

M A R V E L L[®]

WHITE PAPER

TD-SCDMA and China 3G

Lu Chang, Ph.D.
Director of Mobile Products
Marvell

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Executive Summary

Since the development of Time Division Synchronous Code Division Multiple Access (TD-SCDMA), China's 3G technology, there have been many naysayers. However, the rapid growth of its commercialization since 2009, and especially its acceleration in late 2011 to more than 45 million subscribers, has put any doubt to rest. The unique time division duplex and spectrum bandwidth of TD-SCDMA has made it cost effective and flexible for deployment in both densely populated and low population rural areas, both important for China's vast geography and high concentration of metropolitan areas. With the 2011 introduction of affordable TD-SCDMA smartphones, powered by Marvell®'s communication processors, consumer adoption of this 3G technology is gaining momentum. Marvell is committed to supporting TD-SCDMA and opening up a wide opportunity for product development for the world's OEMs, not only in China, but also for world phone platforms. These include smartphones, tablets and other mobile devices that can be operated and supported anywhere in the world. The time is now for OEMs to jump into this exciting worldwide market opportunity.

Introduction

Since the advent of mobile telephony, mobility has ushered in the rapid growth of telecommunications. 3G technologies were developed in the late 1990s and further evolved in the first decade of the new millennium. Today, there are three major 3G standards worldwide. Wideband Code Division Multiple Access (WCDMA), is a third-generation (3G) wireless standard, that was first published in the year 2000, and initially offered data speeds up to 384 Kbps. WCDMA is the 3G technology used in the United States by AT&T and T-Mobile. CDMA 2000 and EV DO (Evolution-Data Optimized) were first published in 2002. By mid-2011, both of these two 3G technologies have been deployed by major operators around the world. China, as the most populace country in the world, also developed their own 3G technology, Time-Division Synchronous Code Division Multiple Access (TD-SCDMA), part of the Universal Mobile Telecommunications System (UMTS). Many aspects of TD-SCDMA make it uniquely suitable for deployment and commercialization and it is beginning to gain momentum in this country of more than 1.4 billion people. It is the intention of this whitepaper to introduce the technology and its unique characteristics, to provide an update on China's 3G market and Marvell's line of TD-SCDMA-based products that can enable a wide array of mobile devices for this exciting market opportunity.

Primer in 3G Technologies

History of TD-SCDMA

TD-SCDMA is jointly developed by the China Academy of Telecommunication Technology (CATT) and Siemens®. It was first started as research for a wireless local loop (WLL) system and later combined with time-division duplexing (TDD) and network technology. TD-SCDMA was first proposed to the International Telecommunication Union (ITU) in 1998, based on TDD and synchronous CDMA technology, as one of the third generation public land mobile communication standards. In May 2000, TD-SCDMA was approved by ITU as one of three global 3G standards, along with WCDMA and CDMA2000. In March 2001, the 3rd Generation Partnership Project (3GPP), an organization which helps unite telecommunications standards bodies, adopted TD-SCDMA as part of its Universal Mobile Telecommunications System (UMTS) Release 4, making TD-SCDMA one of the three main global telecommunications standards along with CDMA2000 and WCDMA.

The first voice call over a TD-SCDMA network was made on April 2001 and the first video call was followed in July of the same year. Technical certification of TD-SCDMA was conducted in 2002. A field trial began in October 2001. Live network testing started in 2005 in Baoding, Qingdao and Xiameng.

Large-scale TD network trials began in 2006 and expanded to 10 cities by three telecom operators. China Mobile® Communications Corporation (CMCC), the world's largest wireless network operator with 630,000 subscribers, deployed 14,000 TD base stations in eight cities. CMCC is a main driver of the adoption of the TD-SCDMA standard, which is gaining momentum since China began issuing 3G licenses in 2009. By the end of 2010, CMCC had 20 million TD subscribers.

