

# Evolution of TD-SCDMA Networks

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## INTRODUCTION

As the basic 3G choice in China, TD-SCDMA has been widely accepted and adopted. The performance of China Communication Standard Association (CCSA) N-frequency TD-SCDMA DCH (Dedicated Channel)-based services has been well testified in both the trial and real networks. It is no question that DCH-based TD-SCDMA is able to provide both voice service and some packet services.

Nowadays, for the ever-increasing demand on the multimedia services, the evolution of TD-SCDMA networks has become a hot issue. Single carrier TD-SCDMA HSDPA (TD-HSDPA for short) was introduced in 3GPP in the R5 version as the downlink evolution of TD-SCDMA networks. Multi-carrier TD-HSDPA, introduced by CCSA, is the enhancement version of the 3GPP single carrier TD-HSDPA, which adopts the multi-carrier to improve the system performance. It offers backward-compatible upgrades to both former N-frequency TD-SCDMA networks and single carrier TD-HSDPA systems. In 2006, 3GPP made its effort to standardize the uplink evolution of TD-SCDMA networks. Released by 3GPP R6 version, TD-SCDMA HSUPA (TD-HSUPA for short) is believed to be able to enhance the system uplink capacity significantly. In order to offer the backward-compatible upgrade to both the N-frequency TD-SCDMA and multi-carrier TD-HSDPA, CCSA started the standardization work of multi-carrier TD-HSUPA in August, 2007.

Armed with both the downlink and the uplink evolution, TD-SCDMA is believed to be able to provide various multimedia services. This article aims at introducing key concepts of the evolution of TD-SCDMA networks, including system architecture, key techniques, protocols, and channels. The article begins with the introduction of the basic characters of TD-SCDMA. Then, the downlink evolution of TD-

SCDMA networks is presented. After that, we present the uplink evolution of TD-SCDMA networks. Key principles of TD-SCDMA Long-Term Evolution (LTE TDD) are discussed at the end of the article.

## BASICS OF TD-SCDMA

Jointly developed by China Academy of Telecommunications Technology (CATT) and Siemens, TD-SCDMA is one of the IMT-2000 standards approved by the ITU. The main benefits of TD-SCDMA are that it can be implemented less expensively than the other comparable 3G systems since it is much more spectrum-efficient and is compatible with the current deployment of GSM network elements, allowing 3G asymmetric services without installation of completely new infrastructures.

Compared with WCDMA and CDMA 2000, TD-SCDMA adopts the TDD duplex mode and uses the same frequency band for both the uplink and the downlink. Meanwhile, the TDD mode has the adjustable switch point between the uplink and the downlink timeslots, which can adapt to the asymmetrical service in uplink and downlink and makes full use of the spectrum resource. Furthermore, the symmetrical channel feature of TDD systems makes it very flexible and convenient for TD-SCDMA to adopt the advanced techniques such as joint transmission, smart antenna, and so on, which can improve the system capability and spectrum efficiency. Key techniques that TD-SCDMA adopts include joint detection, smart antenna, dynamic channel allocation, and so forth. The interested reader is referred to Peng, Chen, and Wang (2007) and Peng and Wang (2007) for more information about key techniques of TD-SCDMA systems.

## KEY CONCEPTS OF TD-SCDMA EVOLUTIONS

### Downlink Evolution: TD-HSDPA

#### System Architecture

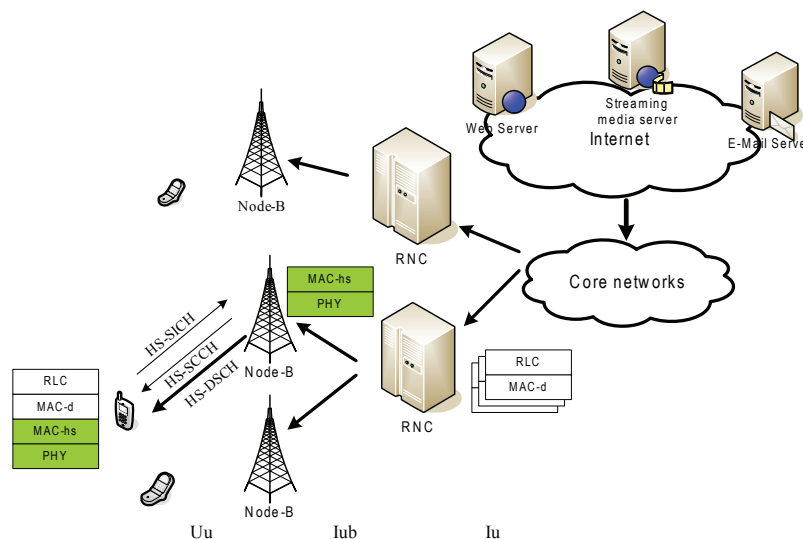
Figure 1 shows the system architecture of TD-HSDPA. The downlink data was originated from a multimedia service server, such as Web server, streaming media server, and so forth, then passes through the core networks and arrives at RNC. After the data is being processed by each layer residing at RNC, namely PDCP/RLC/MAC-d layer, the data was encapsulated into MAC-d PDUs, which are further routed to the specific base station to which the target user belongs. The MAC-d PDUs are further packed into MAC-hs PDU at base station and then are sent via TD-HSDPA air interface (3GPP 25.858, 2002). When the data correctly arrives at the user terminal, each layer at the user terminal does the exactly opposite operations. In order to enhance the ability of providing multimedia services, the new entity that is being introduced into TD-HSDPA is the MAC-hs sub-layer, which is in charge of user/packet/PDU scheduling, transmit format selection, and Hybrid Automatic Retransmit reQuest (Hybrid ARQ) -related processing. Due to the Hybrid ARQ retransmission operation, packets arriving at MAC layer of Node-B are typically out of sequence. Another key function of MAC-hs is the in-sequence

delivery of MAC-d PDU to MAC-d layer. There are three HSDPA-related channels, which are High-Speed Downlink Shared Channel (HS-DSCH), High-Speed Shared Control Channel (HS-SCCH) and High-Speed Shared Information Channel (HS-SICH) (3GPP 25.308, 2007; 3GPP 25.321, 2007). HS-DSCH is the transport channel, which is used to carry the HSDPA-related traffic data. HS-SCCH and HS-SICH are physical channels designed for transmitting HSDPA signaling. HS-SCCH is the downlink control channel. It carries HS-DSCH-related information such as TFRI (Transmission Format and Resource Indicator), Hybrid ARQ process identity and redundancy version, and so forth. HS-SICH is the uplink control channel which is used to signal Hybrid ARQ acknowledgement and the CQI (Channel Quality Indicator) up to Node-B.

#### Hybrid ARQ

Hybrid ARQ with soft combining allows the rapid retransmission of erroneous transmitted packets at MAC layer. It is able to reduce the requirement of RLC layer retransmission and the overall delay; thus, it can improve the QoS of various multimedia services. Prior to decoding, the base station combines information from the initial transmission with that of later retransmissions. This is generally known as the soft combining and is able to increase the successful decoding probability. Incremental redundancy is used as the basis for the Hybrid ARQ operation, and either

Figure 1. TD-HSDPA system architecture



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