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Chinese cellular telecommunications in the past and the 21st century

Hao Xu

Chinese Cellular Telecommunications in the Past and the 21st Century

By

Hao Xu

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B. Thomas Golisano College
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B. Thomas Golisano College
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Student Name: Hao Xu

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Thesis Committee

Prof. Bruce Hartpence Chair		3/18/03
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Abstract

Cellular telecommunication technology is one of the hottest topics of the last two decades. The annual rate of user growth is more than 30 percent. It began with the first generation (1G) networks and bloomed with second generation (2G) of cellular technologies. New third generation cellular (3G) technologies aim at offering high-speed, superior-quality information service to mobile subscribers. [2]

The Chinese cellular market is developing with unbelievable speed. China launched its first cellular network in 1987. At the end of 2002, it was the biggest wireless market in the world, with more than 200 million subscribers. [56] Technologies used in the migration from the 2G networks to the 3G networks are referred to as 2.5 generation or 2.5G. It is no doubt that the 3G pattern selected in China will deeply affect the competition among the 3G technologies. This thesis will forecast the 3G systems to be selected for use in China.

It will begin with the 1G and 2G networks and then look into the 2.5 G and the 3G cellular telecommunication technologies in more detail. Analysis the history, culture and business conditions in China will follow. Finally, this paper will make a prediction of the principal Chinese 3G technologies that will be chosen based on analyzing concrete information. An examination of other Asia markets, such as the 3G markets in Japan, and South Korea will be included.

The conclusion of this thesis is that WCDMA (Wideband Code Division Multiple Access), a 3G technology that is developed and supported by European telecommunication manufacturers, will take the lion's share of the Chinese 3G market,

about 65% to 70%. Another technology, CDMA2000, will take more than 20% of the Chinese 3G market share. There is also a Chinese oriented 3G technology named TD-SCDMA (Time Division Synchronous Code Division Multiple Access). With the Chinese government's support, it will collect the remaining 10% to 15% market share.

1 The History of Wireless Telecommunication

Chapter 1 will introduce the wireless telecommunication history and mainly used wireless technologies.

Wireless telecommunication is one of the boom technologies of the last twenty years. In the middle of the 1980s, European telecommunication manufacturers, regulators and service suppliers developed the GSM (Global System for Mobile) standard and launched the system at the beginning of the 1990s. Within ten years, April of 2001, there were more than 500 million GSM subscribers all over the world. [66] There is no doubt that wireless telecommunication has deeply affected our lives in the twentieth century and will continue to do so in the new century.

The wireless network was introduced in 1946. Although wireless communication methods such as cordless, paging, microwave, and satellite exist in our daily lives, the cellular telecommunication takes the most important position in the wireless field. In this thesis, the word "wireless" refers to "cellular mobile" specifically.

1.1 Several Capstones

A brief history of wireless telecommunication follows:

1. In 1946, AT&T launched the first wireless network. The system used a frequency modification method named FDMA (Frequency Division Multiple Access) and each voice channel occupied 120 KHz of bandwidth. [38]

2. In the mid 1960s, Bell Systems introduced the IMTS (Improved Mobile Telecommunication Service) system. IMTS still used the FDMA method, but each channel occupied only 20—30 kHz. [38]
3. The first cellular network appeared in 1960s. The basic structure of a cellular network divides a whole wireless network into many cells. Different cells use different frequencies, time-slots, or codes to communicate with their mobile terminals. In this way, cellular networks can support multi-users and prevent interference.
4. By the end of the 1970s, the development of the semi-conductor and the microprocessor enhanced the capacity of cellular networks and supported the cellular technologies' development with unbelievable speed. During this time, AMPS (Advanced Mobile Phone System) was launched in North America, TACS (Total Access Communication System) was introduced in the UK, and NMT (Nordic Mobile Telephone) was used in northern European countries.
5. At the beginning of the 1990s, developed countries launched 2G cellular systems such as GSM, CDMA (Code Division Multiple Access), and DAMPS (Digital Advance Mobile Phone Service).
6. Since the mid 1990s, more and more countries and manufacturers have invested huge funds and human hours in the development of the next generation of cellular systems or 3G. There are several reasons for this boom: Firstly, the 1G and 2G networks yielded large profits, which motivated manufacturers and operators to develop more advanced cellular technologies. Secondly, frequency resources are limited. Governments and cellular carriers focused on mechanisms to use the

same frequency resources to serve more users. Finally, in addition to voice services, cellular subscribers want to enjoy multimedia services.

1.2 1G cellular networks

1G networks are all analog systems. They apply the FDMA (Frequency Division Multiple Access) multiplexing method. FDMA works by assigning different frequencies to different channels. During conversation, each user fully occupies the channel assigned to him/her to communicate with the base station.

Table 1.1 summaries several main 1G technologies. [56]

	Frequency MT TX/BS TX (MHz)	Channel frequency (KHz)	Number of channels	Mainly used in
TACS	890-915/935-960	25	1000	Europe, China
ETACS	872-905/917-950	25	1240	Europe, China
AMPS	824-849/869-894	30	832	North America, China
NMT450	453-457.5/463-467.5	25	180	North Europe
NMT900	890-915/935-960	12.5	1999	North Europe
C450	450.3-454.74/461.3-465.74	20	222	Germany
NTT	925-940/870-885	6.25	2400	Japan

Table 1.1 Several 1G technologies

1G networks offered limited coverage and limited services. Moreover, in 1G, there were too many different mobile technologies and standards: AMPS, TACS, NMT and so on. AMPS (Advance Mobile Phone Service) was designed by Bell Laboratories and mainly used in North America. TACS (Total Access Communication System) and NMT (Nordic Mobile Telephone) were used in Europe. Because different technologies used various standards, roaming among different networks was impossible at that time. For

example, an AMPS phone could only roam inside its North American networks. If it was in Europe, it would not work.

The first Chinese 1G wireless network was established in 1987. By 1995, there were about six million 1G subscribers in China. The 1G technologies used in China were TACS, ETACS and AMPS. Twenty-five of thirty Chinese provinces selected TACS and ETACS technologies. The other five provinces built AMPS networks. In July of 2002, China closed all of its 1G networks.

1.3 2G cellular networks

1.3.1 Overview of 2G Technologies

Table 1.2 lists several important 2G technologies:

Parameters	GSM 900	GSM1800	D-AMPS	CDMA	PDC
Orig. Country	Europe	Europe	USA	USA, Korea	Japan
Standardized by	ETSI	ETSI	TIA 53	TIA95	MPT
Uplink (MHz)	890—915	1710—1785	824—849	824—849	810—826
Downlink (MHz)	935—960	1805—1880	869—894	869—894	940—956
Channel spacing (KHz)	200	200	30	1230	25
Duplex range (MHz)	45	95	45	45	130
Access Method	TDMA/TDD	TDMA/TDD	TDMA/TDD	CDMA	TDMA/TDD
Speech data rate (kbps)	13	13	7.25	8.55	6.7
Frequency No.	124	374	832	10	1600
Timeslot/frequency	8	8	3	--	3
Data service rate (Kbps)	9.6 – 14.4	9.6	8	--	9.6-14.4
Output power (W)	2, 5, 8, 20	0.25, 1	0.6, 1.2, 3, 6	0.5, 2, 6	0.3, 0.8, 2

Table 1.2 Several important 2G technologies

(From: "Mobile Radio Networks" Bernhard H. Walker, WILEY Publishers, 1998, P8)

1.3.2 The Story about GSM and CDMA

At the beginning of the 1990s, the second-generation wireless technologies began to emerge. Once more, too many technologies were introduced. At this time, different wireless manufacturers and governments began to care about international roaming. Through fierce competition, two leaders emerged. One was GSM, which was developed by European companies. GSM employs the TDMA (Time Division Multiple Access) method. TDMA works by dividing a frequency into several short time slots. Each channel is assigned a specific time slot to transmit voice or data signal. Because of rapid slot switching at hundreds of times per second, each user is under the impression that the channel is serving him/her all the time. The other leading standard was CDMA (Code Division Multiple Access), which was put forward by Qualcomm Incorporated in the United States. CDMA allots different codes to different wireless devices to encode and decode communication signals. First, a user's signal is multiplied with its code. Then, all users' signals are spread over a wide band of frequency. The receiver knows the unique code that is used by the sender enabling the receiver to uniquely decode the signal while others can only hear a noise. From a technology standard point, CDMA is superior to GSM. It offers a more secure line and better voice quality services to wireless subscribers. Furthermore, using the same frequency resources, CDMA can serve more subscribers. However, CDMA was not mature by the time GSM commercial networks were successfully launched in Europe. There, thanks to successful marketing strategy, GSM holds a monopoly position in the 2G market. By the end of September 2002, there were 869 million mobile users all over the world. The number of total Global GSM users was 591 million which accounts for 68 percent of total users. The number of total

CDMA users was 127 million or 14.9 percent of total users. [65] Yet, CDMA is a better wireless solution than GSM. Today, most 3G technologies are based on the idea of CDMA, such as WCDMA and CDMA2000. Figure 1.1 shows the subscribers' percentage of different wireless technologies in June 2002.

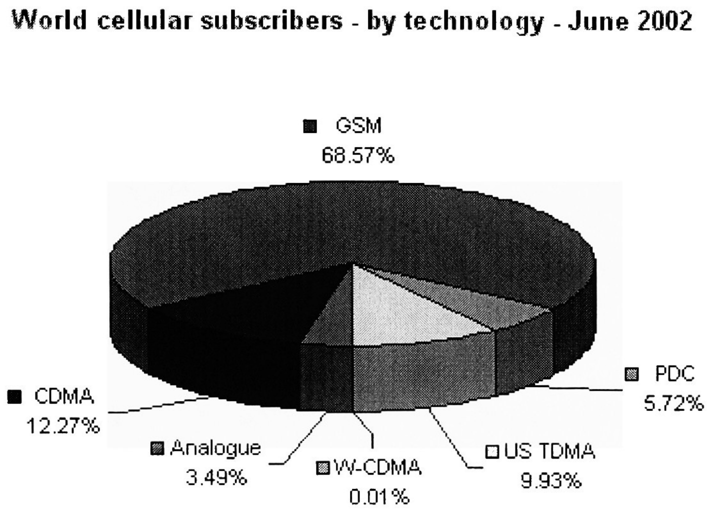


Figure 1.1 The subscribers' percentage of different wireless technologies

(From: *http://www.gsmworld.com/news/statistics/index.shtml*)

Both GSM and CDMA are used in China. In October of 1995, the first commercial GSM networked was launched in Beijing. By the end of 2002, there were 200 million GSM subscribers in China. GSM is offered by two Chinese operators; China Mobile and China Unicom. In January of 2002, China Unicom launched the sole Chinese CDMA network. By the end of 2002, the Chinese CMDA network had more than seven million subscribers. [73]

1.3.3 GSM

GSM emerged as the leader of the 2G technology competition. Today, there are more than 380 GSM networks on-air in 171 countries. [66] One advantage of GSM is its open

structures. The GSM standard is agreed upon worldwide. Thus, a GSM network can be composed of different items that are made by different manufacturers and the newest equipment can be easily added to an existing GSM network.

1.3.3.1 GSM Frequency

At present, GSM networks operate on three different frequency bands:

1. 900MHz. The original GSM bandwidth is assigned to 890-915MHz and 935-960MHz frequency bandwidth. As a result, sometimes, GSM900 is also called GSM. GSM originated from European countries and spread all over the world. Later, when the 900MHz frequency resource was almost dried up, another bandwidth, 1800 MHz, was added to the GSM frequency family. [58]
2. 1800MHz. As mentioned above, the GSM1800 is a byproduct of GSM900 technology. It is also called PCN (Personal Communication Network), or DCS1800 (Digital Cellular System). GSM1800 further extended the market share of the GSM family and is widely used in Europe and Asia. [58]
3. 1900MHz. GSM1900 is the Northern American version of GSM. It is also called PCS (Personal Communication Service), or PCS1900. 1900MHz is the only available GSM bandwidth in the USA and Canada. GSM1900 takes a small slice of the North America cellular market share. [58]

Each GSM frequency takes a 200 KHz bandwidth and is divided into eight timeslots, called channels. That is a TDMA method. Compared with FDMA, TDMA has a very distinct advantage. If one wishes to communicate on a frequency, one must use a transmitter and a receiver, which is combined into a transceiver. In FDMA, each frequency is called a channel. Thus, for an FDMA site to support eight channels, it must

have eight transceivers. However, a GSM site that supports 8 channels needs only one transceiver. Huge equipment costs are saved while the expense of maintenance and power is considerably reduced.

1.3.3.2 GSM Structure

The architecture of GSM network is shown in Figure 1.2:

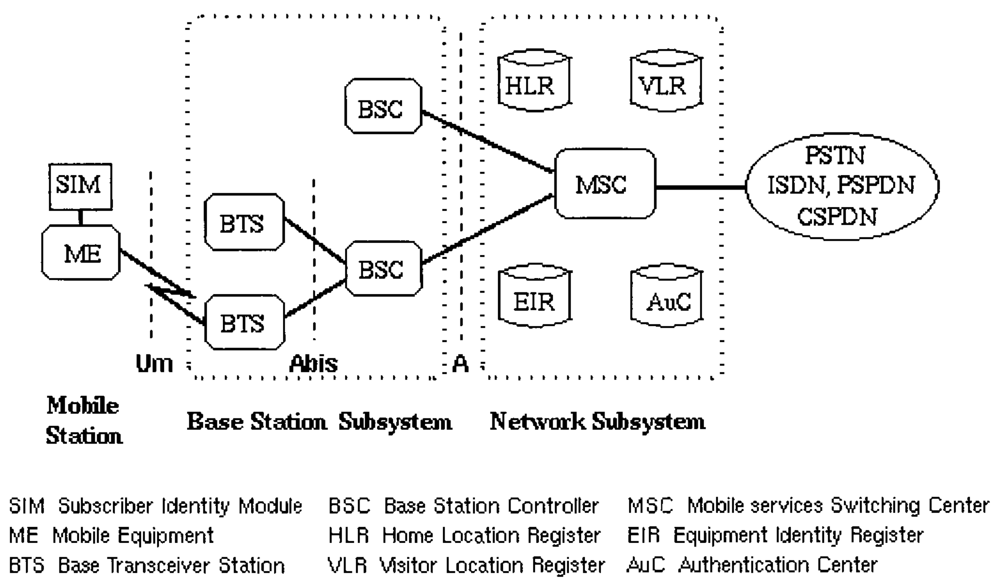


Figure 1.2 GSM Structure

(From: http://ccnga.uwaterloo.ca/~jscouria/GSM/gsmreport.html)

1. An ME (Mobile Equipment), also known an MS (Mobile Station), UE (User Equipment), or MT (Mobile Terminal), is a phone used in a cellular network. For the purpose of keeping consistency, since this paragraph, This paper will use the term “MT” to describe the concept “mobile phone”. A mobile user needs such services as voice, data, short messages, and so on. An MT uses a SIM (Subscriber Identity Module) card to identify a mobile subscriber and to support security functions. The SIM card concept is a smart idea. A user can change the

SIM card from one GSM mobile phone to another within 10 seconds and begin to use the second mobile phone. The SIM card concept greatly promotes the consumption of GSM mobile phones. [85]

2. A BTS (Base Transceiver Station) is the equipment that communicates directly with MT. BTS is also abbreviated as BS (Base Station). Normally, the signal from BS to MT is called a downlink signal (or forward link signal) while the signal from the MT to BS is called an uplink signal (or reverse link signal). Each BTS occupies one or more frequencies and thus has 8*n channels (n= 1, 2, 3 ...). A BTS can simultaneously communicate with multi-users in its area. When an MT user travels from one BTS area to another, it needs correct technology to roam from one BTS to another. In GSM networks, one or several BTSs are controlled by a BSC.
3. A BSC (Base Station Controller) has basic MT management functions. It connects with one or more BTSs and handles such functions as communication channel setup, frequency hopping, and roaming. Moreover, BSC sends information about MT and BTS to MSC and executes commands from the MSC.
4. An MSC (Mobile services Switching Center) is the kernel of a GSM network. It manages all the users inside its network and is in charge of other functions such as roaming and billing. As indicated in the diagram, there are several registers or databases associated with the cellular network. Interiorly, an MSC combines with VLR and connects with the HLR, EIR, AuC, and BSC. Exteriorly, an MSC acts as an interface to other networks, such as another GSM network, ISDN

(Integrated Services Digital Network), or PSTN (Public Switched Telephone Network). [84]

5. An HLR (Home Location Register) holds all-important information relating to each mobile terminal that takes the local area as its home location area. The information contains: telephone number, equipment type, subscription basis and supplementary services, access priority, and so on. Temporary data, such as current location area and roaming number, which are necessary for setting up a connection, is also saved. When a mobile terminal roams to another area, the temporary data is updated immediately.
6. Regarding hardware, a VLR (Visitor Location Register) is integrated into an MSC. VLR keeps the information of all the roaming users in the local mobile network. It gets such information from the responsible HLR. Both HLR and VLR help MSC realize such functions as handover, paging, and billing.
7. An EIR (Equipment Identity Register) helps a network realize authorization functions. An EIR has three different lists: white-list, grey-list and black-list. The white-list contains information about users who have clean telecommunication histories and are permitted to communicate in the mobile network. The grey-list delineates users that are under observation and may exhibit some problems. The black-list gives local network information about users that are not allowed to connect with the network. [84]
8. An AuC (Authentication Center) functions as a security and ciphering unit. Each mobile subscriber is given a secret key, one copy of which is stored in the SIM card of a mobile phone and the other is in the home AuC. During authentication,

the AuC generates a random number and then sends it to the mobile phone. Both the mobile phone and the AuC then use the secret key to calculate the random number. After that, the MT sends its result to AuC. Only when the result from the MT is same as the result from the AuC, is the mobile phone authenticated to communicate in the local mobile network. [84]

9. SMSC (Short Message Service Center) is the unit that stores and forwards short messages. It is used to support value-added services.

1.3.4 CDMA

Developed originally by Qualcomm, CDMA is characterized by high capacity and small cell radius. CDMA, originally known as IS95, employs a special coding and spreading spectrum scheme. The first CDMA system was launched in 1992. In 1993, it was adopted by TIA (Telecommunications Industry Association). With the efforts of Qualcomm, the first formal CDMA standard, IS95-A, was announced in 1995. In 1996, IS95-A was further modified, and IS95-B was set out in 1998. Today, the IS95 family also contains IS95-C, IS95-HDR, IS99, IS657, and so on. Normally, we use a term CDMAone to represent the 2G CDMA product group. [56]

Over 35 countries have either commercial or trial run CDMA networks. Although the USA is the original CDMA market, at present, the biggest CDMA market is in South Korea. [60]

1.3.4.1 CDMA Strong Points

A CDMA channel is nominally 1.25 MHz wide. Compared with GSM, CDMA has the following strong points:

1. CDMA uses advanced power control methods such as open-loop power control and close-loop power control, and thus the interference between users is dramatically reduced. In addition, CDMA employs spread spectrum technology that can provide up to 10-20 times the capacity of analogue equipment and more than 3 times the capacity of GSM. [60]
2. Owing to CDMA's special power-control methods, CDMA users can enjoy longer talk time, longer battery life, and smaller phones.
3. CDMA filters out background noise, cross-talk, and interference. In addition, its special coding scheme helps it provide much better voice and call quality than does GSM. [60]
4. CDMA improves security and privacy. With approximately 4.4 trillion codes, it virtually eliminates the possibility of cloning and other types of fraud. [60]
5. CDMA uses the soft-handoff scheme to enjoy a much lower dropped calls rate and less disruption than GSM. Because of its coding and spreading schemes, CDMA can use a same frequency at different radio stations or even across the whole network. When a user is roaming from one site to another, his/her CDMA phone is actually communicating with two or more radio base stations simultaneously. Only when the signal from one radio station is much better than those from other radio stations, will the user's signal be logically handed off from one base station to another.

1.3.4.2 CDMA Structure

The architecture and the basic unit functions of CDMA are also the same as GSM.

CDMA is a backward compatible technology. It can be smoothly upgraded to 3G technologies, step by step, by the following method: CDMAone, CDMA2000-1X, CDMA2000-3X, and higher CDMA2000 phase. [60]

2 2.5G Technologies

Chapter 2 will introduce two GSM 2.5 G technologies: GPRS and EDGE. The structures, interfaces, and applications of GPRS and the principles of EDGE will be illustrated.

2.1 What is 2.5G?

Wireless cellular networks are very expensive, normally cost billions of dollars. As a result, wireless operators want to keep their cellular networks profitable for as long as possible. If they have to upgrade their networks, they prefer to improve their networks incrementally. The 2.5 generation (2.5G) refers to technologies used in the migration from the 2G networks to the 3G networks. At present, GSM and CDMA take most of the 2G market share. GRPS and EDGE are 2.5G methods for GSM. For CDMA, there are no commonly agreed upon 2.5G technologies. The ITU takes all CDMA2000 group technologies, such as CDMA2000-1X and CDMA2000-3X, as 3G technologies. [56] For this reason the thesis will introduce CDMA2000-1X and CDMA2000-3X in chapter 4.

2.2 GPRS

GPRS (General Packet Radio Service) offers wider bandwidth than GSM 9.6kbps data speed. Defined in GSM Phase 2.1, GPRS uses the same spectrum, frequency, modulation scheme, and TDMA frame as GSM. Upgrading a GSM network to a GPRS one requires few modifications in hardware but needs major modifications in software.

2.2.1 Circuit Switching and Packet Switching

Traditional communication methods utilize circuit-switching mode. During communication, a physical path connects the users at the two ends of the line; and that path stays open until the end of the conversation. In the process of communication, those two users exclusively occupy that physical path and no other users can use that path at that time.

The packet switching mode originated from data telecommunication. This advanced concept is widely used in present telecommunication fields. Most modern telecommunication networks convert information into bits. During the message transmission, the information is chopped into equal small pieces. Then each piece is given a header and padding if necessary to form a packet. The major part of a packet's contents is reserved for the data to be transmitted. This part is called the payload. The information about source and destination addresses is included in the header. The communication source and relay equipment transmits each packet according to its destination address. Each equipment can dynamically select a transmitting path to send the information to its destination. At the destination, all the packets are reassembled to revert to the original information. The data carrying capacity of a modern telecom network is very large. They are able to cascade and transmit the packets from different users through one physical line. This means that packets from many different phone users can be mixed into the same transmission channel, and correctly sorted at the other end. A constant, exclusive, direct channel between the sender and the receiver is no longer needed.

