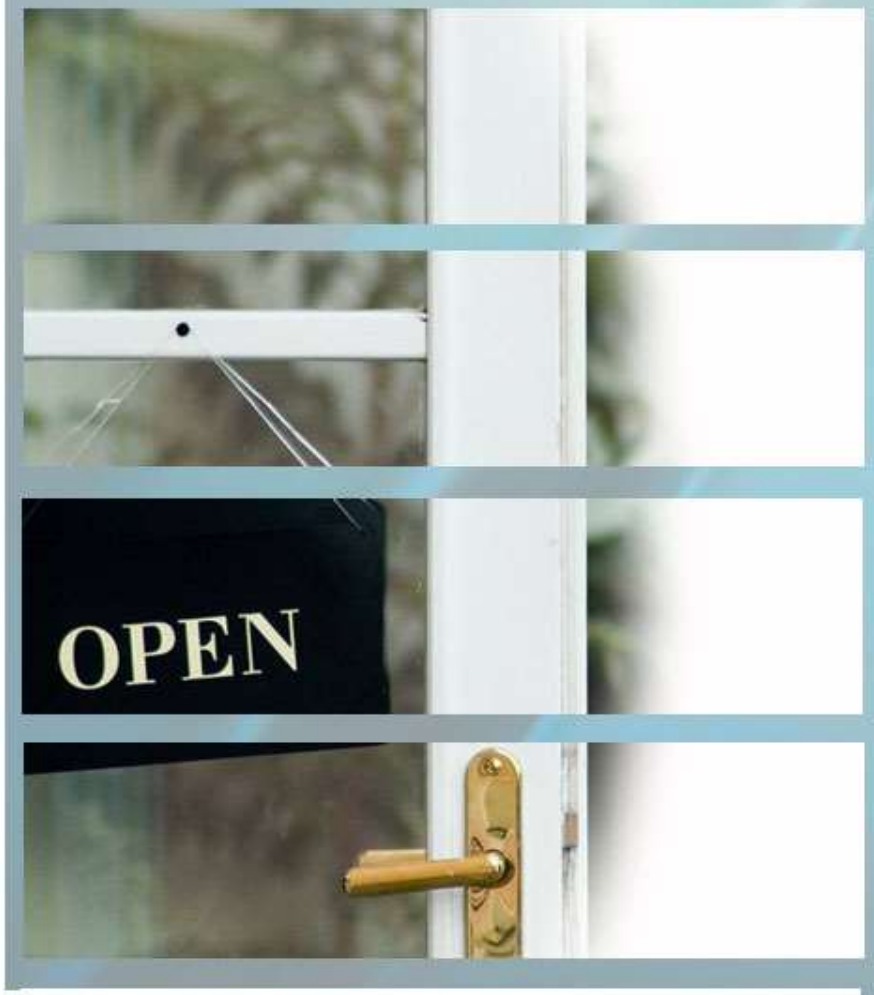
Chapter Nine

Mobile communication network

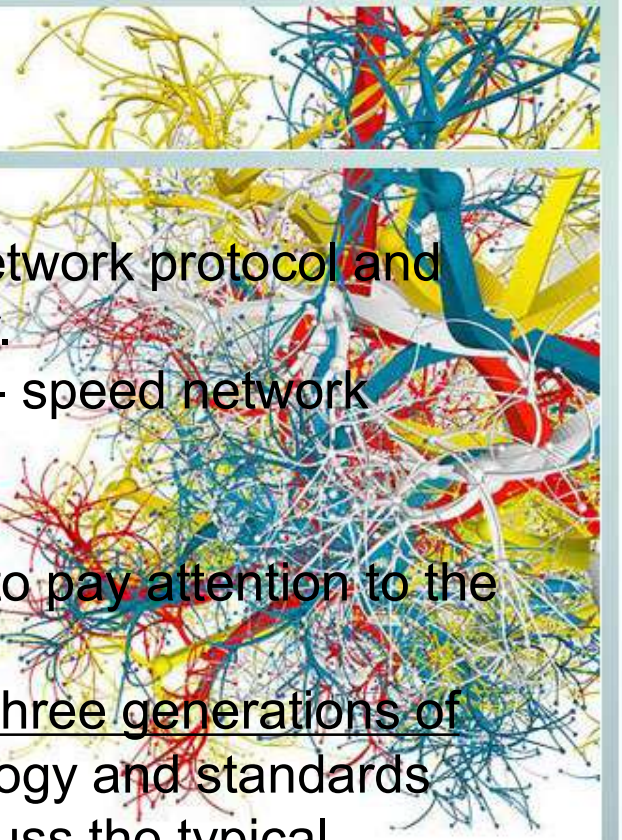


Mobile communications, especially 3G, will become an effective platform for "comprehensive, anytime, anywhere" transmission of information.

