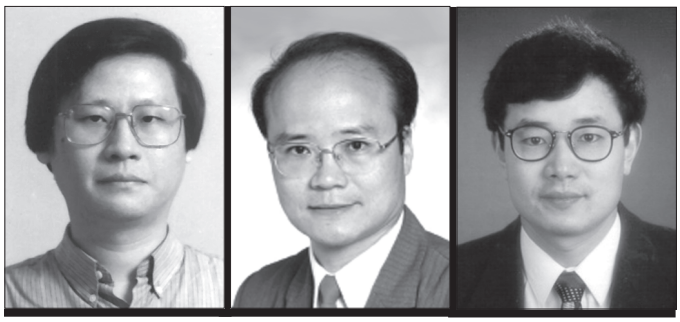
# NEXT-GENERATION CDMA VS. OFDMA FOR 4G WIRELESS APPLICATIONS



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The great success of the Internet and wireless communications has opened a new vista for future all-IP wireless applications, driven by increasing demand for packet data services in worldwide third-generation (3G) and 3.5G networks. It has been envisioned that the future wireless systems will operate based mainly on burst data services carrying multimedia contents, including voice, data, image, and video. The need to support high-speed burst-type traffic in wireless channels has already posed a great challenge to the current air link technologies based on code-division multiple access (CDMA). There has been a great deal of debate on the air link technologies most suitable for 4G wireless. It has been suggested from the research that traditional CDMA technologies are suited only for slow-speed continuous transmission applications such as voice, but not for high-speed all-IP wireless applications. Therefore, multiple access/multiplexing technology, such as orthogonal frequency-division multiple access/multiplexing (OFDMA/OFDM), has been proposed to replace traditional CDMA as a prime air link design for 4G wireless.

Today, both CDMA and OFDMA have been adopted by various standards. CDMA is used in IS-95, CDMA2000, wideband CDMA (W-CDMA), time-division synchronous CDMA (TD-SCDMA), and so on. Its spread spectrum multiplexing technique has found wide applications, including early IEEE 802.11 and 802.11b/g WLAN, Bluetooth, and cordless telephony. CDMA technology with its many unique features, such as universal frequency reuse, processing gain, and soft handoff, may have great potential for further technological evolution. Interleave-division multiple access (IDMA), which can be considered a special case of CDMA, has also gained attention, especially for wireless uplink applications. On the other hand, OFDMA/OFDM is used in IEEE 802.11a/g/n WLAN, HIPERLAN/2, WiMAX, DVB-T, asymmetric digital subscriber line (ADSL), very high rate DSL (VDSL), and others. It has also been chosen as the physical layer architecture for 3GPP long-term evolution (LTE). The major advantage of OFDM is its ability to deal with multipath fading and narrowband interference without using complicated channel equalization.

Being independent of the powerful access technologies based on CDMA and OFDMA, multiple-input multiple-output (MIMO) antenna systems have been identified as one of the key technologies to support higher data rates through spatial multiplexing and diversity in comparison to single-antenna systems. MIMO techniques can be elegantly combined with OFDMA as well as CDMA.

In this special issue, various important issues pertaining to next-generation CDMA and OFDMA technologies are addressed. The six articles have been included herein to cover state-of-the-art research in various aspects of CDMA- and OFDMA-based technologies.

The first article, contributed by T. Frank, A. Klein, and E. Costa, reviews different multiple access schemes based on the combination of techniques from single- and multicarrier transmissions under a unified framework. It is shown that interleaved frequency-division multiple access (IFDMA), which can be regarded as either a CDMA or an OFDMA variant, can combine the advantages of CDMA — low complexity for signal generation, low peak-to-average power ratio (PAPR), and high frequency diversity — and the advantages of OFDMA: low complexity for user separation and channel equalization. Consequently, sufficient robustness and flexibility in terms of different data rates can be achieved.

In the second article, L. Ping, Q. Guo, and J. Tong compare the OFDM-IDMA scheme with other alternative technologies such as OFDM-CDMA and OFDMA. OFDM-IDMA has advantages in terms of spectral and power efficiency, low-cost iterative multi-user detection, flexible rate adaptation, and frequency diversity.

The third article, authored by H. Jiang, W. Zhuang, and X. Shen, deals with the limitations of existing distributed CDMA-based medium access control (MAC) schemes by using a generic network model with distributed control. By letting active receivers estimate the potential increase in the interference level, the authors propose a MAC scheme that can enable various features such as bit-level quality of service (QoS), low overhead, accurate channel/interference estimation, and high bandwidth efficiency.

In the fourth article, W. Zhang, X. Xia, and K. B. Letaief provide an overview of space-time (ST) coding, space-frequency (SF) coding, and space-time-frequency (STF) coding schemes for MIMO-OFDM systems. The obtained results show that STF coding can achieve the maximum diversity gain

in an end-to-end MIMO-OFDM system over broadband wireless channels. However, joint detection is needed in STF-coded OFDM, and this, in turn, results in high decoding complexity.