Packet data is added to the channel only when there is something to communicate, and the user is only charged for the amount of data been sent. For example, when reading a small article, the user will only pay for what's been sent or received. However, both the sender and the receiver get the impression of a communications channel is "always on". Thus, packet switching method sufficiently utilizes telecommunication resource. Moreover, GPRS does not use a dial-up modem. The connection time for GPRS is only 1 to 3 seconds, which is the reason that GPRS is also referred as an "always connected" technology.

2.2.2 GPRS Hardware Structure

Figure 2.1 shows the basic structure of a GPRS network.

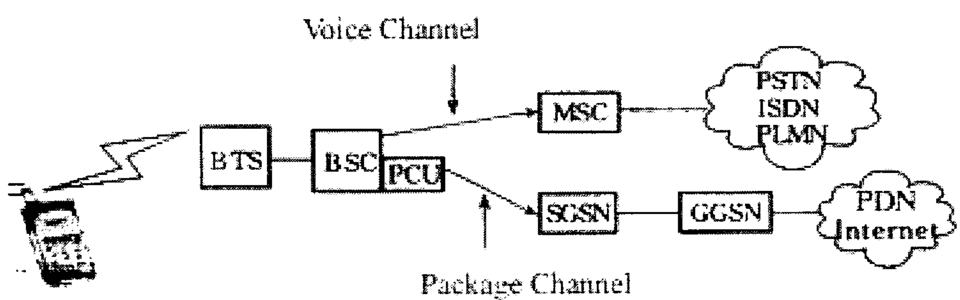


Figure 2.1 Basic GPRS Structure

(From: http://www.mc21st.com/techfield/systech/cdma/main.htm)

In a GPRS network, the voice service still follows the path: MT → BTS → BSC → MSC, or vice versa. However, the data communication takes another one: MT → BTS → BSC → PCU → SGSN → GGSN, or vice versa.

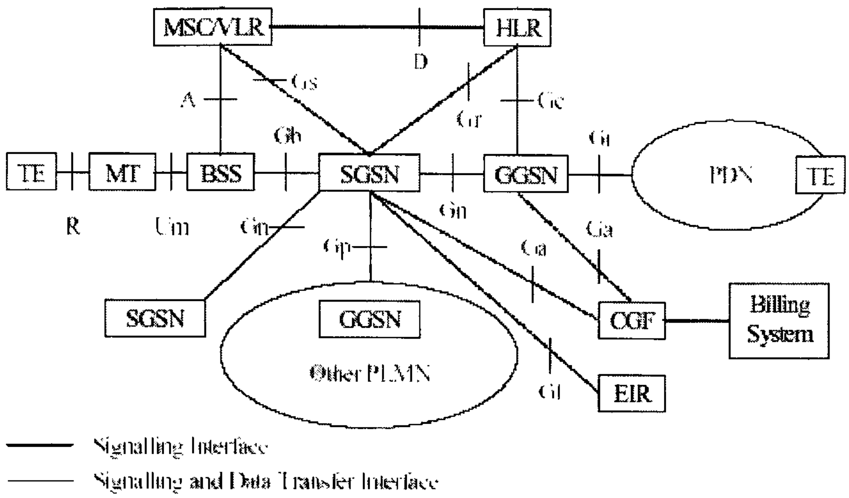
Several new pieces of hardware need to be added to the GSM network.

The PCU (Packet Control Unit) is added to or connected with BSC. It offers functions like data transmission of BSS, air interface controlling, and supporting multi-users sharing the same radio resource. [56]

The SGSN (Serving GPRS Supporting Node) is connected with MSC, HLR, and VLR. The SGSN has two functions. Firstly, it is the supporting interface to MT. When an MT actives its GPRS function, the SGSN supports a management environment for that MT. It also performs security functions, mobility management, and access control. Secondly, SGSN sends packets to an MT or receives packets from an MT. [59]

The GGSN (Gateway GPRS Supporting Node) acts as a router and gateway to a GPRS network. It connects with SGSN and different external data networks, such as IP or ISDN networks. It has the routing table of all the activate GPRS mobile phone and external networks. When an external user sends a packet to an MT, the GGSN receives the packet from external network and forwards it to the related SGSN, using a tunneling technology named GTP (GPRS Tunneling Protocol). Then, SGSN will send the packets to the related MT. As well, GGSN can covert different packets between the internal GPRS network and external IP or X.25 network. [59]

The detailed logical structure of GPRS is listed out in figure 2.2



GMSC – Gateway MSC CGF – Charging Gateway Function

Figure 2.2 GPRS interfaces Structure

(From: *http://www.mc21st.com/techfield/systech/cdma/main.htm*)

2.2.3 GPRS Software Modifications

In order to update to GPRS, the GSM network needs the following software modifications:

1. Update the software for HLR;
2. Upgrade the software for MSC;
3. Upgrade the software for BSC to cooperate with the PCU;
4. Upgrade the software of BTS to cooperate with the BSC.

2.2.4 The Data Speed of GPRS

GPRS supports four different Data Rates. The higher data rates are achieved by using fewer error protection bits. However, error detection can still be ensured through

methods available in upper layer applications. The four different Data rates are 9.05kbps, 13.4 kbps, 15.6 kbps, and 21.4 kbps. [66]

Like GSM, GRPS uses TDMA, with eight timeslots in each frame. If we devote all 8 timeslots to one user, GPRS can get its theoretical maximum speed: 8 * 21.4 = 171.2 kbps. This is about three times as fast as the 56kbps possible over today's fixed telecommunications networks, and seventeen times as fast as current Circuit Switched Data services on GSM networks. Even if only one time slot were allotted to a user, the minimum speed is still two times of today's 2G data speed. By allowing information to be transmitted more quickly and efficiently across mobile networks, GPRS can act as a promoter for the wireless data boom.

2.2.5 GPRS Services

According to GSM Phase 2.1, GPRS supports the following services:

1. Point to Point Connectionless Networking Service
2. Point to Point Connection Oriented Networking Service
3. Point to Multipoint Service

As a result, a wide range of corporate and consumer applications are enabled via GPRS, such as chatting, Web page surfing, file sharing, file transmission, information services (stock market, sports, news, weather, traffic, and so on), and E-mail.

2.2.6 GPRS Terminals

There are three classes of terminal defined in GPRS:

1. Class A: supports simultaneous voice and data services. This means that a Class A phone user can enjoy talking and receiving data at the same time. [56]

2. Class B: supports both voice and data services. However, it cannot offer the two services simultaneously. The terminal can automatically distinguish between the two services and switch to the correct function. [56]
3. Class C: supports both voice and data services. However, it cannot simultaneously support the two functions and cannot automatically switch between them. The MT user needs to manually switch between the voice and data services. [56]

2.3 EDGE

EDGE (Enhanced Data rate for GSM Evolution) is a technology based on high mobile data speed standard. It still employs GSM/GPRS network and uses the TDMA scheme. When all eight timeslots are used, EDGE allows a maximum data speed up to 384 kbps, which means that the maximum data speed on each time slot is 48 kbps. Even higher speed can be achieved in good radio conditions.

EDGE was formerly called GSM384. It is developed by mobile operators who failed to get part of the European 3G spectrum, as known as UMTS (Universal Mobile Telephone System) spectrum. EDGE gives incumbent GSM operators an opportunity to offer data services that is almost as fast as the speed of UMTS networks.

EDGE makes major changes in the radio interface. GSM/GPRS networks use GMSK (Gaussian Minimum Shift Keying) method. To support higher data rates, EDGE employs 8-PSK (8 Phase Shift Keying) Modulation to coexist with GMSK.

Table 2.3 lists the differences between 8-PSK and GMSK. [56]

	8-PSK	GMSK
Bits/Symbol	3	1
Payload/Time Slot	346 bits	114 bits
Gross User Rate/Time Slot	69.2 kbps	22.8 kbps
Gross User Rate/Carrier	553.6 kbps	182.4 kbps
User Rates /Slot after coding	22.8 -- 69.2 kbps	11.2 -- 22.8 kbps

Table 2.3 Comparison of 8-PSK and GMSK

Changing modulation method means that operators have to modify the BTS and other crucial equipment in GSM, which will cost vast amounts of money. However, this change is mandatory in order to offer high speed data services. The software upgrade of the BTS and the BSC can be implemented remotely. The new EDGE capable transceiver can handle standard GSM traffic and will automatically switch to EDGE mode when needed.

For EDGE services, an EDGE capable terminal is also needed as GSM/GPRS terminals do not support EDGE service. Initially the EDGE terminal transmission can be asymmetric, higher data speed on downlink than on uplink. Later the device can support high data speeds on both downlink and uplink. In September of 2002, Nokia launched the first EDGE network in the world. The trial run condition needs further observation.

3 Key Technologies for the 3G Mobile Communication

Chapter 3 will introduce several new concepts and technologies that will be used in the 3G systems.

3.1 Power Control Technologies

In a CDMA family BTS, all users share the same bandwidth. The level of a users' transmission power will directly influence the capacity of the network. This makes the power control technology one of the most important core technologies of the CDMA family.

There are three different power control methods in CDMA family: open-loop power control, close-loop power control and outer-loop power control.

Open-loop power control is based on the principle that the product of a user's receiving power multiplied by transmitting power is a constant. The open-loop power control method is realized as follows: An MT first measures receiving power and then determines transmitting power accordingly. Open-loop power control doesn't consider the transmitting differences between the uplink and downlink. It is used for determining users' initial transmitting power or the condition that an MT encounters suddenly changing telecom environment. [60] The forward link and the reverse link still need the help of close-loop power control to help them modify the transmit power from time to time.

Close-loop power control can be preformed hundreds of times per second. Power control information is determined by comparing the measured receiving power and the

signal/interference ratio threshold. Then, power control bits are transmitted from one telecommunication end (BS or MT) to the other (MT or BS). Finally, the received terminal adjusts its transmitting power accordingly. [60]

Outer-loop power control determines its signal-interference ratio threshold based on the result of the received frame error rate. [60] Outer-loop power control usually needs variable step method to speed up the adjustment of the signal-interference ratio threshold.

In WCDMA, CDMA2000, and TD-SCDMA systems, open-loop power control, close-loop power control and outer-loop power control are used in uplink channels, while the close-loop power control and outer-loop power control are adopted for downlink channels.

3.2 Smart Antenna Technology

The use of smart antennas is a new application of adaptive antenna arrays in the telecommunication fields. It uses several antennas to form an array to receive and send wireless signals. Owing to the limited size and computing complexity, it is suited for Base Stations only. The smart antenna is composed of two parts. The first part of a smart antenna figures out the brief path and direction of the signal sent by an MT and suppresses interference from other MTs. The second part sends signal back to the MT according to the path and direction that was calculated by the first part. The transmitted signal is directed toward the MT originating the communication. In this way, the BS transmit power can be reduced and the interference between mobile phones is also obviously decreased. [79]

3.3 Rake Receiver

The radio propagation environment is complicated. Figure 3.1 gives out a brief illustration of different propagations:

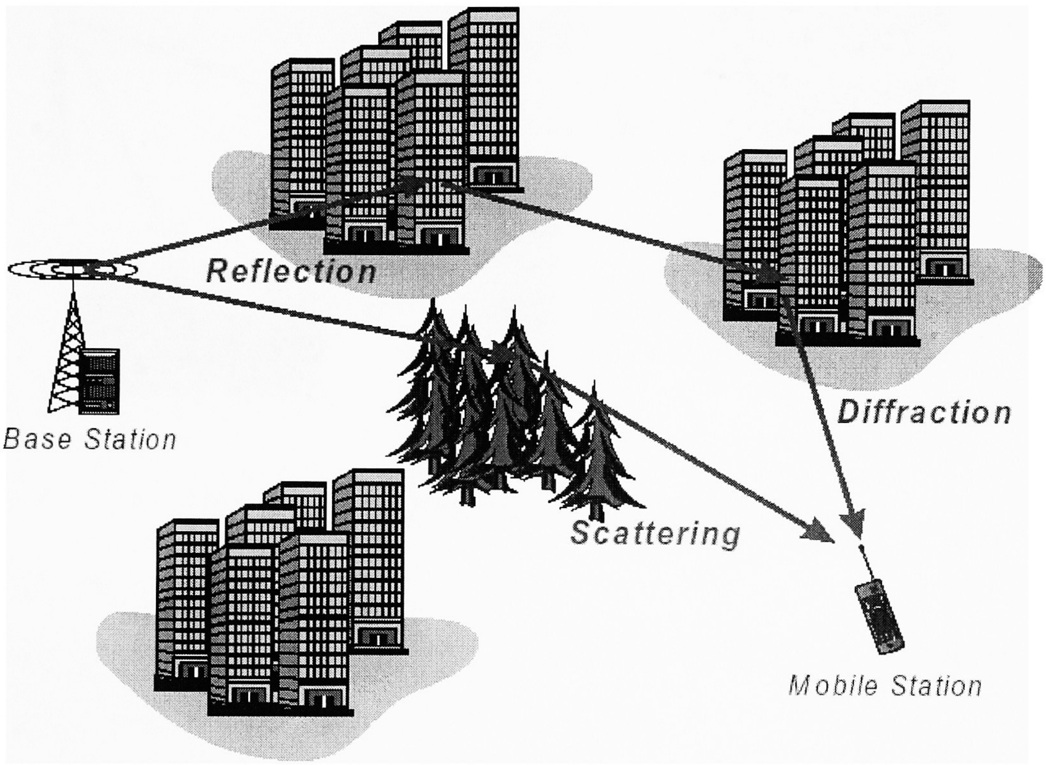


Figure 3.1 Principle of propagation

(From:

http://www.utdallas.edu/~gxm016000/Lecture%2018%20November%201%202001.pdf)

Multi-path is a result of different propagation paths. According to the different transportation paths, such as directly arrived, reflected, or scattering path, the signal received by an MT or a BS is composed of several peaks or signals, as illustrated in figure 3.2. [28]

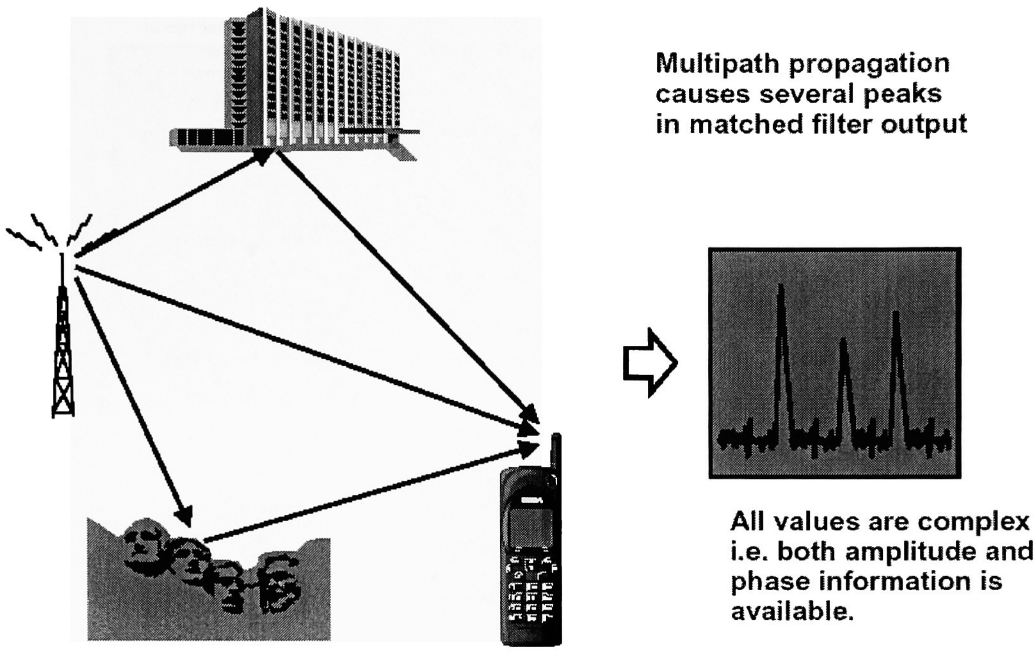


Figure 3.2 Propagation caused multi-path

(From:

http://www.utdallas.edu/~gxm016000/Lecture%2018%20November%201%202001.pdf)

Figure 3.3 illustrates the principle of Rake Receiver:

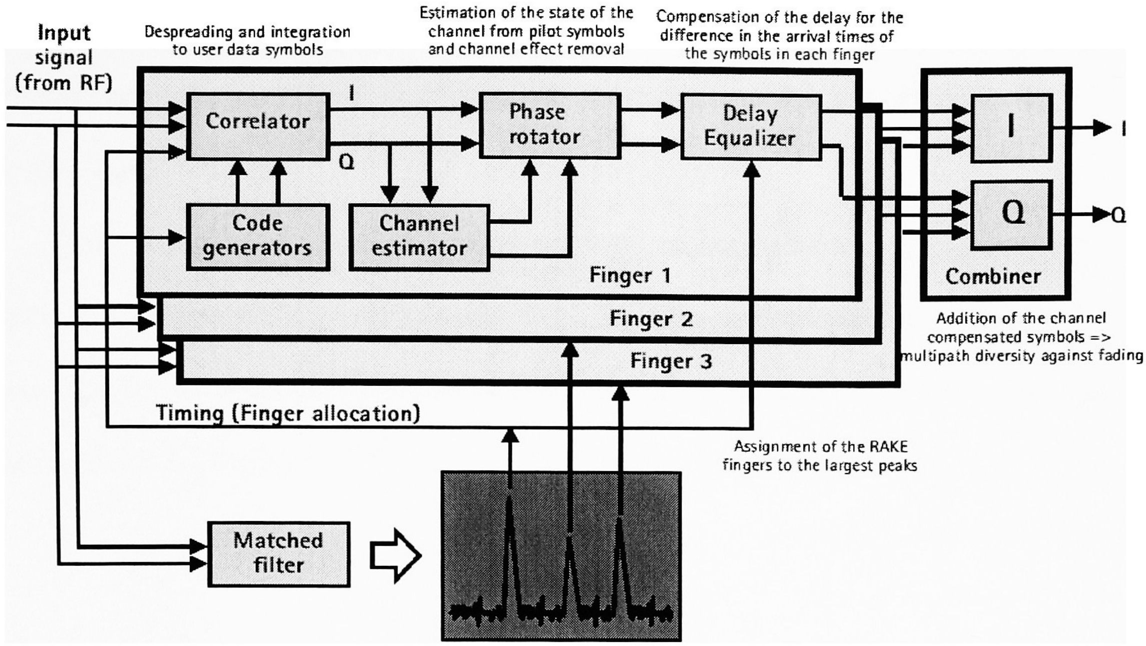


Figure 3.3 The principle of Rake Receiver

(From:

http://www.utdallas.edu/~gxm016000/Lecture%2018%20November%201%202001.pdf)

The received signal is imported into several rake finger receivers. In figure 3.3, finger 1, 2, and 3 represent different finger receivers. Each finger receiver only focuses on one peak and decodes the signal independently. Then, the rake receiver gets several results of the same signal and combines them together. As a result, the multi-path propagation signal does not degrade the received signal quality but improves it.

3.4 Multi-user Detection

In a traditional CDMA system, each MT's reception is done independently. Under multi-path fading environment, it is usually hard to keep the orthogonality of the user codes, causing mutual interference among users which limiting the system capacity. A good solution is to employ multi-user detection technology. Using a matrix inversion and

an interaction approach method, multi-user detection technology can eliminate mutual interference among users through measuring and can correct the non-orthogonality among users. [28]

Theoretically, multi-user detection technology can enrich the system capacity to a great extent. But it will greatly increase the complexity of Base Stations. At present, lowering the complexity of the multi-user offset equipment to an acceptable level is the focus of this technology.

4 3G Technologies

Chapter 4 will illustrate the concepts of 3G and introduce the three main 3G radio interface schemes: WCDMA, CDMA2000, and TD-SCDMA.

4.1 3G Overview

Today, the outline of the 3G systems has become clear. It will be composed of satellite nets and terrestrial cellular nets and form a three-dimensional communication network that covers the whole world. Section 4.1 will give an overview of 3G, such as 3G services, data speed, structure, and radio interface.

4.1.1 3G Services

A 3G device will blur traditional boundaries of technology and can act as a PC, a phone, and a PDA (Personal Digital Assistant) all in one. It would not be too much of an exaggeration to say that people will live their lives around their 3G devices. They can connect to anybody at anytime and anywhere.

Besides audio conversation, 3G terminals will also provide:

1. High-speed, mobile access to the Internet.
2. Entertainment on demand, which will include movies and music.
3. Video-conferencing (using the device's build-in micro-video camera).
4. Mobile shopping. Browse available items and pay using electronic cash.
5. Travel information: congested roads, flight departures, location services, hotel reservation, and so on.

4.1.2 3G Data Speed and Migration Guidelines

The 3G mobile communication systems will have markedly better services capabilities than the second-generation systems. They should be able to support voice to packet data multimedia services, and should be able to provide bandwidth according to needs. Of the requirements the ITU (International Telecommunication Union) set for the 3G mobile communication wireless transmission systems, 3G technologies should meet the following:

1. Maximum rate up to 144Kb/s in a high-speed moving environment; [2]
2. Maximum rate up to 384Kb/s in an outdoor to indoor or walking environment; [2]
3. Maximum rate up to 2Mb/s in an indoor environment. [2]

During the introduction of 3G technologies, the networks must evolve gradually and be flexible. This is due to the size and complexity of the 2G networks. The 3G networks must also be compatible with the 2G systems. In the meantime, 3G networks should meet the following standards:

1. High spectrum efficiency;
2. High QoS;
3. Low cost;
4. High security than 2G networks.

4.1.3 The standardization of 3G

The ITU started the process of defining the standard for 3G systems, referred to as International Mobile Telecommunications 2000 (IMT-2000).