This chapter will introduce the development of mobile communication, focusing on 3G communication technology and mobile Internet applications.

内容提要

Review



Chapter 8 introduces the wireless low speed network protocol and wireless sensor network networking technology.

- Bluetooth, infrared and other traditional low - speed network protocol characteristics
- 802.15.4 / ZigBee protocol
- Wireless sensor network networking needs to pay attention to the problem

This chapter will introduce the development of three generations of mobile communication, focusing on 3G technology and standards (TD-SCDMA, W-CDMA, CDMA2000), and discuss the typical applications of mobile Internet (video phone, mobile TV), briefly discuss the development of 4G.

Content

9.1 Development history of mobile communication

9.2 3G communication technology and standards

9.3 Mobile Internet

9.4 About 4G

What are the representatives of three generations of mobile communication technology?

9.1 First generation mobile communication: analog voice

- In 1928, Purdue University students invented the Superheterodyne radio receiver, which was then used by the Detroit police department and built the world's first mobile communication system (vehicle-mounted radio system).
- In 1946, bell systems in Saint Louis established the first automobile telephone system.
- West Germany, France and Britain completed the development of public mobile phone systems in 1950, 1956 and 1959 respectively.

BELL SYSTEM

9.1 First generation mobile communication: analog voice

In the 1960s, the United States began to use IMTS, an improved mobile phone system with small and medium capacity.

- ✓ IMTS has two frequencies for receiving and sending functions.
- ✓ IMTS supports 23 channels with a frequency range of 150 ~ 450MHz.

A design that covers only one base station in a large area is called a large area system.

The regional system has the following **features**:

- ✓ The base station covers a large area
- ✓ High transmitting power
- ✓ Available frequency bandwidth is limited, system capacity is small
- ✓ Suitable for professional network, not suitable for commercial use

9.1 First generation mobile communication: analog voice

In 1982, in order to solve the problem of large area system capacity saturation, bell laboratories invented the advanced mobile phone system AMPS.

AMPS put forward the concept of **"cell system"** and **"cellular cell",** which was the first real **"cellular mobile communication system".** At the same time, the technology of Frequency Division Multiplexing (FDM) was used to solve the contradiction of large capacity requirement and spectrum resource limitation of public mobile communication system.

IMTS allows only one phone call per frequency within 100km;AMPS allows for 100 10km cellular units, thus ensuring 10 to 15 phone calls per frequency.

Cellular systems

The system structure

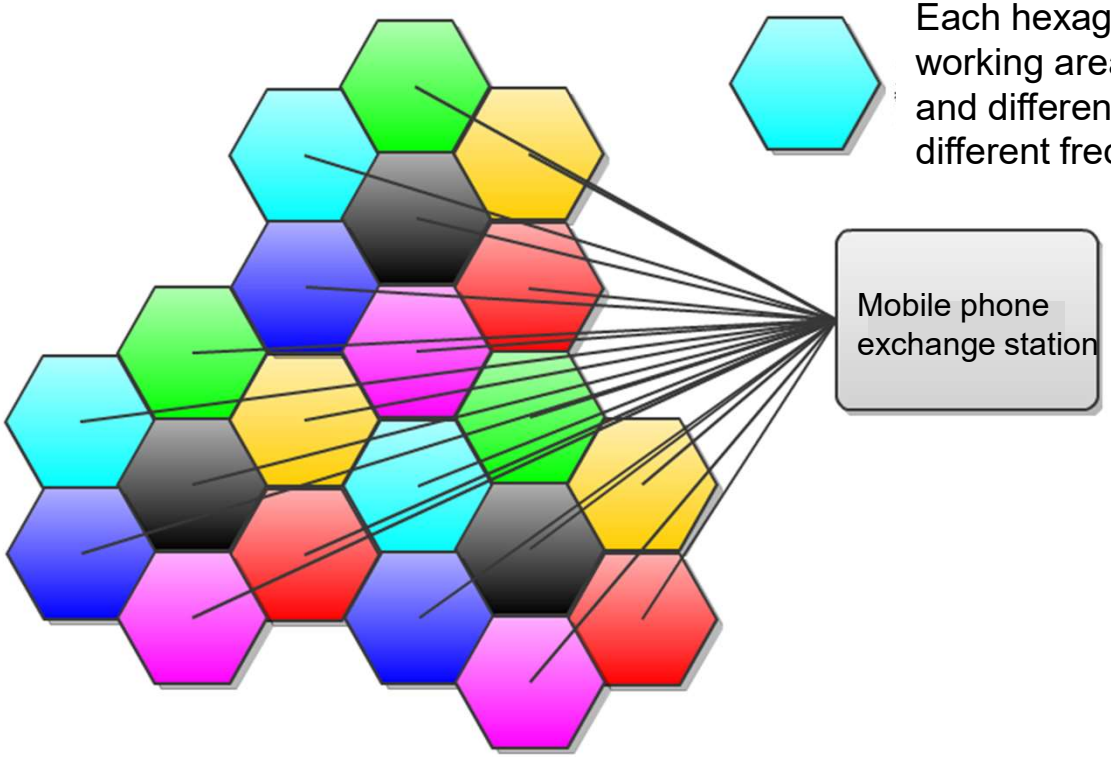
- Each cell unit has a base station that receives information from the phones in that cell.
- The base station is connected to Mobile Telephone Switching Office (MTSO).
- MTSO adopts layered mechanism, and the one-level MTSO is responsible for direct communication with the base station; The advanced MTSO is responsible for business processing between the lower MTSO.