Comparison of 3G Technologies

The fundamental characteristic of TD-SCDMA is its use of time-division duplex for multiple access. Rather than symmetric downlink (DL) and uplink (UL) spectrum used in WCDMA and CDMA 2000, TD-SCDMA is capable of providing downlink and uplink transmission in the same frequency band. This is enabled by its unique frame structure, as shown in Figure 1. Each radio frame is 10ms long and is divided into 2 subframes of 5ms each. Each subframe further consists of seven normal timeslots (TS) and three special timeslots. These normal timeslots can be used flexibly for either downlink or uplink transmission, with the exception of TS0 and TS1, which are always allocated for downlink and uplink, respectively. The flexible allocation of timeslots for downlink and uplink makes it ideal for asymmetric data services, such as Internet browsing or social networking. Because of its time-division nature, TD-SCDMA needs an unpaired spectrum band for both downlink and uplink transmission, compared to WCDMA and CDMA 2000, which both need paired spectrum bands with one band for downlink transmission and the other for uplink. This makes deployment of TD-SCDMA networks easier and the associated spectrum management simpler.

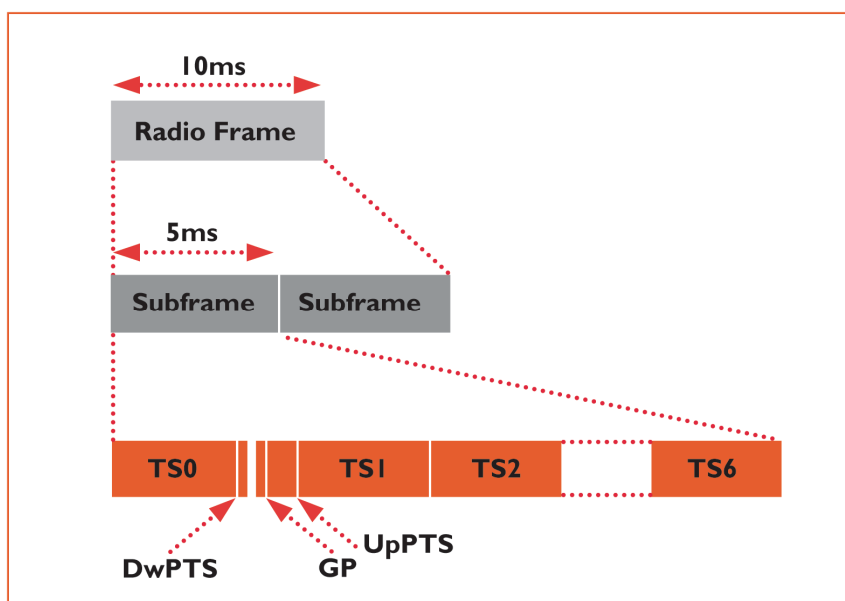


FIGURE 1. TD-SCDMA FRAME STRUCTURE

The TD-SCDMA design adopted many advanced signal processing techniques, such as smart antenna and joint detection method. Since both uplink (UL) and downlink (DL) transmissions occupy the same frequency resource, it is possible to estimate the DL multipath characteristics through the received UL signals. This makes it possible to use smart antenna technology in the base station to reduce interferences between terminals and concentrate transmitted power at active terminals. Through the use of antenna array and advanced algorithms in DSP, smart antenna technology is able to obtain location information of mobile terminals and to steer transmit beams to specific terminals. The benefit of spatial beamforming is reduced interference on the same channel, and as a result, improvement in the downlink capacity. The use of smart antenna enables efficient network deployment for both high-density urban areas and low-population rural areas alike, a critical factor in China.

Multiple-access interference is a major problem in CDMA-based systems. Joint detection technology treats signals from all users as useful and processes them in parallel. Since the number of users in any given time slot in TD-SCDMA is limited to 16, the processing complexity of joint detection is kept manageable.