The ITU, ITU-R and ITU-T direct the standardization work of 3G. The ITU-R is in charge of the standardization of RTT (Radio Transmission Technology) and selecting international spectrums for 3G systems. The ITU-T is divided into several groups. Issues such as services, speech coding, numbering, traffic engineering, QoS and security are handled by the various study groups of the ITU-T. [56]

4.1.4 IMT-2000 Structure

Figure 4.1 shows the basic structure of IMT-2000

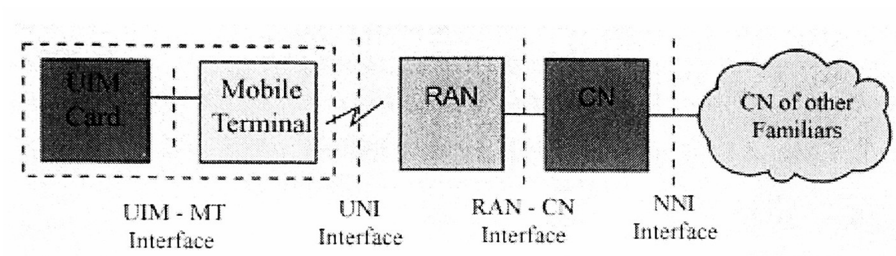


Figure 4.1 IMT-2000 system structure

(From: http://www.mc21st.com/techfield/systech/cdma/c4.html)

As shown in Figure 4.1, IMT-2000 is composed of four systems: CN (Core Network system), RAN (Radio Access Network system), MT (Mobile Terminal system), and UIM (Universal Identity Module system). The CN, RAN, MT and UIM perform the same functions as the MSS, BSS, MT and SIM in a GSM system. [56]

There are four standard interface groups in IMT-2000:

1. NNI interfaces: The interfaces between different Core Networks. There are different 3G technology groups. The ITU defines different groups as different “families”. The NNI are interfaces between different “families”. NNI interfaces ensure the interconnection and roaming among 3G systems. [29]

2. RAN-CN interfaces: The interfaces between CN and RAN.
3. UNI interfaces: The radio interfaces between RAN and MT.
4. UIM interfaces: The interfaces between MT and UIM.

4.1.5 Different 3G Schemes

To realize seamless coverage, 3G has to combine different air interface technologies. It will even use satellite to cover maritime or desolate areas. However, the most important 3G technologies are focused on terrestrial schemes of radio interfaces, which support most of the users and bring the predominant business to wireless operators.

There are different 3G terrestrial radio interface schemes. Most of them are based on existing cellular technologies, such as WCDMA, CDMA2000 and, UWC-136. Others are new concepts based schemes such as TD-SCDMA. WCDMA is based on GSM technologies, CDMA2000 is based on CDMA, and UWC-136 is based on IS-136, which is a TDMA 2G scheme used in the North America.

In China, the 3G marketing competition will focus on three schemes: WCDMA, CDMA2000, and TD-SCDMA. The rest of this chapter will introduce the three different schemes.

4.1.6 3G Terrestrial Radio Interface Specifications

ITU asked for proposals of the 3G terrestrial Radio Interface Specifications at the beginning of 1997. In June of 1998, ITU received 15 proposals. In November 1999, a comprehensive set of terrestrial radio interface specifications for IMT-2000 was approved in Helsinki. Five standards were designated as 3G Terrestrial Radio Interfaces, and were

divided into two groups: the CDMA group and the TDMA group. Table 4.1 lists the contents of those two groups. [29]

Group Name	Multiplexing Method	Interface method	Corresponding to
CDMA group	IMT-DS	Direct Spread	WCDMA
	IMT-MC	Multi Carrier	CDMA2000
	IMT-TC	Time Code	UTRA TDD TD-SCDMA
TDMA group	IMT-SC	Single Carrier	UWC-136
	IMT-FT	Frequency Time	DECT

Table 4.1 IMT-2000 Terrestrial Radio Interfaces

IMT-TC corresponds to two schemes. The first one is UTRA TDD, which was put forward by Siemens. The second proposal was named TD-SCDMA (Time Division-Synchronous Code Division Multiple Access), which was proposed by CWTS (China Wireless Telecommunication Standards group) and supported by the Chinese government. Later, Siemens joined the TD-SCDMA group and set up the TD-SCDMA forum with CWTS. [56]

4.2 WCDMA

WCDMA is a radio access scheme based on GSM technologies and is dedicated to using the best migration path from GSM to 3G. WCDMA is mainly promoted by European governments and manufacturers. In Europe, WCDMA is also known as Universal Mobile Telecommunications System (UMTS). The ETSI (European Telecommunications Standards Institute) was responsible for the UMTS standardizations process. [52] At present, 3GPP (3rd Generation Partnership Project) is in charge of the standardization of WCDMA.

4.2.1 3GPP

3GPP is an international collaboration that was established in December 1998. It is composed of six members: ARIB (Japan), CWTS (China), ETSI (Europe), T1 (North America), TTA (South Korea), and TTC (Japan). This organization formulates GSM networks based next generation mobile communication system standards, which are originated from European ETSI UTRA Proposal and Japanese ARIB WCDMA Proposals. 3GPP has five main UMTS standardization areas: Radio Access Network, Core Network, Terminals, Services and System Aspects. [44]

4.2.2 WCDMA Technical Details

4.2.2.1 Parameters

Table 4.2 lists the basic parameters of WCDMA. [56]

Duplex mode	FDD and TDD
Channel bandwidth	4.4 – 5 MHz
Spread method	Direct Spreading
Chip* rate	3.84 Mcps
Spreading modulation	QPSK
Frame length	10 ms
Time slots per frame	15
Channel coding	Convolution and turbo code
Power control method	open-loop, fast close-loop, and outer-loop 1500Hz
Handover	Soft handover, softer handover, and interfrequency handover
Data modulation	Downlink: QPSK Uplink: BPSK
Spreading factors	Downlink: 4 – 512 Uplink: 4 – 256

Table 4.2 WCDMA parameters

* In the telecommunication field, chip is the basic digital code unit used to multiplexing or de-multiplexing the source data.

4.2.2.2 Layers Structure

WCDMA's air interface is divided into three protocol layers

1. Layer 1: Physical layer →Corresponding to ISO/OSI's physical layer.
2. Layer 2: Data link layer →Corresponding to ISO/OSI's data link layer.
3. Layer 3: Network layer → Corresponding to ISO/OSI's layer 3 to layer 7.

Figure 4.2 shows the layers structure of WCDMA:

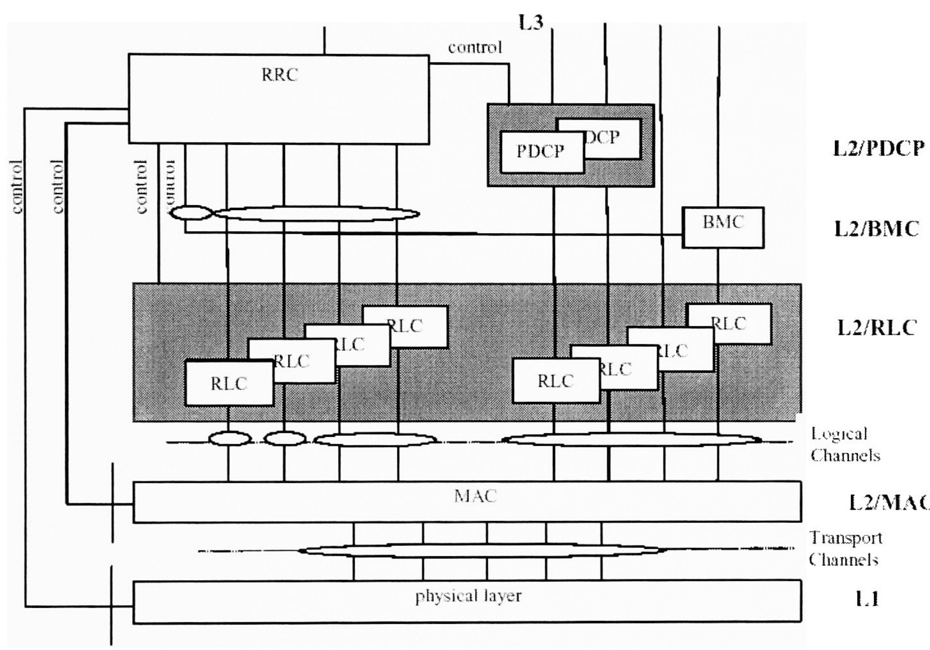


Figure 4.2 WCDMA layer structure

(From: *http://www.privateline.com/3G/WCDMA.pdf*)

4.2.2.2.1 Layer 1

Layer 1 offers physical channels, which provide information transfer services to the MAC layer.

Physical channels are consisted of radio frames and time slots. A WCDMA frame is 10 ms and includes 15 time slots. A time slot is a unit that consists of fields containing bits. The physical channel defines the number of bits in each time slot. Depending on the symbol rate of the physical channel, the configuration of radio frames or time slots varies.

4.2.2.2.2 Layer 2

Layer 2 and layer 3 are divided into a control plane and a user plane. Layer 2 is divided into four sublayers; they are RLC (Radio Link Control), PDCP (Packet Data Convergence Protocol), BMC (Broadcast/Multicast Control), and MAC (Medium Access Control). The PDCP and BMC only exist in the user plane. [56]

4.2.2.2.2.1 RLC Sublayer

The RLC sublayer is used to establish or release connection with upper layers. It can transmit transparent, assured, and unassured data for upper layers. The RLC sublayer has the following functions:

1. Flow control;
2. Error detection and correction;
3. Segmentation and assembly;
4. Data transfer;
5. Supplicate detection;
6. Sequence integrity.

4.2.2.2.2.2 PDCP Sublayer

The main functions of PDCP are as follows:

1. Compressing of redundant Network PDU control information (header compression);
2. Transferring packet data and user data using services provided by RLC sublayer.

4.2.2.2.2.3 BMC Sublayer

. The BMC adapts broadcast and multicast services on the radio interface. It is located above RLC. The L2/BMC sublayer is assumed to be transparent for all services except the broadcast/multicast services.

4.2.2.2.2.4 MAC Sublayer

The MAC sublayer provides data transfer service to RLC and other higher layers. It has the following functions:

1. Selecting TFS (Transport Format Set) to deliver data to the physical layer
2. Priority handling among different users
3. Access controlling on RACH (Random-Access Channel) and FACH (Forward-Access Channel)
4. Multiplexing of RACH, FACH, and other dedicated channels

4.2.2.2.2.4.1 Logical Channels

The MAC sublayer provides data transfer services on logical channels. In WCDMA, logical channels are mapped to transport channels. A logical channel is defined by what type of information is transported over the channel, such as broadcast, paging, access, and so on. Logical channels are classified into two groups, control channels, which are used for transferring control plane information, and traffic channels, which are used for transferring user plane information.

The control channels group has the following channels: [18]

1. PCCH (Paging Control Channel): A downlink channel that sends out paging information and is used when a network does not know the location of an MT.
2. BCCH (Broadcast Control Channel): A downlink channel for distributing system control information.
3. CCCH (Common Control Channel): A bidirectional channel that conveys control information between a network and an MT.
4. DCCH (Dedicated Control Channel): A point-to-point bidirectional channel that transmits dedicated control information between a user terminal and a cellular network.
5. SCCCH (Shared Channel Control Channel): A bidirectional channel that transmits control information between the RRC and MAC sublayers.
6. OCCCH (ODMA Common Control Channel): A bidirectional channel for transmitting control information between user terminals.
7. ODCCH (ODMA Dedicated Control Channel): A point-to-point bidirectional channel that transmits dedicated control information between user terminals.

The traffic channels group contains the following channels: [18]

1. DTCH (Dedicated Traffic Channel): A bidirectional point-to-point channel that transfers user information to and from a user terminal.
2. ODTCH (ODMA Dedicated Traffic Channel): A point-to-point channel that transfers user information between mobile users.
3. CTCH (Common Traffic Channel): A point-to-multipoint channel that used to transfer user information to dedicated user terminals.

4.2.2.2.2.4.2 **Transport Channels**

The transport channels are defined by the methods and characters of the data being transferred over the air interface. There are two types of transport channels: Dedicated Channels and Common Channels.

The Dedicated Channels (DCH) are point-to-point bidirectional channels that carry user or control information between the network and User Terminals.

Common Channels are point-to-multipoint channels that transport data or system information. The following are several common channels: [18]

1. BCH (Broadcast Channel): A fixed-rate point-to-multipoint channel that spreads system information in the whole cell.
2. FACH (Forward-Access Channel): A point-to-multipoint channel that transports data to one or more user terminals.
3. PCH (Paging Channel): A point-to-multipoint channel that pages a user terminal in a cell.
4. RACH (Random-Access Channel): An uplink transport channel used by a user terminal to submit data and control packets.
5. CPCH (Common Packet Channel): An uplink transport channel. The CPCH is a contention-based random access channel used for transmitting gusty data. It associates with a dedicated channel on the downlink, which provides power control for the CPCH.
6. DSCH (Downlink Shared Channel): A downlink transport channel shared by several mobile stations. A DSCH is associated with a DCH.

Each transport channel relates to a TFS (Transport Format Set), which defines encoding, interleaving, and mapping of the transport channel. The MAC layer uses the TFS to select suitable channels.

4.2.2.2.2.4.3 **Mapping between Logical Channels and Transport Channels**

There are many options in mapping different logical channels to transport channels. It depends on a range of criteria such as the type of information to be sent, the connection method, and the broadcast method. Figure 4.4 lists out the relationship between the logical channels and transport channels:

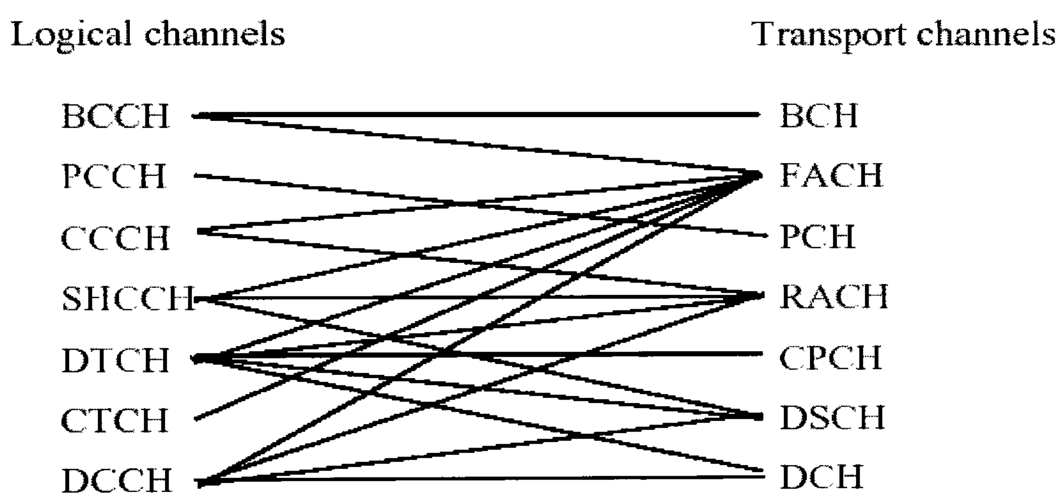


Figure 4.3 WCDMA logical channels to transport channels mapping method

(From: *http://www.privateline.com/3G/WCDMA.pdf*)

4.2.2.2.3 Layer 3

WCDMA Layer 3 corresponds to OSI layer 3 through layer 7. It supports applications and services for WCDMA users. As mentioned in 4.2.2.2.2, Layer 3 is also divided into control plane and traffic plane. Meanwhile, it is split into different sublayers. The RRC sublayer is the lowest sublayer of Layer 3.

4.2.2.2.3.1 RRC Sublayer

The RRC sublayer can provide the following services to core networks:

1. Notify paging services;
2. General control service, which is used as an information broadcast service;
3. Dedicated control service, which is used to establish or release a connection and transfer data through the connection.

It has functions as follows:

1. Radio resource handling;
2. System information broadcasting;
3. Quality of Service controlling.

4.2.3 The WCDMA Radio Access Network Structure

Figure 4.5 describes the Radio Access Network of WCDMA, which is named UTRAN (UMTS Terrestrial Radio Access Network) in Europe.

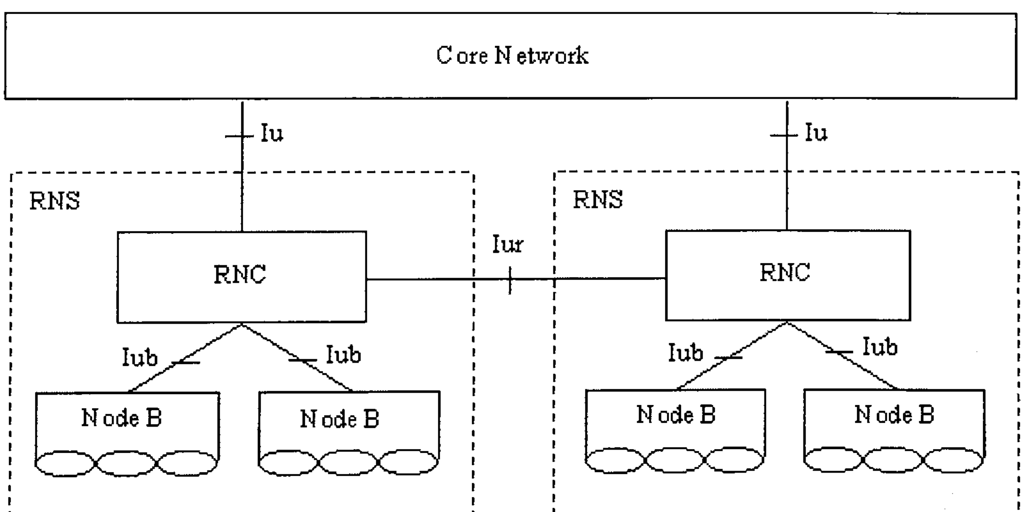


Figure 4.4 WCDMA radio access network
(From: http://www.mc21st.com/techfield)

UTRAN is composed of several RNSs (Radio Network Subsystems). The interface between an RNS and a Core Network is the Iu. Each RNS, corresponding to the BSC in 2G networks, contains a RNC (Radio Network Controller) and several Node Bs. The interface between different RNCs is the Iur. [10] The Node B, corresponding to the BTS in 2G networks, supports FDD, TDD, or dual mode. The interface between an RNC and a Node B is the Iub. [11]

4.2.4 The Migration Path from GSM to WCDMA Network

Figure 4.6 shows the migration path from a GSM network to a WCDMA network.

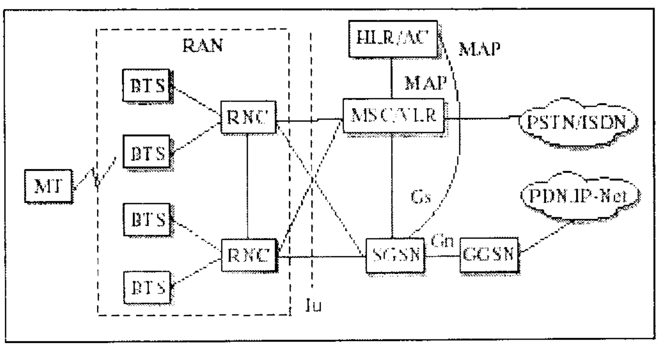


Figure 4.5 WCDMA migration method

(From: *http://www.mc21st.com/techsubject/subjects/cdma/main.htm*)

The migration path is based on GSM/MAP and GPRS networks. MAP (Mobile Application Protocol) is the control protocol used in GSM networks. The MSC/VLR will handle the voice and circuit data services; while the SGSN and GGSN will manage the packet data services. The RNC will replace the BSC in GSM networks, which supports the voice, circuit, and packet services to MT. [83]

4.3 CDMA2000

The CDMA cellular scheme was developed by Qualcomm in the beginning of 1990s. Until now, most CDMA methods are raised by the TIA (Telecommunications Industry Association) of the ANSI (American National Standard Institute). The TIA focuses on IS (Interim Standards) standards, such as IS95, IS41, and IS634. In 1995, it put forward standard IS95-A. After further modification, in 1998, it set out IS95-B. At that time, ITU was collecting drafts for 3G. Because it was busy at preparing the IS95-B standard, TIA did not devote much time or energy systemically compiling the 3G draft. It put forward the CDMA2000-1X and CDMA2000-3X standards quickly. The precise CDMA2000 standard was actually finished in March of 2000. [56]

Today, a group named 3GPP2 (3rd Generation Partnership Project 2) is in charge of the standardization of CDMA2000 series technologies.

4.3.1 3GPP2

3GPP2 was also formed in 1998. It consisted of five main groups: ARIB and TTC in Japan, CWTS in China, TTA in Korea and TIA in North America. 3GPP2 aims at completing the formulation of CDMA familiar's 3G standard – CDMA2000. [45] CDMA2000 is based on IS95 and IS41. It intends to offer high-speed data services with maximum of 2Mbps.

4.3.2 CDMA2000 Technical Details

4.3.2.1 Parameters

Table 4.3 lists the main technical features of cdma2000 series technologies. [56]

Bandwidth (MHz)	1.25	3.75	7.5	11.25	15
Source of Radio Interface	IS95				
Source of network structure	IS41				
Max. bandwidth (bps)	307.2K	1.0368M	2.0736M	2.7648M	3.6864M
Chip Rate (Mcps)	1.2288	3.6864	7.3728	11.0592	14.7456
Frame time	Normally 20ms, but can select 5ms, 10ms, and so on.				
Synchronization	Yes, using GPS.				
Power Control	Open-loop, close-loop, outer-loop, 800Hz.				
Modulation	QPSK				
Spreading	QPSK				

Table 4.3 CDMA2000 family parameters

4.3.2.2 Difference between CDMA and CDMA2000 group technologies

Table 4.4 gives the comparison of CDMA and CDMA2000. [56]

Feature	CDMA	CDMA2000
Channel bandwidth (MHz)	1.25	1.25/3.75/7.5/11.25/15
Chip rate (Mcps)	1.2288	1.2288/3.6864/7.3728/ 11.0592/14.7456
Single-user data rate (kbps)	9.6 – 115.2	9.6 – 2048
Modulation	BPSK	QPSK
Pilot-based coherent detection	Downlink: yes Uplink: no	Downlink: yes Uplink: yes
Channel coding	Convolution code	Convolution and Turbo code
Dedicated control channel	No	Yes
Fast forward power control	No	Yes
Use of turbo codes	No	Yes
Frame length	20ms	20ms (or 5ms, 10 ms)

Table 4.4 CDMA and CDMA2000 cooperation

Compared with CDMA, the CDMA2000 group has the following features:

1. Besides reducing the power control loop delay, the pilot-based coherent detection offers significant performance gain by providing a coherent phase reference for coherent demodulation at the base station.