Handover: when phones move between cellular units, base stations communicate with each other to exchange control, avoiding channel allocation that can lead to conflicting signals. The transfer of control from the base station to the telephone user is also known as a "handover".

✓ "Soft handover" : the user's call remains coherent.

✓ "Hard handover" : the old base station needs to stop the user talking.

Cellular systems(Next)



9.1 Second generation mobile communication: Digital voice

Second generation mobile communication technology: digital standard

- Support traditional voice communication, text and multimedia SMS
- Support some wireless application protocols

900/1800mhz GSM mobile communication

- ✓ Operating at 900/1800 MHZ
- ✓ The wireless interface adopts TDMA technology, and the core network mobility management protocol adopts MAP protocol

800MHz CDMA mobile communication

- ✓ Working in 800MHz frequency band, core network mobility management protocol adopts is-41 protocol
- ✓ The wireless interface adopts narrow-band code division multiple access (CDMA) technology


GSM System

GSM is a **cellular network system**. Cellular units can be divided into:

- ✓ Macro cellular: the largest coverage area, base station is usually in a higher position, such as mountain peak
- ✓ Micro cellular: base station height is generally lower than the average building height, suitable for urban areas
- ✓ Micro Micro beehive: indoors, within dozens of meters
- ✓ Umbrella cellular : fills in the signal gaps between beehives

GSM background network system includes the following modules:

- ✓ Base station system, including base station and associated controllers
- ✓ Networks and switching systems, also known as core networks, connect the parts
- ✓ GPRS core network, which can be used for message-based Internet connections, is optional
- ✓ An identity module, also known as a SIM card, is used to store user data


CDMA System

CDMA application capacity in cellular mobile communication network can theoretically reach 20 times of AMPS capacity.

CDMA can simultaneously distinguish and separate multiple simultaneously transmitted signals.

CDMA has the following features:

- ✓ Good anti-interference performance
- ✓ Resist multipath fading
- ✓ High security
- ✓ There are trade-offs between volume quality
- ✓ The same frequency can be used repeatedly in multiple cells