Another aspect of TD-SCDMA is the synchronization of user terminals and base stations, like all TDMA systems. This property makes it possible to tune precise timing advances for transmission from terminals so that signals from different users arrive at the base station frame-synchronously. As a result, joint detection can be carried out at the base station effectively. The synchronization leads to faster search for neighboring cells during handover and removes the need for soft-handover.

	TD-SCDMA	WCDMA	CDMA 2000
• Channel Bandwidth	1.6MHz	5MHz	1.25MHz
• Duplex	TDD	FDD	FDD
• Frame Rate	10ms	10ms	20ms
• Chip Rate	1.28Mchips/s	3.84Mchips/s	1.2288Mchips/s
• Spreading Factor	1,2,4,8,16	4...256 UL, 4...256 DL	
• Modulation	QPSK/8PSK/16QAM	QPSK/16QAM	QPSK/8PSK/16QAM

TABLE 1. COMPARISON OF 3G TECHNOLOGIES

A comparison of 3G technologies is shown in Table 1. It can be seen that TD-SCDMA shares many roots with WCDMA and CDMA2000, yet possesses its own unique characteristics. Both WCDMA and CDMA 2000 are frequency division multiple access technologies. WCDMA needs two separate 5MHz wide spectrum bands, one for downlink transmission (from cell tower to handsets) and for uplink (from handset to cell tower). CDMA 2000 also needs two spectrum bands of 1.25MHz each. TD-SCDMA needs only 1 spectrum band of 1.6MHz for both uplink and downlink transmissions. In other words, TD-SCDMA needs one-sixth to two-thirds the spectrum resource. This makes it easier for mobile network deployment planning, as smaller spectrum bands are needed in the already crowded radio spectrum. It also makes network and terminal equipment costs lower as a smaller frequency band needs to be sampled and, uplink and downlink radio frequency (RF) chains can be largely reused as they are centered in the same band.

China's 3G Market Status

In January 2009, China issued 3G licenses, with China Mobile® undertaking the TD-SCDMA networks, and China Unicom® and China Telecom® taking on WCDMA and CDMA2000 networks, respectively. According to their 2010 annual report¹, China Mobile deployed more than 199,000 base stations, covering more than 656 cities by mid-2011. By all accounts, China's 3G user market is exploding. According to market analysis by iSuppli², CMCC will occupy the biggest share in China's 3G subscriber market. Figure 2 shows iSuppli's handset market prediction for 2010 to 2014 by access technologies. Since the commercial launch of TD, CMCC has been driving the TD market through investment in the ecosystem and providing subsidies to consumers. By the end of 2010, CMCC had 20 million TD subscribers. By end of Nov 2011, TD subscribers had already surpassed 48 million. In 2011, it is expected that net add of TD subscribers will reach 30 million.

It is believed that the TD market will accelerate its expansion due to China Mobile's program for affordable smartphones. In the first-half of this year's terminal procurement, 70 percent of the winning bids are in the category of low- to mid-tier smartphones, with retail prices in the range of RMB900 to RMB1600. (*Renminbi, or RMB, is the official currency of the People's Republic of China. RMB 900 to RMB1600 is about equivalent to approximately US\$138 to US\$246.*) Many more TD-based devices from other manufactures are expected to be launched in the next few months. These would all help drive the adoption of TD technology.

By the end of November 2010, there were already 356 TD handsets that have been certified by China Mobile.