2. Fast forward power control significantly improves the performance in the low-mobility environment.
3. Downlink transmit diversity increases the effective frequency diversity and provides improvement in link performance without incurring additional complexity at the mobile receiver.
4. Turbo code can provide higher capacity.
5. Core network is compatible with such schemes as IS41, GSM/MAP and IP.
6. Flexible frame length makes it convenient to transport different applications.
7. Support multi-bandwidth. The forward link supports MC (Multi-Carrier) and DS (Direct Spread) method. The reverse link supports DS only. In the MC method, the bandwidth can be N * 1.25 MHz (N = 1, 3, 6, 9 or 12). Wider channel bandwidth can offer higher statistical multiplexing gain among multiple users and higher single-user data rate. Figure 4.6, figure 4.7 and figure 4.8 show CDMA2000-1X and CDMA2000-3X frequencies:

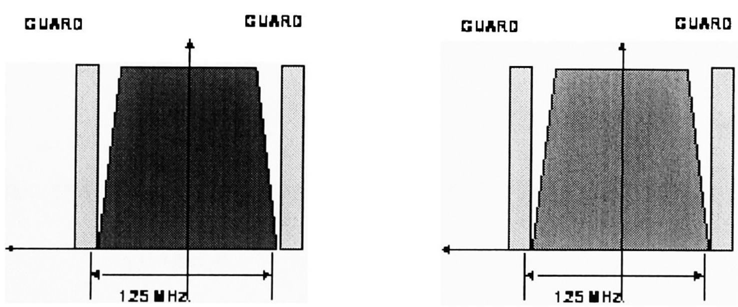


Figure 4.6 CDMA2000-1X forward and reverse link

(From: *http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf*)

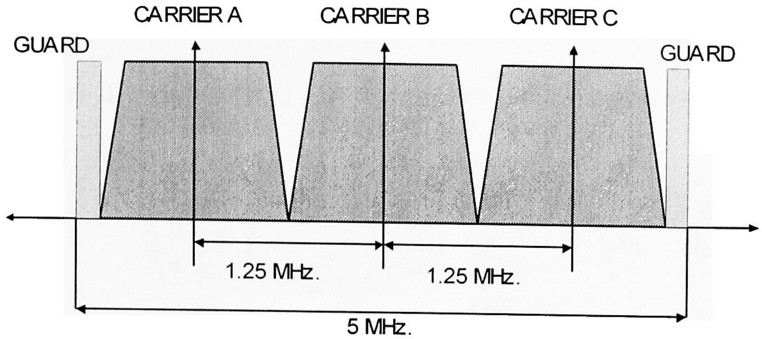


Figure 4.7 CDMA2000-3X forward link

(From: *http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf*)

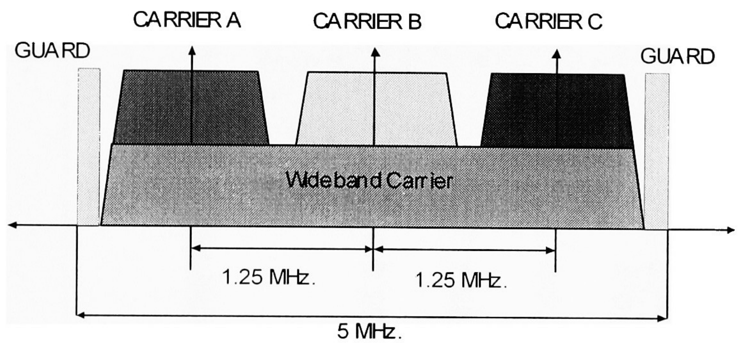


Figure 4.8 CDMA2000-3X reverse link

(From: *http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf*)

From the above figures we can see that, in CDMA2000-1X, the forward link or reverse link occupies a 1.25 MHz frequency independently. In a CDMA2000-3X system, the forward link uses three carriers to transmit information while the reverse link combines the three related frequencies for communication. [61]

4.3.2.3 Layer Structure

Figure 4.9 shows the layer structure of the CDMA2000 family:

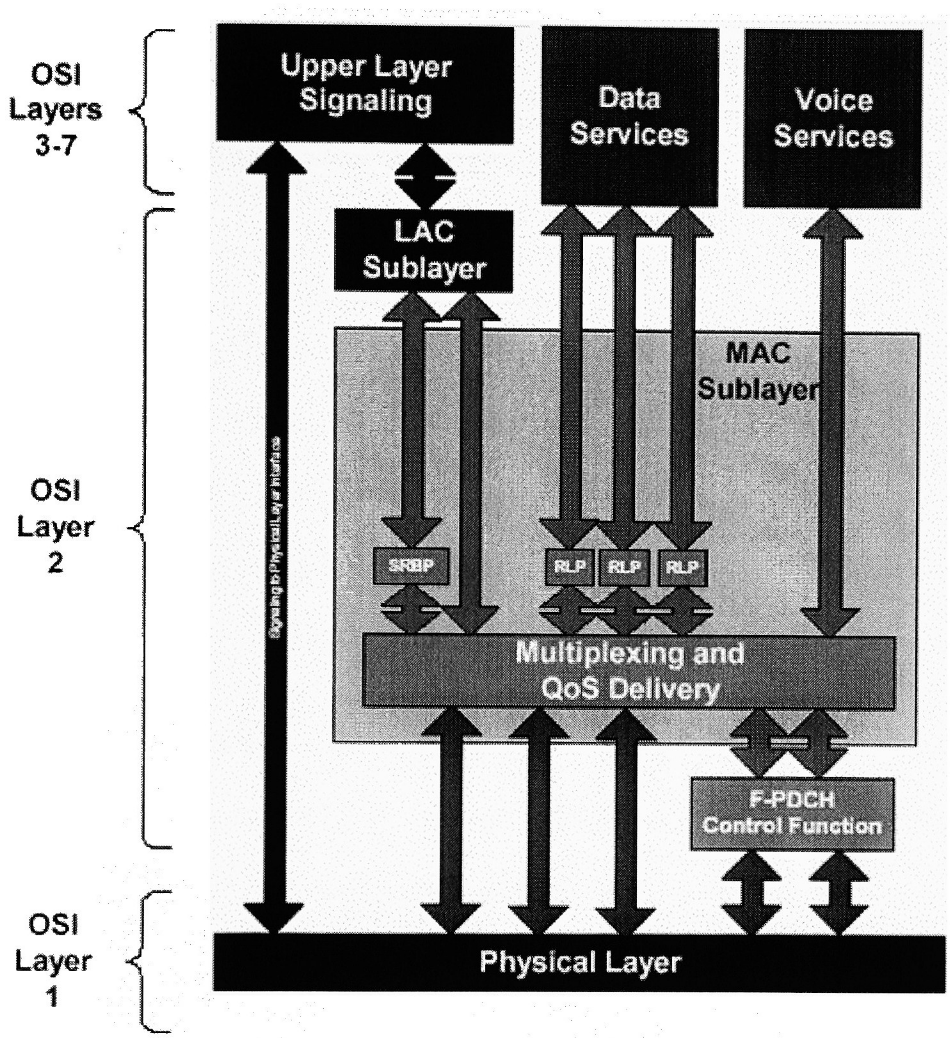


Figure 4.9 CDMA2000 layer structure

(From: http://www.3gpp2.com/Public_html/specs/C.S0002-0_v3.0.pdf)

Like WCDMA, CDMA2000 provides three protocol layers that correspond to ISO/OSI's 7 layers reference mode. Layer 1 and Layer 2 correspond to the physical layer and data link layer. The Physical Layer offers physical channels for voice and data transmission. The Data Link Layer is divided into two sublayers: LAC (Link Access

Control) and MAC (Medium Access Control). The LAC is the upper layer and is involved in signaling only. The lower layer or MAC maps logical layers to physical layers. Layer 3 utilizes the services provided by the two lower layers. The functions of different layers are like those of WCDMA. This section will mainly introduce CDMA2000 items that are different from those of WCDMA.

4.3.2.3.1 Layer 1

Layer 1 provides coding and modulation services to the MAC sublayer of layer 2. Following coding and modulation, layer 1 generates a set of physical channels that are transmitted in the air. In CDMA2000, physical channels are classified in two distinct groups: The DPHCH (Dedicated Physical Channels) offer a point to point connection while the CPHCH (Common Physical Channels) offer a point to multi-point access. [33]

4.3.2.3.1.1 Dedicated Physical Channel (DPHCH)

The DPHCH contains F_DPHCH (Forward DPHCH) and R_DPHCH (Reverse DPHCH). The F_DPHCH channel group contains: [56]

1. F-FCH (Fundamental Channel): It is designed to transport dedicated data.
2. F-SCHT (Supplemental Channel Type): They are channels allocated dynamically to meet a required data rate.
3. F-DCCH (Dedicated Control Channel): It is used to transport mobile-specific control information.
4. F-DAPICH (Dedicated Auxiliary Pilot Channel) (optional): Uses antenna beam-forming and beam-steering techniques to increase the coverage or data rate towards a particular user.

The R_DPHCH channel group contains: [56]

1. R-FCH (Fundamental Channel): It is designed to transport dedicated data.
2. R-SCHT (Supplemental Channel Type): They are channels allocated dynamically to meet a required data rate.
3. R-DCCH (Dedicated Control Channel): It is used to transport mobile-specific control information.
4. R-PICH (Pilot Channel): It provides the capabilities for coherent detection.

4.3.2.3.1.2 Common Physical Channel (CPHCH)

Like DPHCH, The CPHCH contains F_CPHCH (Forward CPHCH) and R-CPHCH (Reverse CPHCH). The F_CPHCP channel group contains: [56]

1. F-PICH (Pilot Channel): It provides capabilities for soft handoff and coherent detection.
2. F-CAPICH (Common Auxiliary Pilot Channel): It also provides capabilities for soft handoff and coherent detection.
3. F-PCH (Paging Channel): It provides paging functions while supporting short burst data communications.
4. F-CCCH (Common Control Channel): It also provides paging functions while supporting short burst data communications.
5. F-SYCH (Sync Channel): It is used for providing system information and synchronization to a mobile terminal.

The R_CPHCH channel group contains: [56]

1. R-ACH (Access Channel): It is the channel that a mobile terminal utilizes to transport access message to a base station.
2. R-CCCH (Common Control Channel): Like the R-ACH, it is used to transport control information to a base station.

4.3.2.3.2 Layer 2

Layer 2 is divided into two sublayers, the LAC (Link Access Control) and the MAC (Medium Access Control). The LAC is used to support upper layer's signaling information. The MAC supports the data services and voice services of CDMA2000's layer 3 directly.

4.3.2.3.2.1 LAC (Link Access Control):

The LAC Sublayer is the upper sublayer of Layer 2. It implements a data link protocol that provides for the correct transport and delivery of signaling messages generated by Layer 3. It is used to manage the point-to-point communication channels between peer upper layer entities. The LAC makes use of the services provided by the lower layers. [35]

4.3.2.3.2.2 MAC (Medium Access Control):

The MAC Sublayer is the lower sublayer of Layer 2. It implements the medium access protocol and is responsible for transporting LAC protocol data units using the services provided by layer 1.

4.3.2.3.2.2.1 Logical Channel Naming Scheme

The naming scheme of logical channels is three lower letters followed by "ch", which means "channel". Table 4.5 lists the meaning of first three lower letters.

First letter	Second letter	Third letter
f = Forward r = Reserve	d = Dedicated c = Common	t = traffic; m = MAC s = Signaling

Table 4.5 CDMA2000 logical channel naming method

For example, the name of the Reserve Common Signaling logical channel is r-csch.

4.3.2.3.3 Layer 3

Similar to that of WCDMA, the Layer 3 of CDMA2000 is corresponding to ISO/OSI's layer 3 to layer 7. It supports applications and services for CDMA2000 users.

4.3.2.4 Migration Path

Figure 4.10 gives the migration path from a CDMA network to a CDMA2000 network.

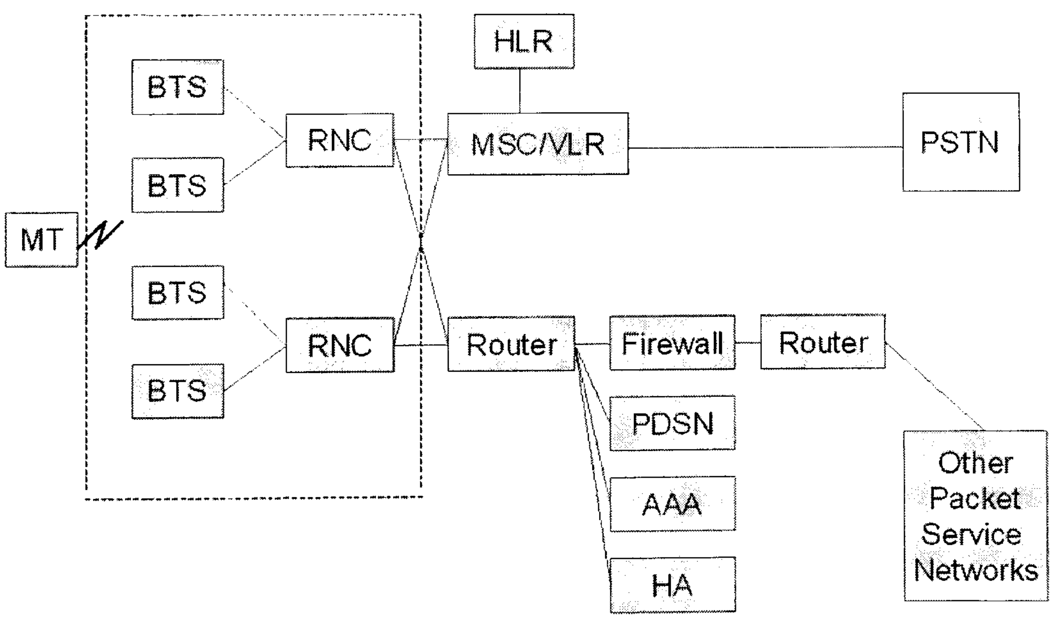


Figure 4.10 CDMA2000 migration method

(From: *http://www.mc21st.com/techfield*)

In order to upgrade to CDMA2000, there are several new modules that need to be added to a CDMAone system, such as PDSN (Packet Data Service Node), AAA (Authentication, Authorization, and Accounting), and HA (Home Agent). [56] Their functions are discussed in the following sections.

4.3.2.4.1 PDSN

PDSN (Packet Data Service Node) is the heart of packet data services of a CDMA2000 system. It is used to support the following major functions:

1. Establishes, maintains, and terminates the PPP (Point-to-Point Protocol) connections with the User Equipment.
2. Sets up the authentication, authorization, or accounting for user equipment and sends the data to the AAA server.
3. Supports the Simple IP and Mobile IP services of a CDMA2000 system.
4. Acts as the interface to external packet services networks.
5. Receives service parameters of user equipment from the AAA and sends user data to the AAA server.

4.3.2.4.2 AAA

AAA (Authentication, Authorization, and Accounting) server supports the authentication, authorization, and accounting functions of a CDMA2000 system. It communicates with the PSDN and supports the following functions:

1. Authenticates the PPP and mobile IP connections
2. Authorizes service profile and distributes the security keys
3. Accounts the packet parameters that are related to billing

4.3.2.4.3 HA

HA (Home Agent) supports many tracing functions. When a user moves or roams in a CDMA2000 system, the HA will ensure that the related packets are send to the user correctly.

4.3.2.4.4 Routers and Firewall

Routers are responsible for sending and receiving packets to and from other packet services networks. The firewall is used to ensure the security of the system.

4.4 TD-SCDMA

TD-SCDMA was proposed by CWTS (China Wireless Telecommunication Standards group) in June of 1998. In May of 2000, the ITU selected TD-SCDMA as one of the 3G radio interface schemes. 3GPP adopted TD-SCDMA as part of UMTS Release 4 in March of 2001. In the beginning, a Chinese telecommunication manufacturer named Datang was devoted to the development of the TD-SCDMA system and Siemens joined the team later. As an innovative 3G radio interface standard, TD-SCDMA can cover all radio environments, from rural to downtown, from pedestrian to high mobility, from micro cells to macro cells. TD-SCDMA is perfect in handling both symmetric and asymmetric traffic, making it ideal to support mobile Internet and mobile multimedia applications. [51]

4.4.1 TD-SCDMA Parameters

Table 4.7 shows main parameters of TD-SCDMA. [56]

Multiplexing scheme	TDMA, CDMA, FDMA
Carrier bandwidth	1.6 MHz
Frame length	10ms
Subframes per frame	2
Time slots per subframe	7
Number of channels per time slot	16
Chip rate	1.28 Mcps
Modulation	QPSK
Channel coding	Convolution and turbo code
Maximum data rate	1.971 Mbps
Capacity: total transmission per slot	281.6 Kbps
Power Control	Open-loop, outer-loop, fast close-loop
Asymmetric ratio (downlink : uplink)	1:6 – 6:1

Table 4.7 TD-SCDMA parameters

4.4.2 Layers Structure

The layers structure and different layers' functions of TD-SCDMA are quite similar to those of WCDMA. This section will mainly introduce the items that are different from those of WCDMA.

Figure 4.11 shows the layer structure of TD-SCDMA:

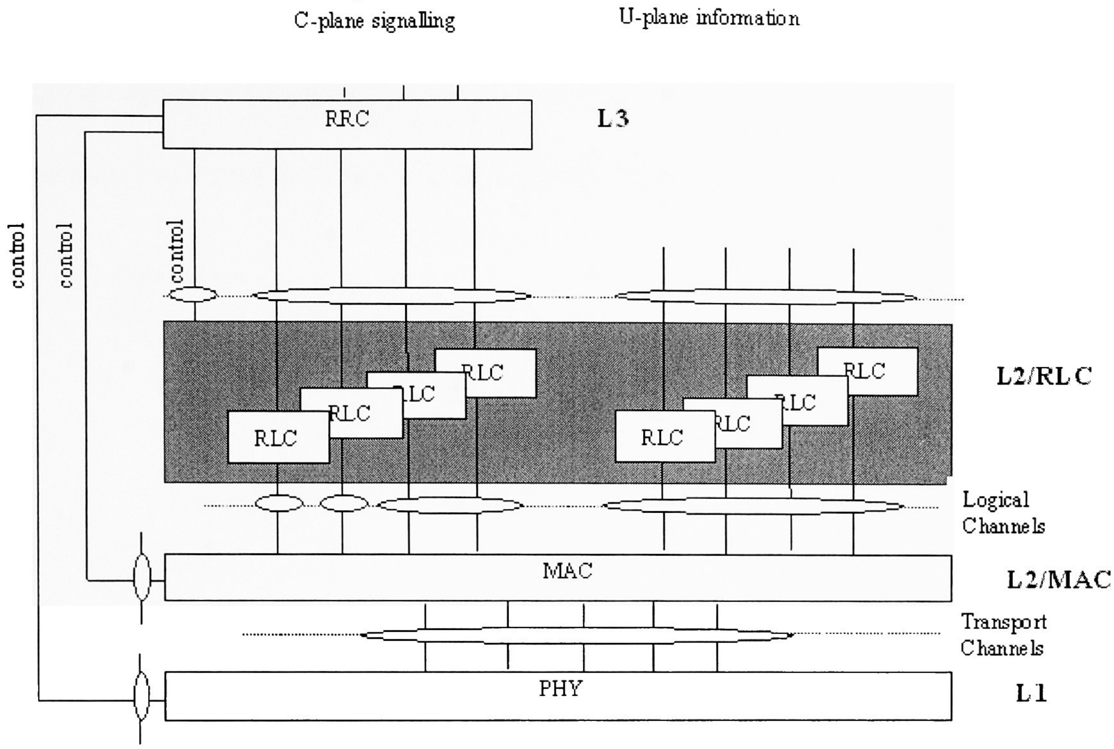


Figure 4.11 TD-SCDMA layer structure
(From: *http://www.geocities.com/tdscdma3g/*)

4.4.2.1 Layer 1

The functions of TD-SCDMA Layer 1 are almost same as those of WCDMA. The major different is in the structure of radio frames in the physical channels.

4.4.2.1.1 Physical Channels

Figure 4.12 lists the signal format of TD-SCDMA frame, subframe and time slot:

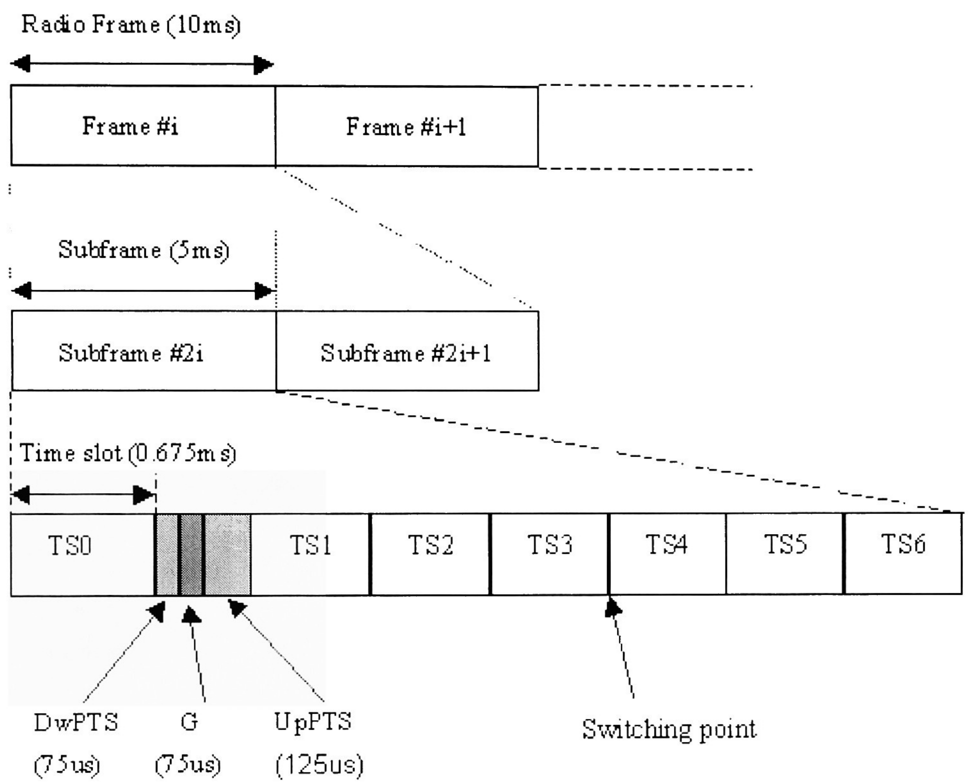


Figure 4.12 TD-SCDMA frame, subframe, and timeslot structure

(From: *http://www.geocities.com/tdscdma3g/*)

As to figure 4.12, each frame is 10ms and is divided into two subframes. Each subframe is further divided into seven time slots (TS) of 675 μs and three special time slots: DwPTS, G, and UpPTS.