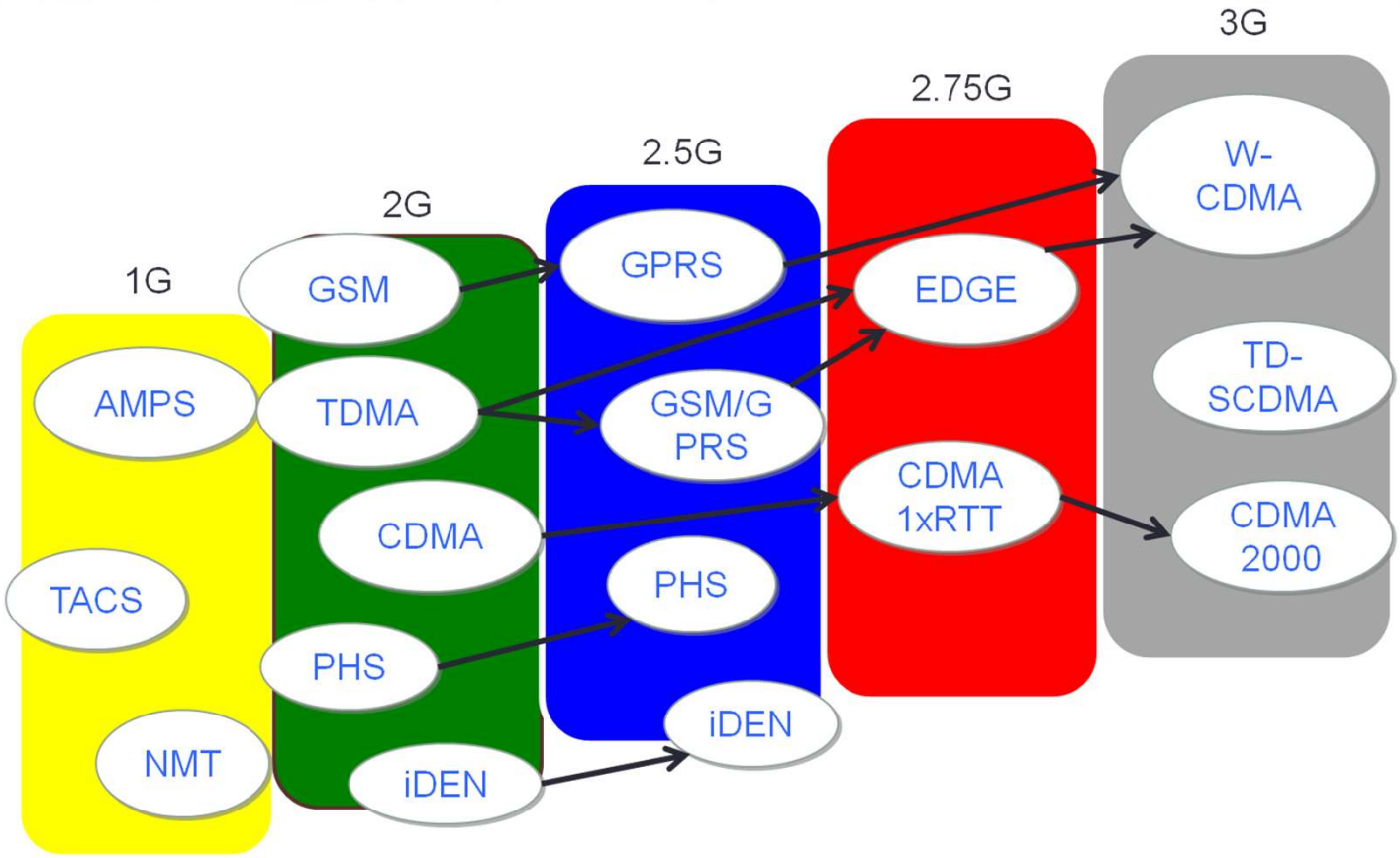

9.1 Third generation mobile communication: Digital voice and data

Third generation mobile communication (3G) can provide all 2G information services, while guaranteeing faster speed and more comprehensive business content, such as mobile office, video streaming services and so on.

The main feature of 3G is to provide mobile broadband multimedia services, including high-speed mobile environment support 144Kbps rate, walking and slow mobile environment support 384Kbps rate, indoor environment should reach 2Mbps data transmission rate, and ensure high reliable service quality.

People found it difficult to jump directly from 2G to 3G, leading to a transition stage of 2.5g (also known as 2.75g later).

The development of 3G




2G to 3G transition industry

HSCSD

- Upgraded version of GSM network
- The rate is five times faster than that of the GSM network
- Dynamic provides different error correction methods

GPRS

- Products based on traditional GSM
- The transformation of the existing base station system, using GSM network unused TDMA channels, the rate can reach 114Kbps
- Immediately online

EDGE

- Commonly known as 2.75g, it is the transition industry between GPRS and 3G
- The transmission rate can reach 384Kbps
- Advocate using existing GSM resources


IMT-2000

The third generation Mobile Telecommunication System was first proposed by the ITU TG8/1 in 1985 and was originally called FPLMTS (Future Public Land Mobile Telecommunication System), which was changed to IMT-2000 in 1996.

The number 2000 has three meanings:

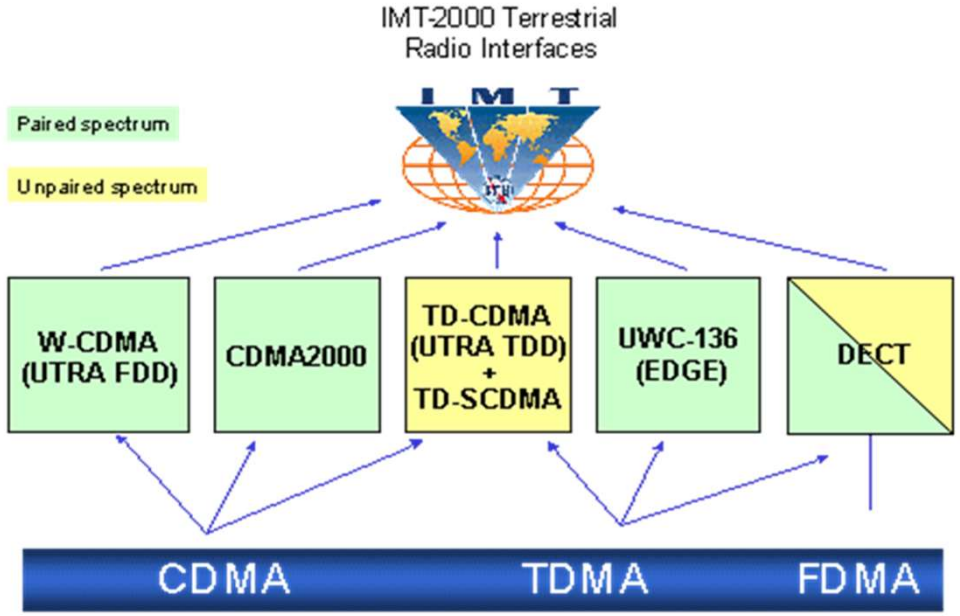
- ✓ It is hoped that the system can be fully applied to the market by the year 2000.
- ✓ 3G is expected to run at 2000MHz.
- ✓ It is hoped that the bandwidth of 2000KHz can be guaranteed by 3G.

In 1999, the imt-2000 wireless interface specification was recommended for adoption.

3G wireless interface standard

Traditional narrowband TDMA technology is far from meeting the high bandwidth requirement of 3G system, while CDMA coding mode is the basis of current 3G communication standard. The three standards of CDMA technology in the figure are:

IMT-DS corresponds to **W-CDMA**
IMT-MC corresponds to **CDMA2000**
IMT-TD, which corresponds to **TD-SCDMA** and **UTRA-TDD**



IMT-2000 Wireless interface with 5 standards

Content

What are the three 3G standards used in China?

What are the characteristics?


9.2 3G communication technology and standards

Review of 3G development:

- The concept of FPLTMS was proposed in 1985.
- In 1991, ITU established the tg8/1 task group, which is responsible for the standard customization of FPLTMS.
- In 1996 FPLTMS was renamed IMT-2000.
- In 1997, the ITU issued a circular letter to all countries, requiring all countries to submit candidates for imt-2000 wireless interface technology before June 1998. A total of 15 technical solutions for 3G interface were received, including TD-SCDMA standard independently developed by China.
- In May 2000, ITU officially announced the third generation of mobile communication standard, CDMA technology with its unique advantages as the basis of many standards.

The three 3G standards adopted in China are TD-SCDMA, W-CDMA and CDMA2000.

TD-SCDMA

TD-SCDMA (Time Division -- Synchronous Code Division Multiple Access) started later than W-CDMA and CDMA2000, and was proposed to ITU by the former academy of telecommunications science and technology of ministry of posts and telecommunications in June 1998.

TD-SCDMA integrates many technologies:

- ✓ SCMDA
- ✓ CDMA and software radio synchronization
- ✓ TDMA, FDMA

CHINA MOBILE TD-SCDMA

TD is divided into:

- ✓ TD-SCDMA: provides data services such as voice and video calls with a maximum downlink frequency of 384Kb/s
- ✓ TD-HSDPA: data service enhancement technology that provides a downlink rate of 2.8Mb/s


The mobile communication problem solved by TD-CDMA

Respiratory effect: in CDMA system, the actual effective coverage area of base station will decrease with the enhancement of interference signal, and vice versa. The phenomenon that the coverage area shrinks with the increase of the number of users is "respiratory effect".

- Jamming signals are closely related to the number of mobile users.
- The main reason of "respiratory effect" is that CDMA system is a self-interference system;
- CDMA2000 and W-CDMA belong to the same frequency self-interference system, and the self-interference between adjacent users is obvious, which reduces the actual transmission rate.

TD-SCDMA

- Low bandwidth FDMA and TDMA limit the maximum interference of the system.
- Applying CDMA technology to improve system capacity in single slot;
- Use joint detection and SDMA technology to track the signal of the customer terminal;
- Make full use of downlink signal energy to minimize the interference between customers.
- TD-SCDMA is no longer a self-interfering system, and the "breathing effect" is basically eliminated.

The mobile communication problem solved by TD-CDMA

"Near and far effects" : another problem with mobile interference.

- The distance to the base station is constantly changing;
- Fixed communication power will not only cause serious power surplus, but also may form harmful electromagnetic radiation.

How to solve it? Dynamic power control: the mobile phone terminal dynamically adjusts its transmission power according to the communication distance from itself to the base station, so as to reduce the surplus as much as possible, and still ensure the connectivity.