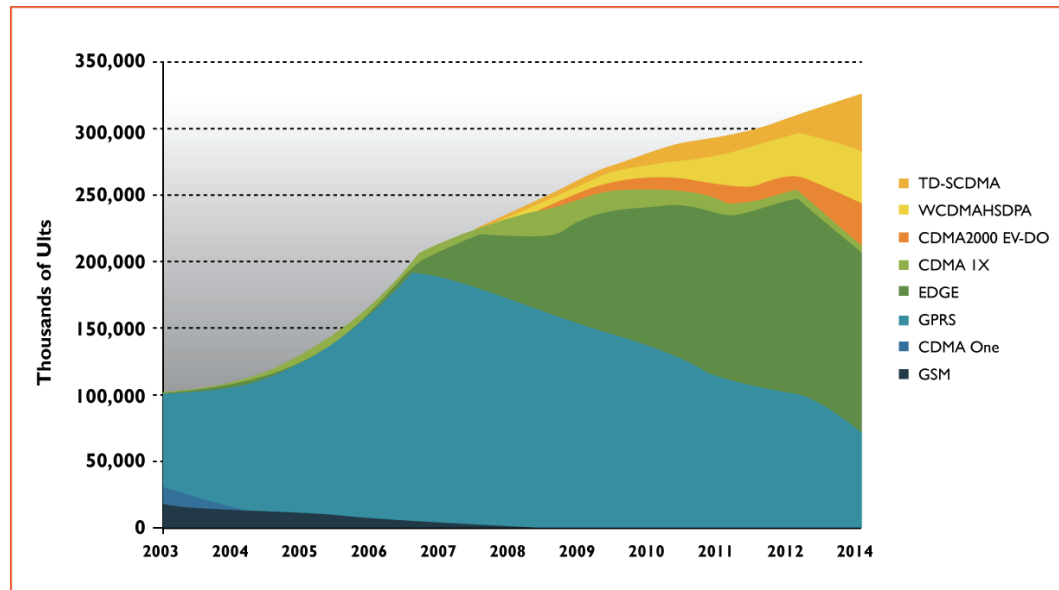


FIGURE 2. CHINA 3G HANDSET MARKET TREND²

Marvell TD Solutions

Recognizing the potential of the China and TD-SCDMA market, Marvell made a strategic decision in 2008 to invest in the development of TD-SCDMA technology for a single-chip smartphone solution. Building on Marvell's state-of-the-art system-on-chip (SoC) technology and partnering with China Mobile, Marvell developed the world's first commercially available TD-SCDMA single chip solution, the Marvell PXA920 platform. The Marvell PXA920 combines a high-performance, low-power application processor with an advanced multimode modem that supports both GSM/EDGE and TD-SCDMA networks. A block diagram of PXA920 is shown in Figure 3.

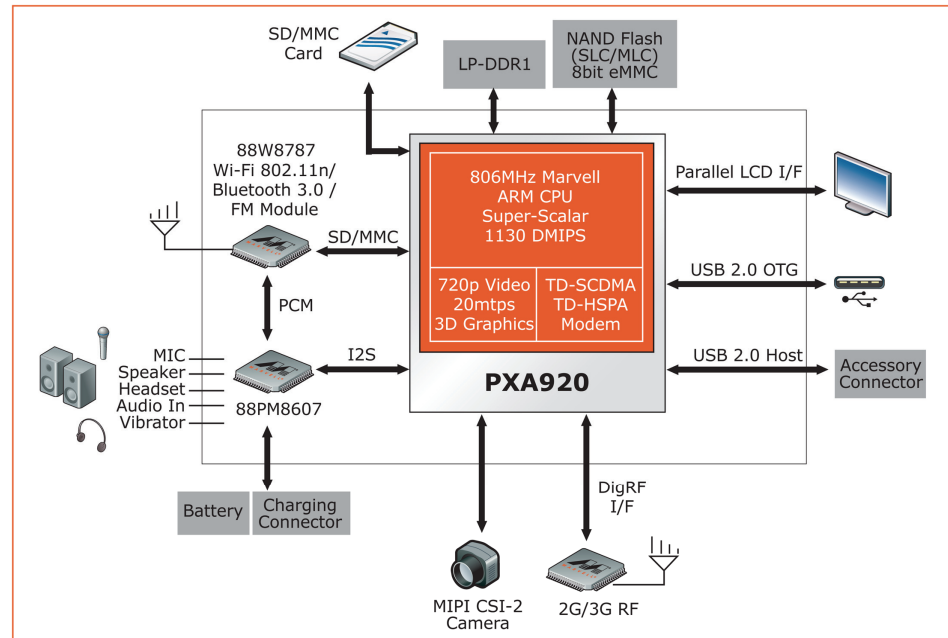


FIGURE 3. MARVELL PXA920 SOC BLOCK DIAGRAM

With built-in accelerators for video and 3D graphics, the PXA920 offers exceptional performance for mobile data services, such as imaging, HD video, music, games and other popular mobile applications.