4.4.2.1.1.1 Downlink Pilot Timeslots (DwPTS)

The DwPTS in a subframe is used in downlink pilot. The node B would transmit it at full power level. A DwPTS has a length of 75 μs and contains 96 chips. [51]

4.4.2.1.1.2 Guard Period (G)

The guard period has the duration of 75 μs and 96 chips.

4.4.2.1.1.3 Uplink Pilot Timeslots (UpPTS)

The UpPTS in a subframe is used for the uplink pilot. When a user terminal needs to randomly access to the network, it will transmit UpPTS first and then transmit RACH after it receives an answer from the network. [51]

4.4.2.1.1.4 Switching point and the asymmetric allocation

Figure 4.13 shows the details of a TD-SCDMA subframe:

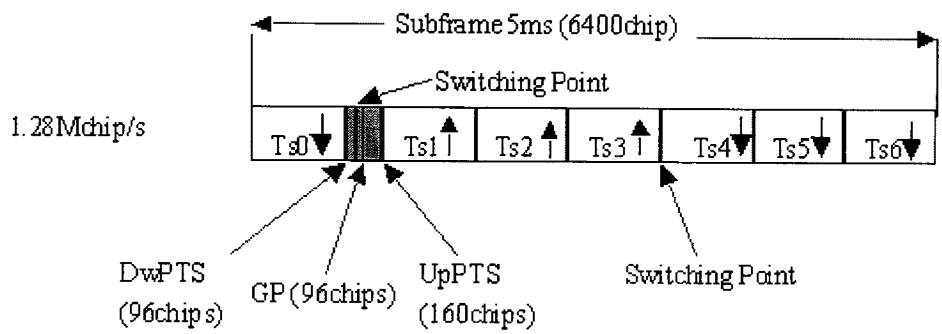


Figure 4.13 Switching Points of TD-SCDMA

(From: *http://www.geocities.com/tdscdma3g/*)

Each subframe consists of 7 time slots. Among the 7 normal time slots, Ts0 is always allocated as a downlink slot while Ts1 is always allocates as uplink slot. The uplink and downlink time slots are separated by a Switching Point. Each subframe contains two Switching Points. One Switching Point is located in the Guard Period. The other one is dynamically allocated in the remaining time slots. The above mentioned time slots allocation scheme is used to support asymmetric allocation.

4.4.2.1.1.4.1 Why Use Asymmetric Allocation?

Figure 4.14 gives a symmetric allocation method:

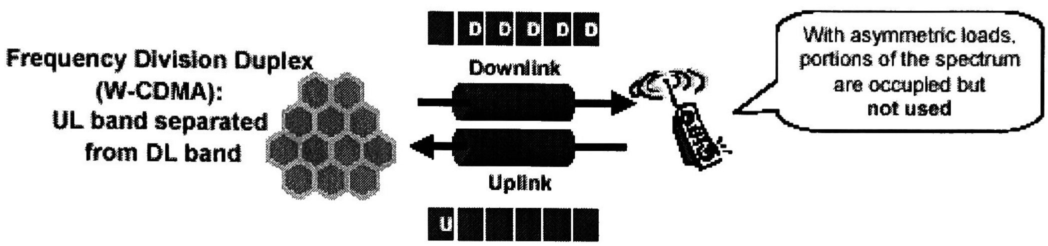


Figure 4.14 Symmetric allocation method
(From: http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf)

As shown in figure 4.14, in a symmetric system like WCDMA or CDMA2000, the downlink and uplink use two separate frequencies. During a conversation or data transmission, a user will occupy a downlink and an uplink path at the same time. The forward information takes the downlink path and the reverse data takes the uplink path. In a data transmission like Internet surfing, the downlink volume will be much higher than that of the uplink. As a result, the downlink bandwidth is fully utilized to transmit to the data while most of the uplink timeslots are idle. [61]

Figure 4.15 shows the TD-SCDMA asymmetric allocation method:

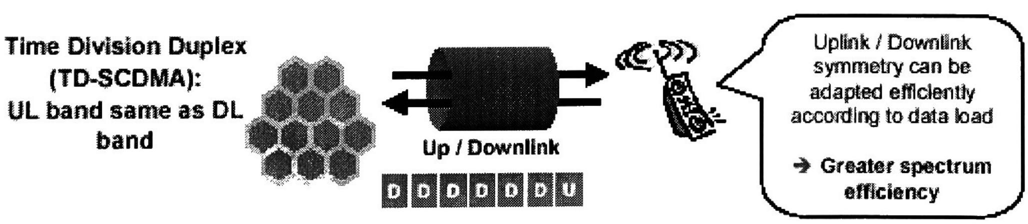


Figure 4.15 Asymmetric allocation method
(From: *http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf*)

In the TD-SCDMA scheme, the uplink and downlink information is located in the same frame, but in different time slots. The system can dynamically allocate the resource, time slots, according to the data volume of the uplink and downlink streams. As a result, TD-SCDMA does not need paired bandwidth and can optimize the radio traffic. This is especially useful in an environment that needs increasing data traffic such as mobile Internet or mobile multimedia, which needs significant bandwidth for downlink information but requires little uplink volume. [61]

4.4.2.1.1.4.2 **Realize Asymmetric Allocation in TD-SCDMA**

In a TD-SCDMA subframe, at least one time slot, Ts0, is allocated for downlink and at least one time slot, Ts1, is allocated for uplink. Other time slots are allocated by the placement of the second switching point.

Figure 4.16 and 4.17 show examples of different allocation methods:

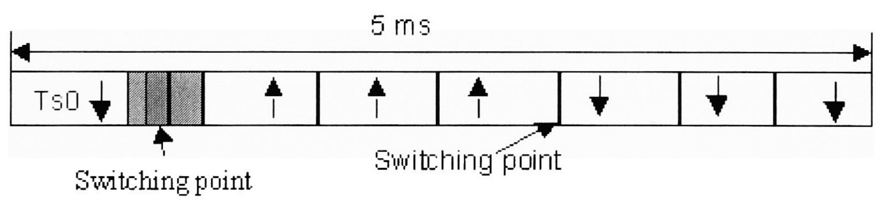


Figure 4.16 Switching point allocation method example 1

(From: *http://www.geocities.com/tdscdma3g/*)

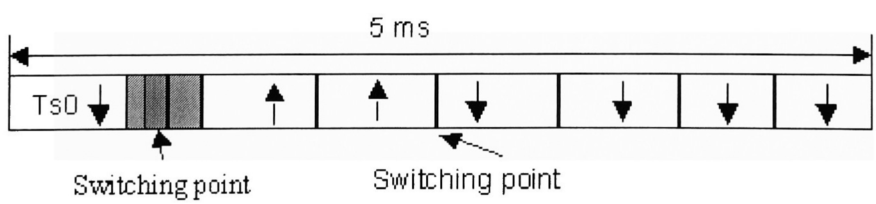


Figure 4.17 Switching point allocation method example 2

(From: *http://www.geocities.com/tdscdma3g/*)

As shown in Figure 4.16, there are four downlink timeslots and three uplink timeslots. While in Figure 4.17, there are five downlink timeslots and two uplink timeslots. According to the position of the second Switching Point, the downlink to uplink timeslots ratio ranges from 6:1 to 1:6. [51]

4.4.2.2 Layer 2 and Layer 3

The logical channels of Layer 2 are almost identical to WCDMA. The mapping method from the logical channels to transport channels is same as that of WCDMA. The functions of Layer 2 and Layer 3 are also same as those of WCDMA.

4.4.3 The technical Strongpoint of TD-SCDMA

Besides using CDMA coding, TD-SCDMA also divides each frame to several timeslots to transmit signals. In this way, it fully uses the radio resource and supports more subscribers based on the same bandwidth. Moreover, TD-SCDMA can further employ FDMA method, employing multi-frequencies in a BTS or even in the whole network.

Figure 4.18 lists the multiplexing methods that can be used in a TD-SCDMA scheme.

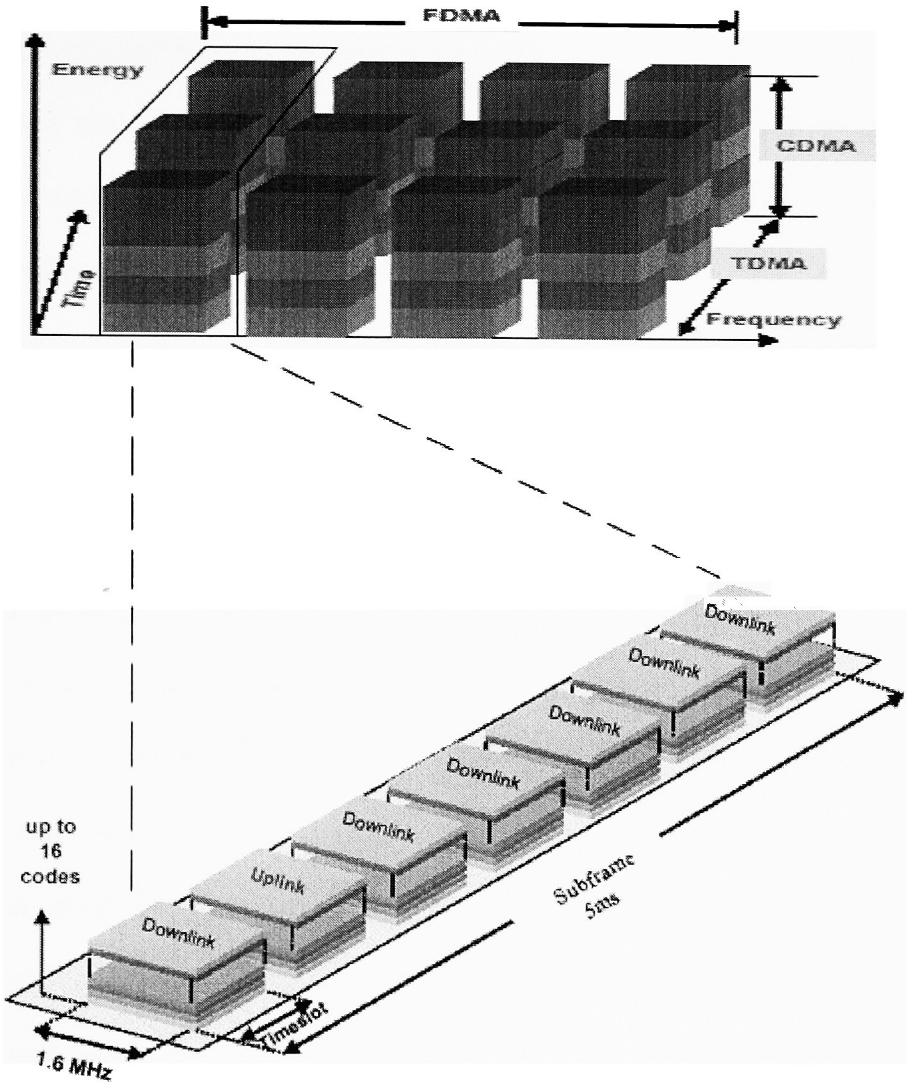


Figure 4.18 The multiplexing methods of TD-SCDMA

(From: *http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf*)

Figure 4.18 shows that TD-SCDMA uses different timeslots in each frequency. This is a TDMA multiplexing method. In each timeslot, TD-SCDMA assigns different

CDMA codes to different users; this is a CDMA multiplexing method. In addition, if multi-frequencies are assigned to a TD-SCDMA system, the system will also utilize the FDMA multiplexing method and supports more users.

TD-SCDMA can efficiently combine with such new technologies as smart antennas and multi-user detection. Those new technologies can minimize inter-cell and intra-cell interference and considerably improve the system preference. This is especially helpful in a high-populated or downtown area, which needs an efficient use of the available spectrum. [61]

4.4.4 The Technical Shortage of TD-SCDMA

Propagation has more obvious effect on a TD-SCDMA network than on other networks. Figure 4.19 shows that there are many transportation paths between the BS and MT, such as directly arrived, reflected, and scattering paths. The transportation distances of different paths are different. Although radio signal transmits in the air with extremely fast speed, the velocity of radio waves is a constant. As a result, the different transportation paths' signals arrive at the destination at different time. So the propagation will slight expand signal timeslot.

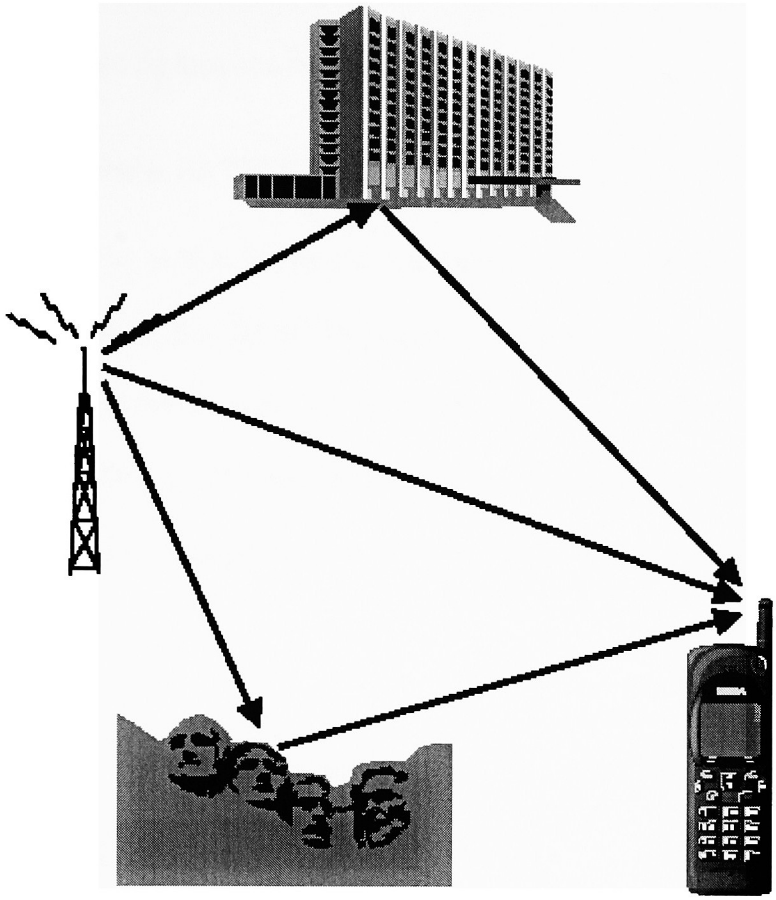


Figure 4.19 Different transportation paths

(From:

http://www.utdallas.edu/~gxm016000/Lecture%2018%20November%201%202001.pdf)

TD-SCDMA is a TDD network, which allocates different timeslots to different users. As a result, TD-SCDMA is extremely delaying sensitive. The capable traveling speed and the maximum radius of a TD-SCDMA cell is less than that of a WCDMA or CDMA2000 network. For example, the ITU requires that the highest moving speed of a TDD system should be 120 km/h while the highest moving speed of a FDD system could

be 500 km/h. The cell radius of a TDD system may only be several kilometers while that of a FDD system could be tens of kilometers. [51]

4.4.5 Migration Path of TD-SCDMA

TD-SCDMA can be used to set up a new cellular network or be combined with other technologies. In addition, the TD-SCDMA equipment can act as a supplementary part in a WCDMA or CDMA2000 system. TD-SCDMA sites can be placed in urban areas while WCDMA or CDMA2000 sites can be used to cover rural and large areas.

Figure 4.20 shows an example of how a TD-SCDMA system can migrate a GSM network to 3G.

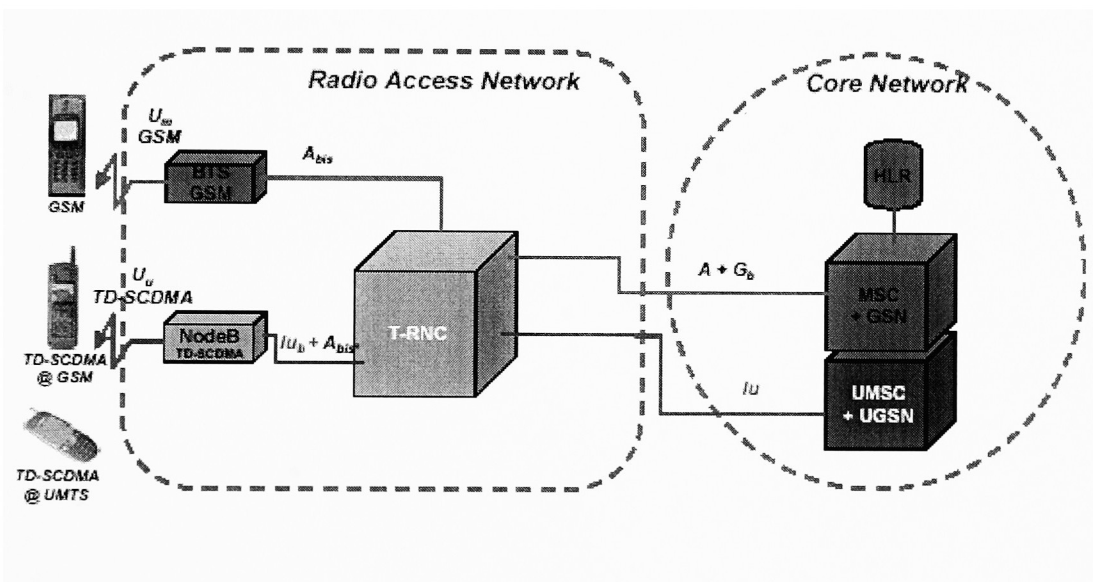


Figure 4.20 TD-SCDMA migrate path

(From: http://www.siemens-mobile.de/btob/external/downloads/TD-SCDMA/TD_SCDMA_White_Paper.pdf)

According to figure 4.20, new equipment such as a T-RNC, an UMSC + UGSN, and Node B must be added to the GSM network. The TD-SCDMA Node B will support TD-

SCDMA & GSM dual-mode terminals or TD-SCDMA & UMTS dual-mode terminals. The T-RNC will replace BSC to serve both the BTS and Node B. The UMSC + UGSN will support data packet service and act as an interface and a gateway to other networks.

5 The Chinese Conditions

Chapter 5 will introduce the real conditions in China. It will illustrate the provinces, history, and economic conditions in China.

5.1 The Chinese Provinces

China is located in eastern Asia, and is bounded by the Pacific in the east. It is the third largest country in the world, next to Russia and Canada. China has 14 border countries, which include Afghanistan, Bhutan, Burma, India, Kazakhstan, North Korea, Kyrgyzstan, Laos, Mongolia, Nepal, Pakistan, Russian, Tajikistan, and Vietnam. Figure 5.1 shows the map of the world and the location of China.

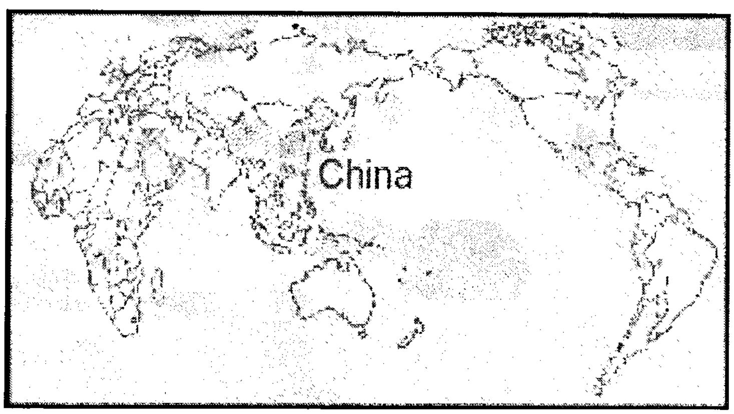


Figure 5.1 China and the world

(From: *http://www.lib.utexas.edu/maps/china.html*)

The People's Republic of China (PRC) is a communist country with a land area slightly bigger than the United States and a population of more than 1.3 billion. The country has 23 Provinces, 5 Autonomous Regions, 4 Municipalities, and 2 Special Regions. [72] These areas are listed below.

1. Special Regions: Hong Kong, Macau;
2. Municipalities: Beijing, Shanghai, Tinajin, and Chongqing;
3. Autonomous Regions: Guangxi, Inner Mongolia, Ningxia, Xinjiang, and Tibet;
4. Provinces: Heilongjiang, Jilin, Liaoning, Hebei, Shanxi, Henan, Shangdong, Shaanxi, Gansu, Qinghai, Jiangsu, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Fujian, Guangdong, Yunnan, Guizhou, Hainan, Zhejiang, and Taiwan.

All of them have equal political positions in China, which is similar to the individual states within the United States. This thesis will use the word "provinces" to represent all the Special Regions, Municipalities, Autonomous Regions, and Provinces. Most of these provinces were set up by the Chinese central government in the beginning of 1950s. There are four exceptions: Hainan was set up in 1988; Chongqing was set up in 1998; Hong Kong was set up in 1997; and Macau was set up in 1999. Figure 5.2 lists the different provinces of China.