TD-SCDMA

- Dynamic channel allocation is adopted, that is, real-time dynamic resource allocation is carried out according to users' requirements, including frequency, time slot and code word.
- Dynamic channel allocation not only improves the utilization rate of channel resources, but also enhances the adaptability to network load and interference changes.

W-CDMA

W-CDMA (Wideband Code Division Multiple Access) is proposed by Ericsson, 3GPP is specifically formulated based on GSM MAP core network, and UTRAN is a 3G system with wireless interface.

- The first commercial W-CDMA network was launched by Japan's NTT DoCoMo in 2001 and was the world's first 3G mobile phone service.
- China Unicom began offering W-CDMA service in mainland China in 2009 and began offering HSDPA service (and HSUPA service in some regions).
- Hong Kong mobile operator SUNDAY and others have also built W-CDMA commercial networks.
- 3G services in Taiwan began in 2005, among which China telecom, Taiwan mobile and fetnet all used W-CDMA systems.

ERICSSON

3GPP
A GLOBAL INITIATIVE

NTT DoCoMo

China unicom中国联通

中華電信


W-CDMA Technology Introduction

The uplink technical parameters are mainly based on the European FMA2 scheme. The descending technical parameters are mainly based on Japanese ARIB W-CDMA scheme.

W-CDMA technology mainly includes FDD and TDD:

- ✓ FDD: works in a large coverage area and can receive and transmit in two symmetrical frequency channels
- ✓ TDD: focuses on small areas where business is heavy

W-CDMA defines three available public control channels and two dedicated channels:

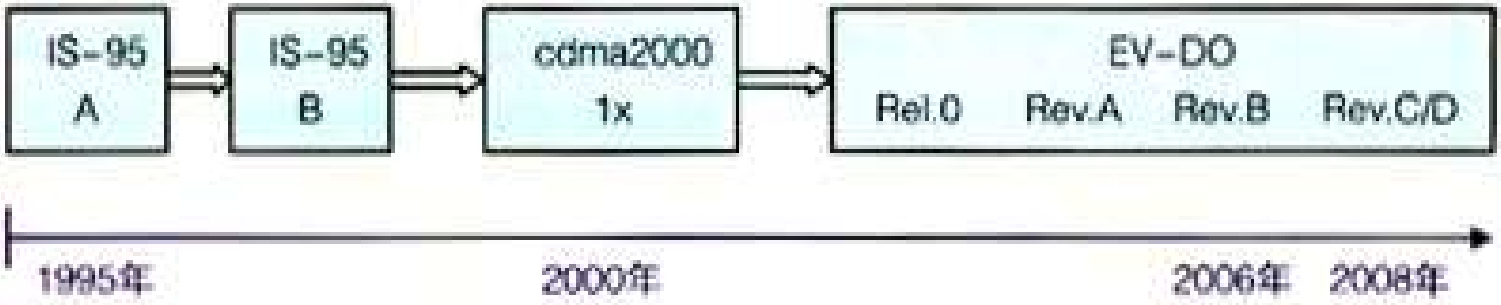
- ✓ Broadcast public control channel (BCCH), paging channel (PCH), forward access channel (FACH)
- ✓ Main private control channel (SDCCH), auxiliary private control channel

CDMA2000

CDMA2000, also known as CDMA multi-carrier, was proposed by Qualcomm North America.

W-CMDA and TD-SCDMA are set by the standards body 3GPP, while CDMA2000 is set by the standards body 3GPP2.

CDMA2000 standard propulsion route:




CDMA2000 Technology Introduction

CDMA2000 1x：

- 1x, or 1xRTT, is the core of 3G CDMA2000 technology.
- The label 1x refers to CDMA2000 wireless technology using a pair of 1.25MHz radio channels.

CDMA2000 1xRTT：

- CDMA2000 1xRTT (RTT radio transmission technology) is a base layer of CDMA2000.
- It is often considered a 2.5g technology because its transmission rate is not as high as other 3G technologies.
- Supports up to 144kbps data rate.

CDMA2000 1xEV：

- CDMA2000 1x adds high data rate (HDR) capabilities.
- The CDMA2000 1xEV first phase (CDMA2000 1xev-do) supports up to 3.1Mbps downstream and up to 1.8Mbps upstream.
- The CDMA2000 1xEV second phase (CDMA2000 1xev-dv) also supports 1x voice users, 1xRTT data users and high-speed 1xev-dv data users using the same channel.