The fifth article, authored by Y. Hu and A. Boukerche, addresses multicarrier (MC) CDMA techniques. A joint detection method called a modified maximum likelihood multistage parallel interference canceller (M-ML-MPIC) is proposed to eliminate frequency offset and multiple access interference (MAI) simultaneously. The results indicate that joint-detection-based MC-CDMA systems can outperform ordinary OFDMA systems.

The sixth article, contributed by L. B. Thiagarajany, Y. Liang, and S. Attallah, considers a reconfigurable transceiver whose blocks can be adaptively configured in order to support any of CDMA, OFDM/OFDMA, and other cyclic prefix (CP)-based air interfaces. Such a low-cost multiple air interface module can be implemented in a single terminal to enable global connectivity and interoperability.

Both CDMA and OFDMA are promising technologies for 3.5G and 4G wireless networking applications. Their future success will depend not only on the technologies themselves, but also on the market demands, industry efforts, and politics. We hope that this special issue can help to accelerate technological evolution of air link architecture for next-generation wireless communications.

We would like to thank all the authors who submitted their papers to this special issue. Among numerous submissions, unfortunately we could only select six papers based on rigorous peer reviews and had to reject many good submissions. We are also grateful to all the reviewers of this special issue for their thoughtful and timely reviews, without which this special issue would not have been possible. Last but not least, we would like to thank the Editor-in-Chief, Professor Abbas Jamalipour, for his approval, support, and help with this special issue.

## BIOGRAPHIES

HSIAO-HWA CHEN [SM] (hshwchen@ieee.org) is currently a full professor at the Institute of Communications Engineering, National Sun Yat-Sen University, Taiwan. He received B.Sc. and M.Sc. degrees with highest honors from Zhejiang University, China, and a Ph.D. degree from the University of Oulu, Finland, in 1982, 1985, and 1990, respectively, all in electrical engineering. He worked with the Academy of Finland as a research associate from 1991 to 1993, and at the National University of Singapore as a lecturer and then senior lecturer from 1992 to 1997. He joined the Department of Electrical Engineering, National Chung Hsing University, Taiwan, as an associate professor in 1997 and was promoted to full professor in 2000. In 2001 he joined National Sun Yat-Sen University, Taiwan, as the founding director of the Institute of Communications Engineering. Under his strong leadership the Institute was ranked second in the country in terms of SCI journal publications and National Science Council funding per faculty member in 2004. National Sun Yat-Sen University was ranked in first place in the world in terms of the number of SCI journal publications in wireless LANs research papers during 2004 to mid-2005, according to the Research Report released by the Office of Navel Research, United States (www.onr.navy.mil/sci_tech/special/354/technowatch/textmine.asp). He was a visiting professor at the Department of Electrical Engineering, University of Kaiserslautern, Germany, in 1999, the Institute of Applied Physics, Tsukuba University, Japan, in 2000, Institute of Experimental Mathematics, University of Essen, Germany, in 2002 (under a DFG Fellowship), the Chinese University of Hong Kong in 2004, and the City University of Hong Kong in 2007. His current research interests include wireless networking, MIMO systems, next-generation CDMA technologies, information security, and beyond 3G wireless communications. He is a recipient of numerous research and teaching awards from the National Science Council, the Ministry of Education, and other professional groups in Taiwan. He has authored or coauthored over 200 technical papers in major international journals and conferences, five books, and several book chapters in the areas of communications, including *Next Generation Wireless Systems and Networks* (Wiley, 2005). He has been an active volunteer in various IEEE technical activities for over 15 years. Currently, he is serving as the Chair of IEEE Communications Society Radio Communications Committee. He served or is serving as symposium chair/co-chair of many major IEEE conferences, including VTC '03 Fall, ICC '04, GLOBECOM '04, ICC '05, GLOBECOM '05, ICC '06, GLOBECOM '06, ICC '07, and WCNC '07. He served or is serving as an editorial board member or/and Guest Editor of *IEEE Communications Letters*, *IEEE Communications Magazine*, *IEEE Wireless Communications*, *IEEE JSAC*, *IEEE Network*, *IEEE Transactions on Wireless Communications*, and *IEEE Vehicular Technology*. He is serving as Chief Editor (Asia and Pacific) for Wiley's *Wireless Communications and Mobile Computing* Journal and Wiley's *International Journal of Communication Systems*. His original work on CDMA wireless networks, digital communications, and radar systems has resulted in five U.S. patents, two Finnish patents, three Taiwanese patents, and two Chinese patents, some of which have been licensed to industry for commercial applications. He is also an adjunct professor of Zhejiang University, China, and Shanghai Jiao Tung University, China.

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