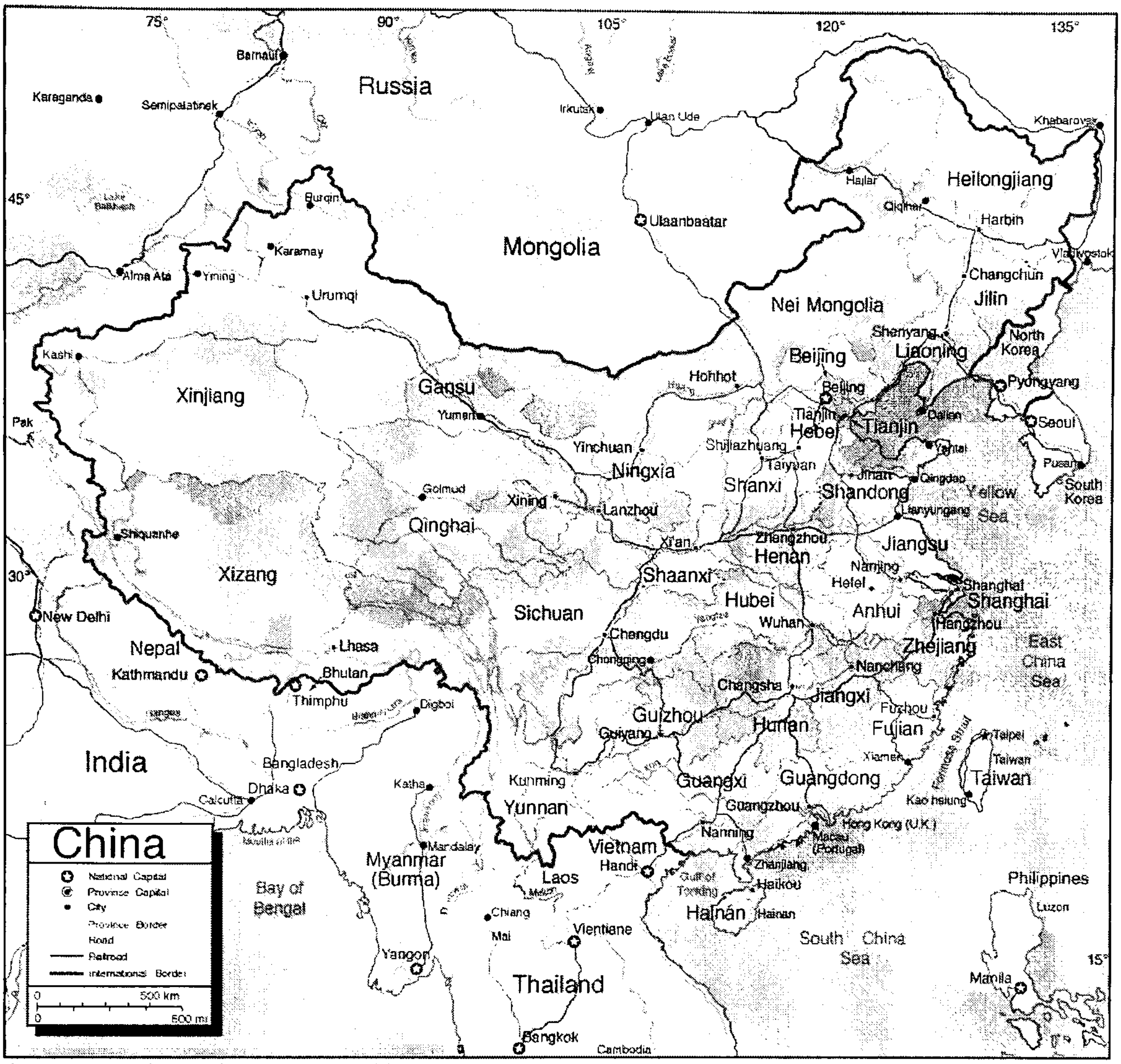


Figure 5.2 The Provinces of China

(From: http://www.lib.utexas.edu/maps/china.html)

5.2 The Chinese History

China is one of the oldest countries in the world with a history dating back more than 5,000 years. For a long time, it is one of the strongest countries in the world. However, about 150 years ago, China became weak and poor and was defeated by many developed countries. Till now, it is the largest developing country in the world.

5.2.1 The History of Peoples' Republic of China

Peoples' Republic of China was founded in 1949, at the end of World War II. The cease fire occurred after the Japanese had invaded China and tens of millions of Chinese were killed. Shortly after it was founded, the PRC government spent about ten years ensuring the development of China in a peaceful international environment. The lives of Chinese people were improved at that time. However, in 1960s and 1970s, the PRC government implemented many faulty policies bringing China to the edge of collapse. At the beginning of 1980s, for the sake of maintaining its rule over China, the government implemented several new economic policies. All of these new policies helped the PRC develop quickly and the economic condition is much better now than it was twenty years ago. There is no supervision or control for the ruling Chinese Communist Party. As a result, corruption and abuse of authority is a common phenomenon among the Chinese Communist Party officers today. Bit by bit, Chinese people show their increasing dissatisfaction with the Chinese Communist Party officers. They even use parades and strikes, which would have been unheard of in the past. More and more people believe that the Chinese government and the Chinese Communist Party need to modify the Chinese political structures. Of course, the political reform is facing fierce resistance and struggle. As China evolves with its' more than 1.3 billion people, there is no doubt that it will deeply affect the world's peace and economy.

5.3 The Chinese Economy

When People's Republic of China was founded in 1949, it was one of the poorest countries in the world. The country suffered a great deal in World War II and the Chinese Civil War. At the beginning of 1950s, the Chinese Communist Party led

Chinese people built the Chinese economy peacefully. However, in 1960s and 1970s, China suffered with fighting for power and series of poor political decisions. At the end of 1970s, China was still one of the poorest countries in the world while many Asia countries, such as Japan, South Korea, and Singapore, made economy successes. At that time, the annual salary of a worker was no more than 100 dollars. The income of a peasant was even less than that of a worker.

Since the beginning of 1980s, the Chinese government carried out many economic policies to encourage the economic development in China. The Chinese economy has grown rapidly under these new policies. According to the newest statistics, Chinese GDP (Gross Domestic Product) was increased from 362.4 billion RMB* ($64.7 billion) in 1978 to 9.59 trillion RMB ($1.16 trillion) in 2001. This means that, in the past two decades, the annual growth of the Chinese economy is more than 9.3%. [72] The following is a list of economic statistics for China: The Chinese GDP was listed number 32 in the world in 1978, number 15 in 1989, and ranked top ten in 1997. In 2001, the Chinese GDP surpassed the Italian GDP and made the Chinese business scale number six in the world. It is predicted that the Chinese GDP will exceed France in 2004 and surpass United Kingdom in 2008. At that time, it will only rank next to the United States, Japan, and German and become the fourth strongest business country. Meanwhile, its foreign trade increased explosively, from about $20 billion in 1978 to $475 billion in 2000. [72]

* RMB is the Chinese monetary unit.

In conclusion, China has emerged as a rising global economic player in the past two decades. No other country has achieved so much, so rapidly.

With its fast development, China still has many economy problems, such as:

1. **Vast amount of unemployment population.** In the process of industry modernization, more and more Chinese workers and peasants lost their jobs, especially in the underdeveloped areas. It is estimated that there are more than 120 million unemployed people in China. Creating jobs for those people is a challenge to the Chinese governments. [75]

2. **The geography imbalance.** Most of the Chinese economy wonders happened in the eastern and coastal provinces, such as Beijing, Shanghai, GuangDong, Fujian, and JiangSu. Those provinces, which take around 15 percent Chinese area and 35 percent Chinese population, offer more than 60 percent Chinese GDP. The broad Middle and Western provinces suffer with shortages of technology, information, and funds. For example, in the field of cellular telecommunication, the Eastern, Middle, and Western provinces have 62.7%, 19.3%, and 18% mobile users respectively. [56] Recently, the central government has raised many policies to encourage investment in those underdeveloped provinces. Figure 5.3 highlights the coastal area of China.

Figure 5.3 The costal area of China

(From: http://www.lib.utexas.edu/maps/china.html)

3. **Income imbalance.** In China, there is a very small middle income class. The income difference between the rich and common people has become larger and larger in the past two decades. Many rich people's annual income is hundreds or even thousands times that of common people. In the mean time, the rich people are accused of evading taxes and other commercial sins. The Chinese people are more and more dissatisfied with such conditions.

5.4 The Chinese WTO Entrance History

In July 1986, China applied to resume its status as an original partner to GATT (General Agreement on Tariff and Trade), the predecessor of WTO (World Trade Organization). The prices asked by foreign countries were far above the Chinese standard of living. As a result, the resumption negotiation lasted 10 years but did not reach an agreement. For example, Western Countries insisted on treating China as a developed country. However, if we consider the huge amount of Chinese people and large country areas, China should be taken as a developing country. In 1995, WTO replaced GATT. The "resumption" was changed to "access" negotiation between China and the WTO members. After another 5 years of tough negotiation, China joined WTO in October 2001. The process is full of struggles and reversals. Several times, China even wanted to withdraw its entrance application. The Chinese government's efforts to join the international trade group lasted for 15 years, much longer than the application process of any other WTO member. [75]

6 The Chinese Telecommunication Conditions

Chapter 6 will introduce the concrete Chinese telecommunication conditions. It will start by describing the history of Chinese telecommunications. Then, focusing on the Chinese wireless market, it will describe administration agents, operators, networks, and manufacturers. It will also illustrate the relationship of the Chinese telecommunication industry and its WTO entrance.

6.1 The Chinese Telecom History

6.1.1 The Conditions before the Economy Reformation

In 1949, the China State Council formed the MPT (Ministry of Posts and Telecommunications). Over more than four decades, MPT acted as the only telecommunication and posting regulator and operator in China. Under China's centrally planned economy, the price for everything was fixed, and no one was concerned about whether a price was reasonable. As a result, the Chinese people were quite satisfied with the MPT. During that time, the demand for telecommunication was fairly limited, with postal letters serving as the main communication method.

6.1.2 Economy Reformation

When Economy Reformation was promoted by Deng Xiaoping in the early 1980s, China had fewer than 5 million telephones, almost all in party and government hands. Small towns and villages generally had no telephones. [56]

In the beginning of the economic reformation, the Chinese central government realized that the backward telecommunication condition was one of the main factors

delaying the Chinese economic advancement. As an example, in 1981, a celebrated United States company sent several people to Beijing, the capital of China, and wanted to set up its office in China. Yet, four days later, they left China and reported to the headquarters that it was impossible to set up an office there. The reason was simple. As soon as arrived in Beijing, they tried to call the headquarters. Although they spent three days in the post office, which was the only place that people could make toll calls in early 1980s, they could not even make one successful connection. To promote Chinese economic modernization, the central government put into place many methods needed to build a more extensive telecommunication infrastructure.

6.1.3 Present Conditions

Today, the Chinese telecommunication condition has changed dramatically. As a late starter, China is able to leapfrog technologies, particularly in the areas of communications infrastructure and wireless applications. Although per capita usage rates are still low, the absolute size of the Chinese market for telecommunication services and products is already the largest in the world. The pace of change is breathtaking. During the 1990s, the Chinese telecommunication industry grew at an annual rate of 44%, making China the country with the fastest growth rate in the world.

The following are statistics showing the Chinese telecommunication market development:

1. The number of fixed-line telephones expanded from 10 million connections in 1990 to 200 million at the end of August 2002. It is increasing by about 30 percent per year, or about 2 million new connections per month. At this rate, China is adding an average-sized regional USA Bell system every year. [56]

2. The number of mobile phone subscribers is increasing at an even faster rate. Wireless systems are in greater demand and can be installed more quickly and offered at a lower cost per subscriber than wired systems. Furthermore, Chinese people like to use mobile phones and spend more money on their cell phones than on fixed-lines. The Chinese cellular market is growing at a torrid 80% annually. At the end of 2002, China had 200 million cellular subscribers and became the largest cellular phone market in the world. [56]
3. The number of Internet users doubled in 2000 and doubled again in 2001. At the end of 2001, the number of the Chinese Internet users was more than 40 million.

6.1.3.1 The Boom Reason of the Chinese Wireless Market

The boom of Chinese wireless market has reasons as follows: Firstly, the Chinese government encourages the development of the wireless telecommunication in China. The government has issued special policies and funds to help wireless operators build their networks. In addition, in 1990s, it formed two wireless operators, China Mobile and China Unicom, to encourage the competition in the fields of services and prices. As a result, now, the Chinese people can enjoy much cheaper and better services than before. Meanwhile, more and more international and domestic wireless manufacturers have enrolled into the Chinese market. The prices of wireless equipment and handsets have dropped dramatically. Secondly, the Chinese people are richer now than before. They can afford the expenses of mobile phones. In addition, modern people find out that wireless telecommunication does them a great favor in their lives, especially when they are traveling or going out. Finally, in recently years, vast amount of peasants have left

their home and enrolled into metropolises. They cannot install a fixed-line for themselves but find out that mobile phone is a good communication tool to them.

6.2 The Chinese Telecom Agents

6.2.1 China MPT

MPT (Ministry of Posts and Telecommunications) had acted as the single telecommunication and posting agents since 1949. It developed quite slowly for about four decades. However, it was renowned for its' hard work.

6.2.1.1 PTA

During the centrally planned economic period, each province had its own PTA (Posts and Telecommunications Administration Bureau). Each PTA was under the control of MPT and its province's government. Except national trunk networks, each PTA was authorized to build and administrate its domestic telecommunication networks.

6.2.1.2 Introducing Competition into the Field of Telecommunication

The MPT ignited the boom in the Chinese telecommunication market at the beginning of the 1990s. With the economic reformation carried out in China, however, the Chinese people became more and more dissatisfied with the MPT. Firstly, the service of MPT was extremely slow. At that time, it normally took more than three months to install a telephone, with a connection fee as high as 5,000 RMB (about $600). Secondly, the MPT price was extremely high. For example, the MPT sold each mobile phone at a price of 20,000 to 30,000 RMB (about $3000). Moreover, it was difficult to register for mobile service even if you had enough money. One important reason for such a situation was that MPT acted as the only service provider in China; there was no other choice for

customers. The Chinese people's voice caused the Chinese government to take some action against the monopoly of the MPT.

6.2.1.2.1 Formed China Unicom

To encourage competition, in July of 1994, the China State Council granted a license to the second telecommunication operator — China Unicom. China Unicom was cosponsored by the Ministry of Electronic Industry, the Ministry of Electronic Power, and the Ministry of Railways. Soon, people found out that China Unicom could hardly compete with MPT because MPT acted as the regulator as well as a telecommunication operator. It always set favorable policies and rules for itself but prevented the expansion of China Unicom. For example, in the field of paging services, the MPT charged 3,000RMB ($350) per month for each trunk line offered to China Unicom but charged no fee for MPT's paging company. Over several years, China Unicom made little progress.

6.2.1.2.2 Divided MPT

Finally, the people and the Chinese central government realized that MPT could not be a regulator and a player at the same time. As a result, the China State Council made the following changes on March 10, 1998:

1. It broke the MPT into two parts. The first part combined with the Ministry of Electronic, and the Ministry of Broadcast, Film and Television to form the MII (Ministry of Information Industry). The MII constructed the China Postal Bureau and TAB (Telecommunication Administration Bureau). China Postal Bureau is in charge of the posting services in China and TAB manages telecommunications related issues. [56]

2. The second part, the commercial portion, was further divided into three different telecommunication operators: China Telecom, China Mobile, and China Satcom. The business fields of those companies will be introduced in section 6.3.2.

6.2.2 China MII

As mentioned above, the MII was founded in 1998 and was planned to act as regulator only. Now, it directs the Chinese electronic manufacturing industry, the communications industry, and the software industry.

The MII is authorized to set telecommunication laws and rules, manage concrete telecommunication agents, supervise telecommunication operators, and arbitrate conflicts between different operators.

6.3 The Chinese Telecommunication Operators

6.3.1 MPT and China Unicom

As mentioned in 6.2.1.2, before 1994, the MPT was the only telecommunication operator in China. The second telecommunication operator, China Unicom, was formed in 1994. Today, China Unicom is the only full service operator. It provides local, domestic, and international long distance fixed-line, Internet, paging, mobile, and VoIP services. [56]

6.3.2 China Telecom, China Mobile, and China Satcom

In 1998, the China State Council divided MPT into three parts. The last part was furthered divided into three telecommunication operators: China Telecom, China Mobile, and China Satcom. The MPT paging service was merged into China Unicom. The following are the business fields of those three operators:

1. China Telecom provides local, domestic and international long distance fixed-line, Internet, and VoIP services; [56]
2. China Mobile offers mobile and VoIP services; [56]
3. China Satcom provides satellite communications services. [56]

6.3.3 China Jitong and China Netcom

When Internet became popular in the mid 1990s, MPT was the single Internet service provider in China. Later, the Chinese government issued Internet licenses to four companies: China Telecom, China Unicom, China Jitong, and China Netcom. Both Netcom and Jitong provide wholesale bandwidth, VoIP, and data services in China. [56]

6.3.3.1 China Jitong

The history of Jitong can be traced back as early as 1994. The pioneer company of Jitong built the Chinese national data telecommunication network, the Golden Bridge Network. However, Jitong has had few business successes since its foundation.

6.3.3.2 China Netcom

In August 1999, four Chinese government related entities formed China Netcom: the CAS (Chinese Academy of Sciences), the SARFT (State Administration of Radio, Film and Television), the MOR (Ministry of Railways), and the Shanghai Municipal Government. [72]

6.3.4 China Railway Telecom

On December 26, 2000, the Ministry of Railways founded China Railway Telecom, who was moving toward offering local, domestic fixed-line and VoIP services. [56] It is

making use of existing railway communications lines, an extensive network in China, to provide telephone services.

6.3.5 Reforming China Telecom and China Netcom

Divided from the MPT in 1998, China Telecom still had a monopoly position in the local, domestic, and international long distance fixed-line services. At the beginning of 2002, it had 87 percent of Chinese long distance fiber-optic transmission lines and took more than 70 percent of the Chinese fixed-line market. The Chinese people became further dissatisfied with the bureaucracy and unreasonable prices of China Telecom. Several hearings were held to debate whether or not the China Telecom's price was reasonable. As a result, on May 17, 2002, the China State Council made the following major reforms:

1. It divided China Telecom into two parts. One of them contains the assets and capital in the ten northern provinces of China: Beijing, Tianjin, Helongjiang, Jilin, Liaoning, Inner Monogola, Hebei, Henan, Shanxi, and Shandong. This part combined with China Netcom and China Jitong to form a new telecommunication operator. The new company took the title China Netcom. [72]
2. China Telecom, as the other part, occupied the remaining 21 provinces' assets and capital and kept its name. [72]

Both the new China Netcom and the new China Telecom compete in local, domestic, and international long distance fixed-line services, Internet, and VoIP services all over China. The reconstruction is a complex task, involving $80 billion of assets and capital and 1.2 million employees in 60,000 branches all over China. [72] This reconstruction is still ongoing and is predicted to be finished by mid 2003. During their reconstruction,

neither China Netcom nor China Telecom will have enough time and energy to strengthen their services and submit big contracts for the telecommunication manufacturers. However, both of them will begin their bulk equipment purchasing at the end of 2003 or the beginning of 2004 if they want to promote their regional services and prepare to carry out their business in competitor's regions.

6.3.6 The Condition of the Six Chinese Telecom Operators in 2001

Table 6.1 lists the statistics of the six Chinese Telecommunication operators for the year 2001 (refers to MII's annual report of 2001).

Operator	Revenue		Fixed-line		Mobile		Internet		Trunk Fiber	
	Billion Dollars	Market Share	Million Users	Market Share	Million Users	Market Share	Million Users	Market Share	Kilo KM	Market Share
China Mobile	16.2	37.5%			103.8	71.7%			12	3.6%
China Telecom	14.2	32.8%	111.31	61.7%			19.1	47.6%	162	48.4%
China Netcom	7.77	18.0%	67.55	37.4%			13.1	32.8%	84	25.1%
China Unicom	4.56	10.6%	0.16	0.1%	41	28.3%	7.9	19.6%	77	23.0%
China Railway Telecom	0.43	1.0%	1.36	0.8%						
China Satcom	0.04	0.1%								

Table 6.1 statistics of the six Chinese Telecommunication operators

6.4 *The Chinese Mobile Operators*

6.4.1 China Mobile

China Mobile branched from the MPT in 1998 and became the most powerful operator in China when China Telecom was divided into two telecommunication operators. China Mobile has branches in 31 provinces. It selects directors for its branches. Each branch has the right to select its telecommunication equipment. Having stocks listed in Hong Kong, China Mobile raised about $11 billion from the Hong Kong market. [73] China Mobile plans to list its stocks in the Chinese domestic market in 2003.

6.4.1.1 China Mobile Market Share

China Mobile is the biggest wireless operator in China. When it formed in 1998, it occupied about 93% of the Chinese wireless user market. In the past four years, China Mobile faced more and more competition from the second wireless operator, China Unicom. In September of 2002, China Mobile still had about 70% of the Chinese wireless user market. [56]

6.4.1.2 China Mobile Networks

6.4.1.2.1 1G Network

China Mobile was the only 1G cellular service operator in China. In 1987, China MPT launched its first analogue cellular network in Guangdong province, which is next to Hong Kong and Macau. Today, as the richest province in China, Guangdong has more cellular subscribers than any other provinces. At the end of 1980s and the beginning of 1990s, a cell phone was a symbol of wealth and high social position in China. Few people could support a mobile phone at that time.

At the beginning of the 1990s, the 31 provinces in China were using different cellular technologies. Five provinces in north-western China, Shaanxi, Ningxia, Gansu, Xinjiang, and Qinghai, built AMPS networks. The remaining 26 provinces chose TACS and ETACS. Because of the limitation of 1G technologies, it was difficult to roam among the different provinces' analogue cellular networks.

Almost all 1G subscribers are high-end users, who spend more money on mobile communications than other users. Both China Mobile and China Unicom target these users with their marketing. Because these users utilized the China Mobile's services for such a long time, they were not likely to change their service provider. At the beginning of 1995, China had about six million analogue cellular subscribers. Because of the fierce development speed of advanced 2G technologies, the number of 1G subscribers has decreased since 1995. At the beginning of 2002, China Mobile closed all 1G cellular networks, and 1G cellular phone users were switched to China Mobile's GSM services free of charge.

6.4.1.2.2 2G Networks

Having inherited its GSM networks from MPT, China Mobile operates the largest GSM networks in the world. The process of MPT selecting GSM as its 2G technology is interesting.