Major technical differences between the three 3G standards

Content \ Standard	TD-SCDMA	W-CDMA	CDMA2000
Channel bandwidth(MHZ)	1.6	5/10/20	1.25/10/20
Chip rate	1.28	3.84	3.6864
Synchronization	Asynchronous/synchronous	Asynchronous/synchronous	Synchronous
Frame size	10	10	20
Duplex technology	TDD	FDD/TDD	FDD
Multi-access mode	TD-SCDMA	DS-CDMA	DS-CDMA and MC-CDMA
Speech coding	Constant rate	Constant rate	Varible rate
Mulit-rate	Variable spread spectrum factor, multiple code RI monitoring	Variable spread spectrum factor and multi-code RI monitoring;Blind monitoring of high rate operations;Low rate service	Variable spread spectrum factor and multi-code RI monitoring;Low rate service, pre-scheduled, high level signaling required
Power control	Open loop + slow closed loop(20b/s)	FDD: open loop + fast closed loop (1600b/s);TDD: open loop + slow closed loop	Open loop + slow closed loop (800b/s)
Interweave	Convolution code: interleaving within the frame;RS code: interframe interleaving	Convolution code: interleaving within the frame;RS code: interframe interleaving	Piece of woven

Content

9.1 Development history of mobile communication

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9.3 Mobile Internet

9.4 About 4G

What are the typical applications of mobile Internet?

9.3 Mobile Internet

Data transmission over 3G networks

- Diversity: video information, streaming data, music TV...
- Immediacy:
  - ✓ 2Mb/s in indoor fixed environment
  - ✓ 144Kb/s in outdoor fast-moving environment
- Location: cell phone signals can cover areas where Wi-Fi and other wireless signals are difficult to reach

Mobile Internet: combine mobile communication and Internet to provide web browsing, video conference and other Internet application services

3G and Internet of things: 3G is an effective platform for information transmission in the Internet of things.

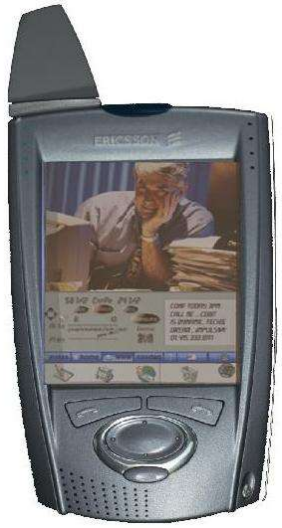
Video phone

Video telephony technology is the basic requirement of other integrated services:

- Ensure that the delay is close to the voice service
- Provide richer means of data exchange
- Improve the quality of service for mobile users

Two video codecs:

- H.263 codec
  - ✓ Based on the 64Kb/s rate,
  - ✓ Used for video calls
- H.264 codec
  - ✓ Applied to video streaming
  - ✓ Widely used in film and television



Mobile TV

Technically, **Mobile TV** falls into two categories:

- Based on terrestrial broadcast networks
  - ✓ Loosely coupled or relatively independent from mobile networks
  - ✓ DVB-H in Europe, T-DMB in South Korea, ISDB-T in Japan, CMMB in China...
- Based on mobile communication network
  - ✓ You can't network independently
  - ✓ MBMS, BCMCS...

CMMB (China mobile multimedia broadcasting)

- Facing mobile phone, PDA, MP4, GPS navigator, laptop and other mobile terminals
- "Celestial body integration, star network combination, unified standards, national roaming"
- Frequency range: 470 ~ 798MHz;Transmission attenuation is small; Coverage: 40 km
- Difficult to support VOD and two-way interaction
- Complementary with 3G video technology


Other applications

Mobile email: bind mobile phone with email account, receive email in real time, reply, delete and other management.
WAP: bring Internet content and data services to mobile phone terminals.
Mobile payment: allows users to pay for goods through their mobile phones for remote shopping.
Mobile advertising: provide direct and personalized advertising to specific geographical areas for the target population.
Mobile blog: real-time photos video and other multimedia information on the Internet, anytime and anywhere to update the blog.
Video on demand: mobile phone users can watch news, movies, sports and other TV programs online through the mobile communication network.

Content

What does 4G mean?
What are the future directions?