Marvell provides a complete solution for the PXA920 platform, including RF transceiver, power management IC (PMIC) and integrated WLAN/BT/FM connectivity. In addition to PXA920, Marvell offers the PXA978 communications processor with High-Speed Packet Access (HSPA) modem. PXA978 is the industry's first single-chip solution that features WCDMA and China's TD-SCDMA standard with HSPA+ support, and is intended to enable mobile OEMs to design 3G cellular devices and tablets that can be used and supported globally. And as part of its commitment to the TD-SCDMA vision, Marvell continues to expand its portfolio of TD-SCDMA-based solutions with the introduction of the Marvell PXA1202, an advanced, highly integrated 3G modem for multimedia-centric handsets.

Since the launch of its PXA920 platform, more than a dozen of the world's leading handset OEMs have designed and launched PXA920 based products in China. A wide array of products has been enabled including smartphones, tablets and MiFi mobile hotspot devices. The PXA920 helps enable the long-standing quest for mass-market TD smartphones that are priced at RMB1000 (\approx US\$150). This makes it possible for consumers to have a wide selection of TD smartphones, similar to those offered for WCDMA and CDMA2000.

Conclusions

Since its launch in 2009, TD-SCDMA technology has proven its technologic maturity and commercial viability. The adoption by consumers is expanding rapidly. TD-SCDMA technology is continuously evolving to provide newer capabilities. For example, in 3GPP Release 8, TD-HSPA+ (time division high speed packet access plus) technologies were adopted, that features 64-QAM modulation technology, enhanced L2 including CPC and CELL_FACH, receiver diversity and dual-carrier aggregation. In the next-generation mobile technology, Long Term Evolution (LTE), time division (TD) technology has have equal importance to the frequency division (FDD and TDD) version. Both LTE technologies are being actively developed by leading technology providers and deployed by leading mobile operators around the globe.

Marvell is committed to the TD-SCDMA market. Marvell offers the Marvell PXA920, a single-chip high-performance, low-power application processor with an advanced multimode modem that supports both GSM/EDGE and TD-SCDMA networks, as well as the Marvell PXA978 communications processor with HSPA modem and the Marvell PXA1202, an advanced, highly integrated 3G thin-modem for data card, mobile hotspot and multimedia-centric handsets, to help enable TD and world phone platform devices. The TD market is continuing to accelerate providing ample opportunities for new devices ranging from smartphones, to tablets to mobile hot spot devices. Marvell is committed to driving continued innovation in this important and growing market so that global OEMs can take advantage of this exciting market opportunity.

References

- [1] China Mobile Annual Report, July 2011
- [2] iSuppli, China 3G Handset Market Analysis, Feb. 2011

About the Author:

Lu Chang, Ph.D.

Director of Mobile Products

Lu Chang is Director of Mobile Products at Marvell. He is responsible for mobile communication processors, including PXA920 family, PXA1202, PXA1802. Prior to Marvell, Lu was the Director of Signal Processing at PicoMobile, where he lead the development of multimedia processing for VoIP and video telephony. Prior to PicoMobile, he was at Sonim Technology, where he developed the leading IMS solution for voice and messaging applications. Lu spent 10 years at Motorola, leading research and development of advanced technologies in signal processing, voice processing, and pattern recognition. Lu holds a Ph.D. degree in Electrical Engineering from Queen's University, Kingston, Canada.

Marvell Semiconductor, Inc.

5488 Marvell Lane
Santa Clara, CA 95054, USA

Tel: 1.408.222.2500

www.marvell.com

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