6.4.1.2.2.1 The Origin of China Mobile GSM Networks

At the beginning of the 1990s, the 2G technologies began to emerge. At first, the MPT did not want to implement 2G networks. One reason was that MPT wanted to earn more profits from its 1G network. Another reason was that the MPT managers could not

decide which 2G technology should be used in China. At that time, GSM took the leading position in Europe, and CDMA proved to be a promising technology, although not quite mature. The MPT managers wanted to wait for the result of the competition between the GSM and CDMA to help China select the most advanced and popular technology. At that time, the China State Council approved setting up the second telecommunication operator, China Unicom. The first strategy of China Unicom was to offer cellular service in China, the most profitable business at that time. China Unicom selected the GSM standard and began to negotiate contracts with telecommunication manufacturers. In order to defeat its competitor, the MPT decided to set up its 2G networks as soon as possible. It also selected GSM. In October of 1994, the first MPT GSM network was launched in Beijing.

6.4.1.2.2.2 China Mobile's GSM Networks Condition at Present

Today, the GSM networks of China Mobile are composed of equipment from different suppliers. The equipment suppliers' list contains many famous international manufacturers: Motorola, Ericsson, Nokia, Nortel Networks, Siemens, and Alcatel. By the end of November 2002, China Mobile had more than 130 million GSM users. [56]

6.4.1.2.2.3 China Mobile's GSM Value Added Services

In the past four years, China Mobile introduced three GSM value added services, SMS (Short Message Service), WAP (Wireless Application Protocol), and MMS (Multimedia Message Service). SMS was a success, WAP boomed for a year and then failed, and MMS was launched in the May 2002.

6.4.1.2.2.3.1 SMS

In 1999, China Mobile launched SMS. In the beginning, no one believed that SMS would become a fashion in China, although it was pretty popular in Europe. The main challenge was that Chinese characters are very complicated. It is difficult to input Chinese characters on a standard computer key board. How to input the Chinese characters on a cell phone panel that has about 20 keys is really a challenge. In the first year, only a few high-end GSM users sent some English short messages.

The condition changed soon: Firstly, since 2000, simpler methods to input Chinese characters have been introduced. Meanwhile, cell phone manufacturers produced many user-friendly terminals, making it much easier to input Chinese characters than before. SMS also supports multicast and forward functions, which can transmit short messages easily. Secondly, many telecom value-added service companies composed large amounts of short messages and put them on their websites. Mobile users could choose those short messages at low cost. Thirdly, China Mobile and China Unicom users could send short messages to each other. Finally, the SMS price is cheap, merely 0.15 RMB ($0.02) per message; and the message receiver is not charged. Today, a ninth of all world short messages, 40 billion a year, are sent by Chinese cellular phone users. [66]

6.4.1.2.2.3.2 WAP

On May 17, 2002, China Mobile put forward its WAP service. WAP is a technology that can help subscribers using their handsets to surf some Internet websites. Both the wireless telecommunication and Internet were on their highest boom at the beginning of 2000. Many telecom value-added service companies took it as a key to future wealth. However, the wireless market proved that WAP service was immature to launch based on

present technologies. Firstly, the data speed of WAP is slow. Backed by 2G technologies, the highest data speed of WAP is 9.6 kbps, which is even less than the data speed of a modem, 56 kbps. Secondly, WAP utilizes Wireless Markup Language (WML) to write its webpage. [50] However, the WML website resource is very limited in the Internet. Fifthly, the connection time of WAP is extremely long and normally costs about a minute to logon to a WML site. In addition, downloading a mobile screen page normally needs tens of seconds. Finally, the price of WAP service is high. Operators charge a user by the time that he/she occupies a 2G channel. Sometimes, a user spends several minutes trying to logon to a WAP site and it fails. However, a wireless service provider will still charge the user for the connection time. For the above reasons, WAP failed in China and in the world. WAP needs some new technologies to help it overcoming its shortages.

6.4.1.2.2.3.3 MMS

On October 9 2002, China Mobile put forward its MMS service. It is a strategy step of China Mobile to rival with China Unicom's CDMA technology. Today, the price of MMS is 0.9 RMB/message ($0.11). According to the result of a survey, most Chinese users believe that the MMS rate is high.

6.4.1.2.3 GPRS

GPRS is a 2.5G technology. In order to defeat China Unicom's CDMA network, China Mobile launched its GPRS service in May of 2002. The GPRS services of China Mobile focus on high-end users. At the end of October 2002, China Mobile had 3 million GPRS users. Today, The Chinese GPRS users can roam to Hong Kong, Taiwan, and the United States. [73]

In order to convince more subscribers to join its GPRS service, China Mobile plans to offer more attractive service plans in 2003. In those plans, GPRS users can get free minutes or free handsets.

6.4.2 China Unicom

Formed in 1994, China Unicom has focused on offering cellular services. It also sets up branches in 31 provinces and selects directors for branches. China Unicom branches do not have the authority to order their cellular equipment, but the China Unicom headquarters has the power to order equipment from different manufacturers. The headquarters purchases equipment from manufacturers in bulk so that it can get good discount. Like China Mobile, China Unicom also listed its stocks in Hong Kong and raised $5.65 billion. [73] It plans to list its stocks in the Chinese domestic market in 2003.

6.4.2.1 China Unicom Market Share

The MII carried special rules to help the development of China Unicom. For instance, it permitted the prices of China Unicom to be 10% lower than those of China Mobile. China Unicom captured more subscribers than did China Mobile in the past four years. In September of 2002, China Unicom seized about 30% of the Chinese cellular market. [56]

6.4.2.2 The China Unicom Networks

China Unicom has both GSM and CDMA networks.

6.4.2.2.1 GSM Network

China Unicom obtained its wireless operation license in 1994 and launched its first GSM network in 1995. By the end of October 2002, China Unicom had about 60 million GSM users.

As a late starter, China Unicom faces difficulties in attracting China Mobile's high-end users to select its services. However, China Unicom has its price advantages. In the past four years, China Unicom developed much faster than did China Mobile. Today, it is the third largest GSM wireless operator in the world (The first and second operators are China Mobile and Vodafone). [56]

6.4.2.2.1.1 Value Added Services

China Unicom also introduced SMS and WAP services on its GSM networks. The marketing results are same as those of China Mobile.

6.4.2.2.2 CDMA Network

In the past four years, China Unicom successfully expanded its wireless user market share from 6% to about 30%. However, China Mobile holds most of the Chinese high-end mobile users, and the quality of its GSM networks is better than that of China Unicom.

In order to get a better competitive position, in January of 2002 China Unicom opened its CDMA networks in China. It was predicted that the Chinese national CDMA network would cost China Unicom more than 8.4 billion dollars and take several years to develop. [56] China Unicom gambles such a large amount of money on CDMA because it wants to utilize CDMA2000 series technologies to compete with China Mobile.

6.4.2.2.2.1 CDMA Project I

China Unicom put out its CDMA project I orders in May of 2001, for a total of more than 1.5 billion dollars. [73] Many famous international wireless manufacturers and two Chinese equipment suppliers got CDMA contracts. The international manufacturers list included Lucent, Motorola, Ericsson, Nortel Networks, Nokia, Samsung, LG, and so on. The two Chinese manufacturers were Zhongxing(ZTE) and Huawei. At the beginning of 2002, the CDMA project I was finished and could serve 15 million users.

6.4.2.2.2.2 CDMA Project II

On October 23, 2002, China Unicom placed its CDMA project II orders. This time, China Unicom purchased only CDMA2000-1X equipment. After brutal competition, Motorola, Lucent, Nortel Networks, Ericsson, Samsung and Zhongxing got their orders. The CDMA project II orders were worth more than $1.4 billion. Motorola, Lucent, Nortel Networks, Ericsson, and Zhongxing got their orders worth $446 million, $407 million, $280 million, $150 million, and $190 million respectively. [73] After expansion, the CDMA networks will support 30 million subscribers.

6.4.2.2.2.3 CDMA Marketing

6.4.2.2.2.3.1 Initial Marketing Strategy

When CDMA service was just launched, China Unicom targeted high-end users. It advertised CDMA's advantages such as clear voice, better security and low radiation.

In the beginning, China Unicom planned to attract ten million users in 2002. Yet, the price of CDMA handset was pretty high, normally more than $300. Furthermore, there were only a few kinds of CDMA handsets available. The marketing result was disappointing. It took more than five months for China Unicom to reach the first one

million users. Merely a few thousand users joined its new network daily. In July 2002, China Unicom changed its goal to seven million users at the end of the year, but it still seemed unreachable. [56]

6.4.2.2.2.3.2 Modified Its Strategy

China Unicom realized that it had made a mistake. In the second half of 2002, it changed its CDMA strategy and targeted low-end users. It ordered several million CDMA handsets from cell phone manufacturers, sold them to customers at inviting prices, and put out attractive service plans. In some plans, customers could even get free handsets. In a short time, the prices of Chinese CDMA handsets dropped from above $300 to about $150.

The new strategy produced an ideal result. More and more people selected CDMA service plans. Five months after launching CDMA, on June 10, China Unicom recorded its first 1 million users. Two months later, on August 15, it reached 2 million users. The number grew to three million on September 25 and to four million on October 14. By the end of 2002, China Unicom had enrolled more than 7 million CDMA users. [56]

6.4.3 The Comparison of China Mobile and China Unicom

Table 6.2 lists the wireless subscribers of China Mobile and China Unicom in the past four years (Refers to MII annual reports of 1998, 1999, 2000, and 2001):

	1998	1999	2000	2001
China Mobile (Million)	23.5	38.03	66.52	103.8
China Unicom (Million)	1.5	5.21	18.74	41

Table 6.2 The comparison of China Mobile and China Unicom users

6.5 *The Chinese Mobile Phone Market*

6.5.1 The Initial Leader—Motorola

China launched its first cellular network in 1987. In the first seven years, Motorola was almost the only mobile phone and pager supplier in China. During that time, to Chinese people, mobile telecommunication meant "Motorola". There even was a phenomenon in which wireless operators and mobile phone distributors begged Motorola to offer them mobile phones. Under such positive circumstances, Motorola became more and more arrogant and were even negative about developing new handsets, such as the GSM phones.

6.5.2 The Rise of Ericsson Handsets

In the beginning of the 1990s, Ericsson realized that wireless phone, especially GSM phone, was a marvelous business field. It devoted a great amount of funds into the development of the GSM phones and offered many GSM handsets. The Chinese customers were glad to find out that, compared with Motorola phones, the Ericsson handsets were much smaller and more functional. In a short time, the Ericsson handset surpassed Motorola mobile phones with ease and took the first position in the Chinese market.

6.5.3 The Fashion of Nokia Cell Phones in the World

Nokia was a late starter in wireless field and stepped into the wireless field in 1993. However, Nokia had unbelievable success in this area. It injected vigor into cell phone design and originated many smart concepts in this field, such as colorful shells, user friendly platform, and personalized ringing tones. With its handsets becoming a fashion

quickly, Nokia took the championship position of the world cell phone market in 1999 and continues to strengthen its advantage.

6.5.4 The Chinese Market Condition of 2000

The Chinese cell phone market was a bit different from the rest of the world. Motorola realized that it had made a big mistake and devoted great efforts toward developing and launching new mobile phones at the end of the 1990s. Furthermore, it improved its sales and customer service. Meanwhile, Ericsson mobile phones suffered with bad quality and poor service. As a result, in 2000, the Chinese handset market was like this: The champion and runner-up were Motorola and Nokia and they took about 60% percent of the Chinese market. The second group contained Ericsson, Siemens, Panasonic, LG, and Samsung, which occupied a bit less than 30% of the market. Other manufacturers could only share the remaining 10—12% of the market. [56]

6.5.5 The Emergence of Chinese Mobile Phone Manufacturers

At the end of 1999, the MII selected several domestic electronic manufacturers to enroll in the Chinese handset market, such as Eastcom, Capitel, Bird, TCL, and Kangjia. Many people took it as an unwise idea at that time. The total market share of Chinese mobile phone manufacturers was only 3% in 1999. They even asserted that the Chinese handset enterprises would be driven out of this field in 3 years. However, the Chinese manufacturers fully used their advantages, such as familiarity with the Chinese market, flexible sales policies and cheap labor costs. They accomplished a coup in 2001 and 2002. In 2002, the Chinese mobile phones occupied 30% of the domestic market, and it is predicted that they will have more than 50% market at the end of 2005. [56]

6.6 *The Chinese Domestic Telecom Manufacturers*

6.6.1 Summarization

Formed in 1949, the MPT set up its industry bureau to manage all telecommunication factories in China. At the beginning of the 1990s, the MPT industry bureau was renamed to PTIC (China Posts and Telecommunications Industry Cooperation). During this time, PTIC had managed more than 60 domestic manufacturers. Since the mid 1990s, hundreds of new telecommunication manufacturers have emerged. Thanks to the economic environment, the ownership of these manufacturers is different. The owners include Sino-Foreign Jointly Founded enterprises, Sino-Foreign Cooperative enterprises, Foreign-invested enterprises, or even private owned enterprises. [75] Most of them are not controlled by PTIC, which is named Putian now.

6.6.2 Four Celebrated Manufacturers

There are four most prominent Chinese telecommunication manufactures: Julong, Datang, Zhongxing and Huawei. It is interesting that if we put the first characters of those four companies together, it shows "Ju Da Zhong Hua", which means "great and strong China" in Chinese.

6.6.2.1 Julong and Datang

Julong and Datang are joint-stock companies, but the government controls the most shares. Located in Beijing, they are the few initial Chinese companies that manufacture PBX (Private Branch eXchange). Julong and Datang contributed a great deal in modernizing the Chinese telecommunication condition and obviously lowered the PBX prices in the competition with foreign telecommunication manufacturers. However, since

the end of the 1990s, the Chinese switch market has been in a saturated condition. Both Julong and Datang are facing the challenge of expanding to other business fields. Julong has made no obvious changes in recent years.

Datang is the main sponsor of CWTS (China Wireless Telecommunication Standard group), which put forward the TD-SCDMA scheme to the ITU. It is the fiercest promoter of TD-SCDMA in the world. In the past few years, Datang devoted most of its funds and loans into the development of TD-SCDMA systems. It could be the second Qualcomm if, in the future, TD-SCDMA takes a big market share in the world, or even in China. However, it is facing three difficulties: Firstly, TD-SCDMA faces fierce competition from WCDMA and CDMA2000. As we know, both WCDMA and CDMA2000 are supported by powerful Western manufacturers and governments, but there are only two positive partners of the TD-SCDMA: Datang and Siemens. Siemens also put part of its funds and human resources into the development of WCDMA and CDMA2000 systems. Other manufacturers, such as Motorola, Nortel Network and Nokia, announce that they can offer TD-SCDMA systems in a short time if the Chinese government supports the TD-SCDMA technology and issues TD-SCDMA license quickly. Secondly, no wireless operator in the world selected TD-SCDMA as its 3G technologies. On the other hand, both WCDMA and CDMA2000 have been commercially launched in Asia. Finally, Datang has suffered with limited funds for a while. PBX, its main business, can barely make a profit at present. Owing to the huge investment in TD-SCDMA, Datang was suffering with deficit in 2001 and 2002. It is predicted that Datang would be at the edge of bankruptcy if there is not positive marketing news of TD-SCDMA before 2005. As a result, Datang keeps appealing for the

Chinese government to support the first Chinese oriented wireless telecommunication scheme – TD-SCDMA.

6.6.2.2 Zhongxing (ZTE) and Huawei

Zhongxing and Huawei are two privately owned companies and are located in Shenzhen, a city next to Hong Kong. Over the past 10 years, Zhongxing and Huawei developed rapidly. Their assets boomed from tens of thousands of dollars to billions of dollars and their product lines cover: PBX, cellular systems, WLL (Wireless Local Loop), xDSL, fiber optic systems and so on. They even received big volume contracts in the Chinese national telecommunication projects, which were traditional territories of foreign manufacturers. It is believed that both of them will have more and more important roles in the Chinese telecommunication market.

6.7 WTO and the Chinese Telecommunication Industry

The WTO will deeply impact the Chinese telecommunication market. This section fully analyzes the history and effect of WTO entrance about the Chinese telecommunication Industry.

6.7.1 Background Information

China has become one of the largest markets in the world. The WTO membership tends to greatly influence the Chinese telecommunication industry, which is far from mature at present. Compared with established international competitors, the Chinese domestic manufacturers are immature and needs governmental protection to allow them to reach maturity. The Western countries realized that the telecommunication market is

huge in China. It was one of the most important focal points in the negotiation of the Chinese WTO entrance.

For years, Chinese leaders have been very cautious about telecommunication and information services. They believe that telecommunications concern national security and sovereignty and cannot be opened. However, this idea seems to have been increasingly challenged since the end of the 1990s. Then, the quarrel was focused on the concrete opening time schedule and method that would minimize the impact on the Chinese national interests.

In the beginning, China agreed to let foreign investors take 25% of the equity stocks, with five years protection time after WTO admission.

6.7.2 The MII Idea of the Chinese WTO Entrance

The Chinese telecommunication regulator, MII, disliked China's joining WTO in a hurry. It believed that WTO entrance would bring more risks and challenges than benefits to the fledgling telecommunications industry. In its point of view, the Chinese telecommunication equipment market was already saturated by competition among almost all international players and few rising Chinese companies. However, the MII was overruled by China State Council, who had a more positive opinion towards the Chinese WTO entrance. [75]

The MII agreed that there would be two main advantages if China joined WTO: Firstly, the IT equipment tariff would be reduced from 13.5% to 3% on imported components and parts, on which the Chinese companies mainly depend. Thus, the costs would be reduced and the competitive ability of those companies would be raised.

Secondly, WTO access would remove some foreign obstacles which were preventing Chinese manufacturers from obtaining more advanced technologies. [75]

6.7.3 Telecom Related WTO Entrance History

In April 1999, the Chinese Prime Minister, Zhu Rongji, visited the United States. During his trip, Zhu showed significant concessions in telecommunication and other sensitive fields, such as banking, insurance, information, and agriculture. For telecommunications, China agreed to eliminate the restrictions on imports of pagers and mobile phones six years after WTO entrance. Foreign companies could hold 25% equity stocks in telecom basic service joint ventures four years after entrance. The equity stocks rate on mobile and value-added services was up to 35% three years after entrance. This offer package reflected the Chinese government's willingness to join WTO before the new millennium. [71]

Yet the Chinese government's sincerity was suspended by a series of political issues. The prelude to such suspensions was the United States scolding China of plagiarizing its nuclear weapon technologies. Then, in May 1999, NATO planes bombed the Chinese embassy in Belgrade. As a result, Chinese hard-liners became more resistant to the United States and WTO entrance. Some Chinese officials announced that China would not join WTO provided the Chinese government believed that the entry items were beyond the Chinese tolerance level.

Soon, Chinese leaders softened their voices and further pushed the entrance negotiations. With rounds of negotiation and compromise, China joined the WTO in October of 2001.

6.7.4 Telecom Related WTO Items and Laws

The Chinese WTO entrance items about telecommunication were more flexible than before: [75]

1. Allow 49% foreign investment in all services (except value added, paging, mobile, and international & domestic services) in two years.
2. Allow 50% foreign ownership for value added (including internet, e-mail, voice mail, online information, data retrieval, and enhanced fax) and paging services in two years. Remove all geographic restrictions for paging and value added services in two years.
3. Allow 49% foreign ownership for mobile services in five years. Phase out all geographic restrictions for mobile services in five years.
4. Allow 49% foreign ownership for international and domestic fixed-line services in six years. Phase out all geographic restrictions for international and domestic services in six years.
5. Open immediately on accession in all telecommunications services on the three key telecommunications services corridors, Beijing, Shanghai, and Guangzhou, which generate about 75% of the Chinese domestic traffic.

According to the above promises, the Chinese government established the Foreign Investment Telecommunication Enterprises Management Rule on December 20, 2001. The rule took effect on January 1, 2002. It listed the Chinese government's opening standard on the telecommunication services: [75]

1. The MRC (Minimum Registered Capital)* for national or multi-provincial value added services (including internet, e-mail, voice mail, online information, data retrieval, and enhanced fax) provider is 10 million RMB ($1.2 million).

2. The MRC for national or multi-provinces basic telecommunication services provider is 2 billion RMB ($240 million).
3. The MRC for inner-province value added services (including internet, e-mail, voice mail, online information, data retrieval, and enhanced fax) provider is 1 million RMB ($120 thousand).
4. The MRC for inner-provincial basic telecommunication services provider is 200 million RMB ($24 million).

The rule also listed other details, such as examining and approving agents, documents, procedures, time schedule, standards about the qualifications of Sino and Foreign enterprises, punishment methods, and so on.

* MRC is an amount of money that a person/group needs to have in order to register a company in China.

6.7.5 BTA and China

In March 1997, the WTO reached BTA (Basic Telecommunications Agreement) in Geneva. The BTA set less restrained rules for international trade on information technology (IT) field. When the BTA took effect, the annual IT trade of its members took 92.6% of the total international IT trade volume. The Chinese annual IT trade amount is about $40 billion, $20 billion in import and $20 billion in export which took about 3% of the international volume. [73]

By stepping into the WTO, China also became a member of the BTA. According to the principle of the BTA, China agreed to reduce part of its IT products tariff from average of 13.5% to 0% in 2005. [73] The reduced tariff concerns computers, semiconductors, and all Internet-related equipment. Furthermore, according to the pro-

competitive regulatory principles of BTA, Chinese operators can select any technology to provide the telecommunications services. The Chinese telecommunication manufacturers will face more difficult situations, as their advantages on price and policy support will be further undercut. When selecting equipment providers, network services operators will pay more attention on economic and technology factors which may be favorable to foreign equipment manufacturers.