9.4 About 4G

4G is called "multimedia mobile communication" :

- There are megabits of data transfer rates at high speeds
- Expand coverage, improve communication quality and improve data transmission
- Wireless multimedia communication service
- The data transfer rate can reach 10 ~ 20Mb/s, and the maximum is over 100Mb/s

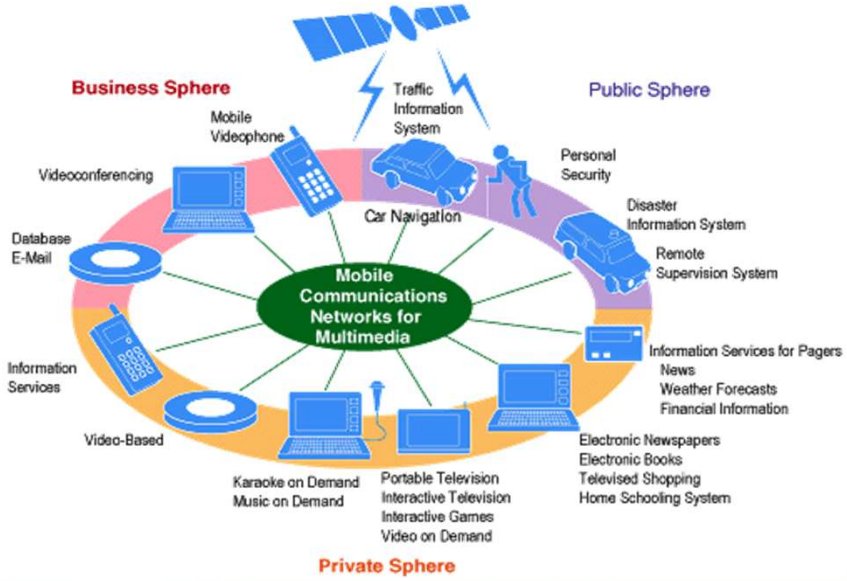
TD-LTE

- OFDM (orthogonal frequency division modulation)
  - ✓ Anti-multipath interference
  - ✓ Implement a simple
  - ✓ Flexible support for different bandwidths
  - ✓ High spectrum efficiency
  - ✓ Support for efficient adaptive scheduling

9.4 About 4G

In the 4G era, wireless will connect everything. It will be truly connected without any restrictions: vehicles, household appliances, buildings, roads and medical equipment will all be part of the network. The Internet of things will bring wisdom to all systems, bringing new ways of managing homes, companies, communities, and the economy as a whole.

- Ivan Seidenberg
(CEO, Verizon communications)



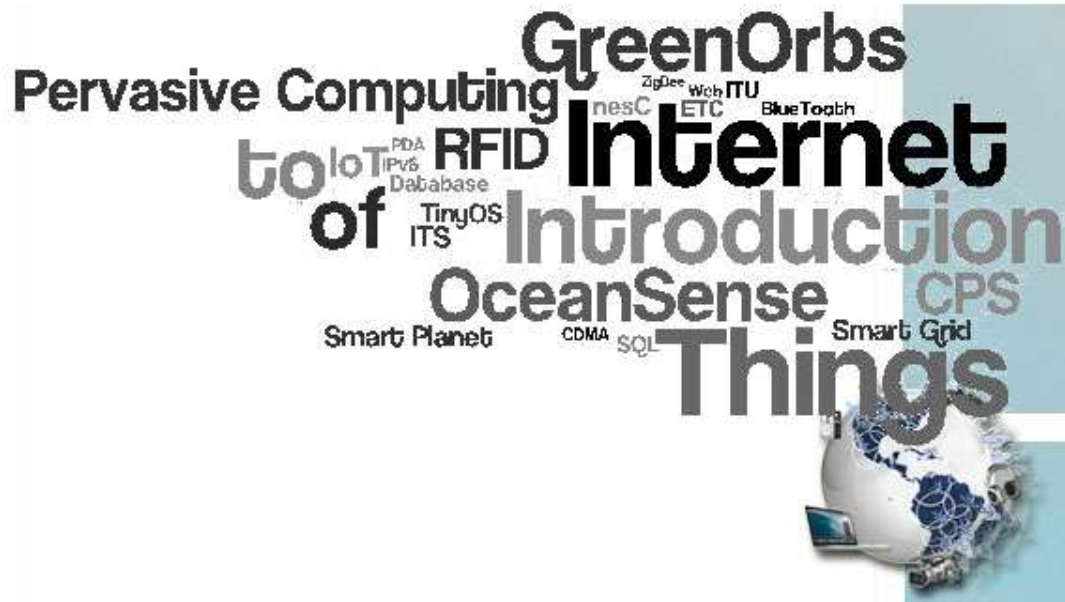
Conclusion

Review

This chapter introduces the development of mobile communication technology, mainly introduces the third generation mobile communication technology and standard (TD-SCDMA, W-CDMA, CDMA2000), and discusses the typical application of mobile Internet.

Key Point

- Understand the development history of three generations of mobile communication technology.
- Understand the characteristics and differences of the three 3G standards used in China.
- Illustrate the typical application of mobile Internet and discuss the development direction of 4G.



Thank you!

Internet of Things