6.7.6 Why Would China Join BTA?

China agreed to join the BTA for its own reasons. Firstly, IT equipment smuggling was serious in China. IT vendors had suffered competitions with non-tariffed foreign goods. Those vendors believed that lowering or even canceling IT equipment tariffs would dramatically reduce the smuggling in this field. As a result, they could enjoy a fair business environment. Secondly, the Chinese government realized that China would lose a good opportunity to learn advanced IT technologies and management skills if China did not join BTA. There were more than 70 member countries in BTA. If China did not join BTA, IT manufacturers would devote their funds to those tariff free countries, such as South Korea, Thailand, and India. Then, the Chinese IT enterprises would miss the chance to get more funds and to learn from their foreign cooperators and could ultimately be defeated. The Chinese government also promised to reduce tariff from 13.5% to about 3% on other IT and telecommunication goods that were not covered by the BTA. [56]

6.7.7 The Chinese Government's Reaction after Joining the WTO

In the processes of opening its telecommunication market, the Chinese government will set strict licensing mechanisms. It will enforce effective legal and administrative

regulations to regulate foreign equity ownership and business operations. It plans to employ special policies to direct initial foreign investments toward the mid or western China where the telecommunication infrastructures and services are underdeveloped.

7 The Chinese 3G Development Tendency

7.1 Compare of the Three Schemes of 3G

In general, all of the main 3G schemes have their strong points and drawbacks. The following several paragraphs will compare the three schemes in the aspects of technical maturity, concept advantage, migration path and international roaming.

7.1.1 Technical Maturity and Concept Advantage

In the aspect of technical maturity, both CDMA2000 and WCDMA have successfully launched several networks. However, TD-SCDMA has not promoted any commercial products. The technical maturity relationship among the three schemes is:

CDMA2000 > WCDMA >> TD-SCDMA

In the aspect of concept advantage, the relationship among three schemes and the 2G technologies is as follows:

TD-SCDMA> WCDMA > CDMA2000>> CDMAone > GSM

The concept advantage relationship between different schemes is relative. TD-SCDMA is more advanced than WCDMA or CDMA2000, but it doesn't mean that TD-SCDMA is the best wireless telecommunication scheme. Technologies continuously develop. For example, the 3G group schemes are much more advanced than 2G group members. Although the 3G technologies are still in the seeding stages, at present, some 4G even 5G concepts are put forward or under the process of researching. Normally, each generation of wireless technologies monopolizes the wireless market for about 10 to 15 years.

Table 7.1 lists the parameters of the three schemes. [56]

	WCDMA	CDMA2000	TD-SCDMA
Duplex Method	FDD/TDD	FDD	TDD
Frequency Band	UL: 1920—1980MHz DL: 2110—2170MHz TDD:1900—1920MHz	Use CDMAone frequency	1880—1920MHz 2010—2025MHz 2300—2400MHz (in China)
Frequency band required	2 * 5MHz	2 * N * 1.25MHz N=1, 3, 6, 9, 12	1.6 MHz
Multiplexing method	IMT-DS	IMT-MC	IMT-TC
Chip Rate	3.84 Mcps	N * 1.2288 Mcps N=1, 3, 6, 9,12	1.28 Mcps
Frame length	10 ms	5, 10, 20 ms	10ms
Slots per frame	15		14
Modulation method	QPSK	QPSK	QPSK
Power control	Open-loop, outer-loop, fast close-loop, Rate: 1500Hz step: 0.5—4db	Open-loop, close-loop, outer-loop Rate: 800Hz step: 0.25—2 db	Open-loop, outer-loop, fast close-loop, Rate: 200 Hz step: 0.25—4db
Synchronization	Can select yes or no	Yes, using GPS	No

Table 7.1 Parameters of the three schemes

7.1.2 Migration Path

Migration path is based on the operator's existing network conditions. For the purpose of system stability and saving costs, GSM operators will normally select WCDMA while CDMAone operators prefer to use CDMA2000. The TD-SCDMA equipment can compatibly work with a GSM or CDMAone system. A new wireless operator can select any technology, but it still needs to consider the aspect of international roaming.

Figure 7.1 shows the migration paths of different 2G technologies:

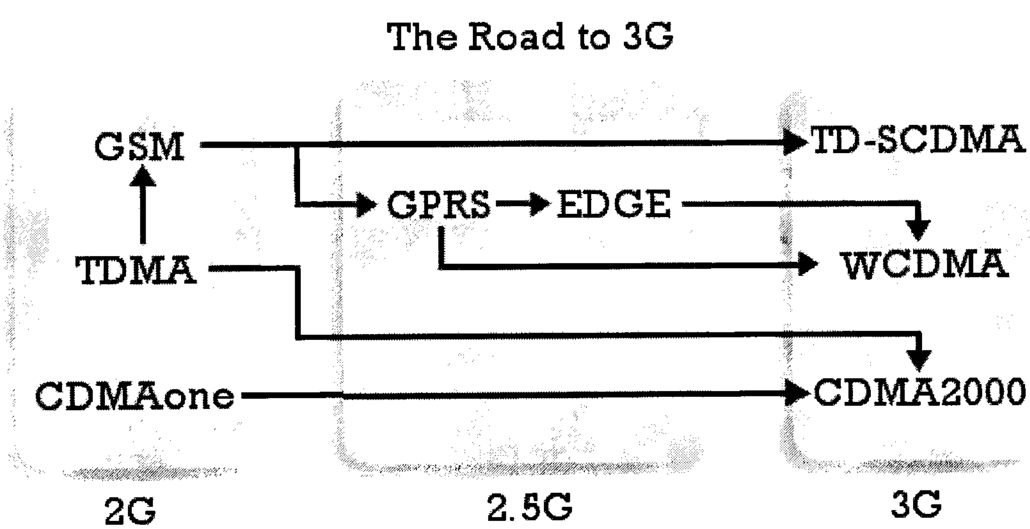


Figure 7.1 Migration paths of different 2G technologies

(From: http://www.mc21st.com/techsubject/subjects/cdma/main.htm)

A GSM network can take the migration path of GSM → GPRS → EDGE → WCDMA, or migrate directly to a WCDMA or TD-SCDMA network. A TDMA network, such as IS136, can follow the same path of GSM or migrate to a CDMA2000 network. For a CDMA network, it normally follows the method of CDMAone → CDMA2000. [56]

7.2 The Competition Condition of the Three Schemes

It is hard to say which technology is better than others based on the parameters alone. Actually, the crucial factor behind this competition is business profit. As the homeland of CDMA, Northern America has vast patents and matured equipment. Qualcomm, Lucent, Motorola, and Nortel Networks have launched CDMA2000-1X networks in the United States and South Korea. They do not want to miss the opportunity to take the monopoly position of the 3G market.

GSM is the leader in the 2G market. European companies have made great profits from the GSM market. Definitely, they do not want to lose their kingdom but want to strengthen their advantage.

China is the biggest wireless telecommunication market in the world. However, all of the 1G and 2G patents and technologies belong to developed countries. Each year, China has to spend tens of billions of dollars in purchasing cellular phones and equipment and paying for the patents. Of course, China does not want to miss the opportunity to have its own 3G technologies and patents. Great money will be saved and the Chinese telecommunication manufacturers can get a good opportunity to enroll into the international market if TD-SCDMA can get part of the world 3G market.

7.2.1 3G Conditions in Europe and North America

The 3G concept was soaring at the end of 1990s. At that time, it was predicted that 3G technologies would mature in 2002. It was hoped that 3G commercial networks would be launched in 2003 and bring in hundreds of billions of dollars. This feeling was strongest in Europe. In this boom, many European governments, such as the UK, and Germany, auctioned their 3G licenses. Desiring to be a winner of the future market,

many European wireless operators devoted tens of billions of dollars to purchase the licenses. However, the world economy went into recession in 2000. The Western telecommunications industry is suffering economically. Tens of thousands of telecom employees are laid off and no one can predict when the spring of those telecom companies will be. In the mean time, 3G faces many technical difficulties. As a result, many European operators, such as KPN, Vodafone, Orange, and Sonera, announced the cancellation or delay of their ambitious 3G plans. [56] Meanwhile, Northern American telecommunication operators are suffering with deficits or financial scandals. They have no energy to consider carrying out 3G technologies.

7.2.2 3G Conditions in Other Asia Areas

7.2.2.1 Condition in Korea

The conditions are different in Asia. The South Korea telecom operator, SKT, announced the promotion of the 3G service at the end of 2003. Its confidence was based on the successful CDMA business in South Korea which is the largest CDMA market at present.

7.2.2.2 Condition in Japan

In Japan, the largest wireless operator, DoCoMo launched WCDMA in October of 2001. The second Japan telecom operator, KDDI offered its CDMA2000-1X service in April of 2002. By the end of November 2002, the Japanese CDMA2000-1X network got about three million subscribers, while the DoCoMo's WCDMA network had only four hundred thousand users. [56]

The reasons that DoCoMo's WCDMA failed to attract sufficient users follow:

1. Japan has its own 1G and 2G technologies, and has no GSM network. DoCoMo has to build an entirely new network from the very beginning. [56]
2. DoCoMo successfully marketed i-mode services in Japan. It does not want the WCDMA services to snatch its i-mode users. [56]
3. The WCDMA networks only cover metropolises, such as Tokyo, Osaka, and Kobe. The nationwide coverage is no more than 70%. [56]

On the contrary, KDDI built its CDMA2000-1X networks based on its CDMAone systems. In a short time, the CDMA2000-1X services covered all of Japan. As a result, the KDDI 3G services are more successful than that of DoCoMo.

7.3 The Chinese 3G conditions

7.3.1 The Chinese Government Showed Its Support to TD-SCDMA

Although its technical concept is very good, the TD-SCDMA is immature and short of support. Before December of 2002, there were only two manufacturers announced to support TD-SCDMA, Datang and Siemens. Siemens bets two ways, WCDMA and TD-SCDMA. Datang is the main sponsor of CWTS (China Wireless Telecommunication Standard group) and is the fiercest promoter of TD-SCDMA. However, it suffered with a vast deficit in recent years.

Although the Chinese government cannot mandate wireless operators to select which 3G technologies, it has other methods to realize that. On October 24, 2002, MII allocated 60*2 MHz to WCDMA and CDMA2000 but assigned 155 MHz to TD-SCDMA. Under the promotion of several Chinese ministries, eight Chinese venders, Datang, Zhongxing (ZTE), Huawei, Putian, Legend, Soutec, CECT, and Holley formed the TD-SCDMA alliance. The Chinese government showed its decision to support TD-SCDMA. [56]

7.3.2 The Chinese Government will be the Winner

The future of the TD-SCDMA is not clear. It is possible that TD-SCDMA could be a loser, but the Chinese government will be the winner. If TD-SCDMA is a success, it will greatly improve the development of Sino-oriented technologies and help the Chinese telecom manufacturers exploit international telecommunication market. Even if TD-SCDMA fails, China will also save a lot in purchasing 3G related products. In the process of competition with the TD-SCDMA, the WCDMA and CDMA2000 groups have to lower their price to lure the Chinese operators and manufacturers to choose their technologies. For instance, several days after the MII assigned the 3G spectrum, DoCoMo, Ericsson, Nokia, and Fujisong, the main WCDMA patents holders, signed an agreement to set the WCDMA patent fee at 5% or lower. This action by the giants was clearly designed with an eye on China. [56]

7.3.3 The Chinese 3G Operators

Based on the real conditions in China, it is reasonable to believe that China will have four or five 3G operators. China Mobile and China Unicom are traditional Chinese wireless operators. It is reasonable to offer 3G licenses to them in the future. China Telecom and China Netcom will finish their reconstruction in mid 2003. The MII officers have announced that MII will let China have four full services operators in the next two years. China Unicom is a full services operator at present. Then, the other three full services operators should be China Mobile, China Telecom, and China Netcom. As a result, China Telecom and China Netcom will get their 3G licenses soon. China Railway Telecom was formed in 2000. It has been complaining for a shortage of revenue resources. It is possible that China Railway Telecom would get a 3G license.

7.3.4 Different 3G Migration Methods of the Chinese Operators

According to the different network conditions, the different Chinese 3G operators will select different migration paths.

7.3.4.1 China Mobile

China Mobile has the largest GSM networks in the world and it has invested tens of billions of dollars into its networks. It wants to fully utilize its 2G networks to migrate to 3G. Most of the Chinese high-end wireless subscribers are China Mobile users; they are more likely to need the international roaming. Right now, China Mobile users can freely roam to many other countries. Because GSM takes the leading position of the 2G market, it is reasonable to believe that there will be more operators supporting WCDMA than those supporting CDMA2000 or TD-SCDMA. As a result, China Mobile managers show great interest in WCDMA but pay no attention to CDMA2000. Although they know that the Chinese government would promote the development of TD-SCDMA application in the future, China Mobile offices are quite negative to build TD-SCDMA commercial networks. Anyway, TD-SCDMA is short of international support at present. As a result, China Mobile will apply for a WCDMA license.

7.3.4.2 China Unicom

Although China Unicom has expended its market share quickly in recently years, it is short of high-end mobile users. The China Unicom officers want to utilize the maturity of CDMA2000 to get an advantageous position in the Chinese 3G market. It has built CDMA2000-1X networks and is trying to find a way to merge its GSM and CDMAone networks in the future. It is clear that China Unicom will ask for a CDMA2000 license.

7.3.4.3 China Telecom and China Netcom

Because China Telecom and China Netcom do not have any wireless networks at present, they can build brand new 3G systems. The Chinese government wants to use 3G licenses to encourage them build TD-SCDMA networks. However, these companies also need to consider the issues of international roaming and the quality of services. The most likely solution is that the MII will issue WCDMA & TD-SCDMA licenses packets to these operators. China Telecom and China Netcom have to build their WCDMA & TD-SCDMA systems. They will construct WCDMA B-Nodes in most areas while build TD-SCDMA sites in urban and high telecom volume areas. As a result, these operators need to cooperate with some manufacturers to offer WCDMA & TD-SCDMA dual-mode handsets, which is quite a challenge. In order to compete with China Mobile and China Unicom, it is possible that China Telecom and China Netcom will cooperate with each other in the field of wireless telecommunication.

7.3.4.4 China Railway Telecom

China Railway Telecom is the weakest Chinese 3G license competitor. The scale of the China Railway Telecom is much smaller than China Telecom or China Unicom. It also does not have an experienced wireless technical team. Thus, it cannot build a wireless network in a short time. In order to gain the support of the Chinese telecom management agents, China Railway Telecom now acts as a very positive TD-SCDMA promoter. Cooperating with Datang, China Railway Telecom is building a TD-SCDMA trial-run network in Chengdu of Sichuan province. If China Railway Telecom can get a Chinese 3G license, it will be a TD-SCDMA one.

7.3.5 Challenges to the Chinese Wireless Operators

Chinese wireless operators have the following challenges in order to promote 3G services in China:

The first challenge is that they need to create really attractive 3G applications. The most important feature of 3G is high data speed and supporting multimedia services. However, which applications can attract the Chinese customers to use them? The applications should be easy to use, interesting, and inexpensive, which is difficult to accomplish simultaneously. For instance, downloading songs with a handset sounds interesting; however, if the cost of downloading a song wirelessly is more expensive than the price of a CD, no one will use such a service.

The second challenge is that operators need the support of powerful 3G handsets. The mobile handsets have many limitations, such as limited CPU speed, limited screen size, and limited battery capacity. In order to better support future 3G applications, the new 3G handsets should eliminate those limitations. To overcome this challenge needs the cooperation of the whole information and electronic industries.

The third challenge is how to make inexpensive and lightweight multi-mode handsets. When the 3G services are just launched, the operators need dual-mode or tri-mode handsets to offer full coverage services to wireless users, such as GSM/WCDMA, CDMAone/CDMA2000, or WCDMA/TD-SCDMA handsets. Those handsets will integrate two or three wireless schemes at the same time. Realizing such an idea is difficult.

The last challenge is roaming among different 3G networks. Theoretically, the Core Network systems can settle the problem of systems interconnection. However, because

of the huge amount of work involving the software and hardware, it will be difficult to accomplish. There are no 3G interconnection networks at present. Furthermore, in order to protect their own profits, many wireless operators are unwilling to support roaming with other wireless operators.

7.3.6 The Chinese 3G Market Share of the Three Schemes

Based on the above information, one can draw the conclusion that the future Chinese 3G technical market will be as follows:

The Chinese 3G market will be shared by WCDMA, CDMA2000, and TD-SCDMA. Different wireless operators will offer different technical solutions. The top three Chinese wireless operators will be China Mobile, China Unicom, and China Telecom.

The WCDMA will have the lion's share, which is about 65% to 70% of the Chinese 3G market. China Mobile is the biggest Chinese telecommunication operator after the division of China Telecom. It will build the biggest WCDMA network in the world. Although China Telecom and China Netcom will get WCDMA & TD-SCDMA licenses, they will focus on building WCDMA systems. Thus, WCDMA will have the strongest support and have more users than will CDMA2000 and TD-SCDMA.

Supported by China Unicom, CDMA2000 will take the second market slice, which is more than 20%. Thanks to the maturity and colorful applications of CDMA2000, China Unicom can attract a vast mount of users in subsequent years.

The TD-SCDMA will collect the remaining 10% to 15% Chinese 3G market. It is fully supported by the Chinese government. China Telecom, China Netcom, and China Railway Telecom will build TD-SCDMA networks in the future. According to the reason that it is short of international support, TD-SCDMA will be mainly used in China.

Whatever the outcome, it is clear that the Chinese wireless market shows tremendous growth potential. Most international wireless manufacturers, like Motorola, Nokia, Ericsson, Siemens, Qualcomm, Lucent, and Nortel Networks, have made fat profits in China. Encouraged by the successful stories of those companies, many other wireless enterprises are planning to enroll into this market. In order to get the preponderance position in China, those enterprises should start as soon as possible.

Acronyms

3GPP – 3rd Generation Partnership Project

3GPP2 – 3rd Generation Partnership Project 2

8-PSK – 8 Phase Shift Keying

AAA – Authentication, Authorization, and Accounting

AMPS – Advanced Mobile Phone Service

ANSI – American National Standard Institute

AuC – Authentication Center

BCCH – Broadcast Control Channel

BCH – Broadcast Channel

BMC – Broadcast/Multicast Control

BS – Base Station (Also known as BTS)

BSC – Base Station Controller

BTA – Basic Telecommunications Agreement

BTS – Base Transceiver Station (Also known as BS)

CAS – Chinese Academy of Sciences

CCCH – Common Control Channel

CDMA – Code Division Multiple Access

CN – Core Network system

CPCH – Common Packet Channel

CPHCH – Common Physical Channels

CTCH – Common Traffic Channel

CWTS – China Wireless Telecommunication Standard Group

DAMPS – Digital Advance Mobile Phone Service

DCCH – Dedicated Control Channel

DCH – Dedicated Channels

DCS – Digital Cellular System

DECT – Digital European Cordless Telecommunications

DPHCH – Dedicated Physical Channels

DS – Directly Spreading

DSCH – Downlink Shared Channel

DTCH – Dedicated Traffic Channel

DwPTS – Downlink Pilot Timeslots

EDGE – Enhanced Data for GSM Evolution

EIR – Equipment Identity Register

ETSI – European Telecommunications Standards Institute

FACH – Forward-Access channel

F-CAPICH – Common Auxiliary Pilot Channel

F_CPHCH – Forward CPHCH

F-DAPICH – Dedicated Auxiliary Pilot Channel

F-DCCH – Dedicated Control Channel

FDD – Frequency Division Duplex

FDMA – Frequency Division Multiple Access

F_DPHCH – Forward DPHCH

F-FCH – Fundamental Channel

F-SCHT – Supplemental Channel Type

GATT – General Agreement on Tariff and Trade

GDP – Gross Domestic Product

GGSN – Gateway GPRS Supporting Node

GMSK – Gaussian Minimum Shift Keying

GPRS – General Packet Radio Service

GPS – Global Positioning Systems

GSM – Global System for Mobile

GTP – GPRS Tunneling Protocol

HA – Home Agent

HLR – Home Location Register

IMT-2000 – International Mobile Telecommunicationas-2000

IMTS– Improved Mobile Telecommunication Service

IS – Interim Standards

ISDN – Integrated Services Digital Network

ITU – International Telecommunications Union

IWF – Interworking Function

LAC – Link Access Control

MAC – Medium Access Control

MAP – Mobile Application Protocol

MC – Multi-Carrier

ME – Mobile Equipment

MII – Ministry of Information Industry

MMS – Multimedia Message Service

MOR – Ministry of Railways

MPT— Ministry of Posts and Telecommunications

MS – Mobile Station

MSC – Mobile services Switching Center

MT – Mobile Terminal

NMT – Nordic Mobile Telephone

OCCCH – ODMA Common Control Channel

ODCCH – ODMA Dedicated Control Channel

ODTCH – ODMA Dedicated Traffic Channel

PBX – Private Branch eXchange

PCCH – Paging Control Channel

PCH – Paging Channel

PCN – Personal Communication Network

PCU – Packet Control Unit

PCS – Personal Communication Service

PDA– Personal Digital Assistant

PDC – Personal Digital Cellular

PDCP – Packet Data Convergence Protocol

PDSN – Packet Data Serving Node

PLMN – Public Land Mobile Network

PRC – Peoples' Republic of China

PSTN – Public Switched Telephone Network

PTA – Posts and Telecommunications Administration Bureau

PTIC – China Posts and Telecommunications Industry Cooperation

RACH – Random-Access Channel

RAN – Radio Access Network system

R-CPHCH – Reverse CPHCH

R-DCCH – Dedicated Control Channel

R_DPHCH – Reverse DPHCH

R-FCH – Fundamental Channel

R-PICH – Pilot Channel

R-SCHT – Supplemental Channel Type

RLC – Radio Link Control

RNC – Radio Network Controller

RNS – Radio Network Subsystem

RTT – Radio Transmission Technology

SARTF – State Administration of Radio, Film and Television

SCCCH – Shared Channel Control Channel

SGSN – Serving GPRS Supporting Node

SIM – Subscriber Identity Module

SMS – Short Message Service

SMSC – Short Message Service Center

TACS – Total Access Communication System

TAB – Telecommunication Administration Bureau

TDD – Time Division Duplex

TDMA – Time Division Multiple Access

TD-SCDMA – Time Division Synchronous Code Division Multiple Access

TFS – Transport Format Set

TIA –Telecommunications Industry Association

UIM – Universal Identity Module system

UMTS – Universal Mobile Telecommunication System

UpPTS – Uplink Pilot Timeslots

UTRA – UMTS Terrestrial Radio Access

UTRAN – UMTS Terrestrial Radio Access Network

VLR – Visitor Location Register

WAP – Wireless Application Protocol

WCDMA –Wideband Code Division Multiple Access

WLL – Wireless Local Loop

WTO – World Trade Organization

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