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Testing Telemedicine Performance and Usability in 3G

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Testing Telemedicine Performance and Usability in 3G

The main focus of this thesis is to give a general description of 3G technologies, including its four international standards, the evolution process, core technologies and basic features. It covers the overall framework of 3G and related knowledge points. The second part models 3G network for telemedicine which is offering medical services in rural areas using communication technology.

As a background project, 3G technology practical capacity was researched on different network standards during the author's practical training in Network Department of China Mobile Communication Cooperation.

In the thesis, a model of 3G network in telemedicine was built to simulate rural areas. The most important property is high speed of data transmission to achieve real-time remote video and web consultation. In rural areas there is usually more need to reduce the waiting time of diagnosis as the patients are located in far away locations and lack medical facilities.

The test results were collected and analyzed which consisted of web browsing, online video playing and files downloading.

The conclusion is that, the speed of 3G could fulfill the basic need of a remote medical network.

Keywords: 3G, 4G, Telemedicine

FOREWORD

Adapting communication technologies into various areas is not new nowadays. However, it will help people's daily life by combining the technology with services. Telemedicine in 3G network could give many advantages to patients to reducing diagnosis waiting time. Hence, there are many steps and processes between the concept and final foundation. This thesis is the first step of modeling the structure of 3G telemedicine networks and evaluation of the usability of 3G. The realization should be improved in a future thesis.

First of all, I would like to thank my supervisor Mr. Yngvar Wikström. Without his guidance, recommendations, assistance, I could not complete the thesis in such short time. At first I planned to do research of business models which I really appreciate Mr. Yngvar Wikström for offering time to help me of my thesis. Then I want to express my gratitude to my friends and family with their support.

Finally, I would like to thank my training company China Mobile Communication Cooperation. With the knowledge learnt during the work placement, I could proceed with my thesis at last. I also want to thank my supervisor Mr Cheng Haitao, colleagues and my partner Zhou Xiaoyu in the Network Department.

Turku, 16.5.2011

Wang Cong

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ABBREVIATIONS

DSL	Digital Subscriber Line
EDGE	Enhanced Data Rate for GSM Evolution
EV-DO	Evolution-Data Optimized or Evolution-Data only
FDMA	Frequency Division Multiple Address
GPS	Global Positioning System
GPRS	General Packet Radio Service
GSM	Global System of Mobile communication
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
IS95	Interim Standard 95
IMT-2000	International Mobile Telecommunications-2000
LAN	Local Area Network
OFDM	Orthogonal Frequency-division Multiplexing
PDA	Personal Digital Assistant
PDC	Personal Digital Cellular
RFID	Radio Frequency Identification
RTT	Radio Transmission Technology
TDD	Time-division Duplexing

1. Introduction

The mobile communication is a technology which achieves the communication any time, any place and between terminal objects. From the perspective of communication networks, mobile networks can be seen as an extension of wired communication network, therefore, a mobile network consists of two parts, wireless and wired. The wireless part provides the access of terminals using limited frequency resources, in the air to transmit voice and data reliably; the wired part is to complete network functions, including switching, subscriber management, roaming, authentication, etc. [1]

Totally 10 theses were found on the subject of mobile communication through the Internet and library but none is about 3G, though there is a thesis about WiMAX which is focused on video conferencing.

The goal of the thesis is to evaluate the usability of 3G as the telecommunication environment in rural areas for telemedicine purposes when using different standards and transfer method for the wireless signal. This model and usability of 3G could help to improve the quantity of telemedicine for people who live far away from the city. A second goal was to publish comprehensive information about the practical reliability and the communication speed in reality.

The main technology environment focuses on 3G. The 4G network is left outside the scope of this thesis as it is not widely in use in rural areas. Compared with 4G, 3G is much easier to be set up in rural areas. However, the usability also needs improvement and implementation.

Most effort is placed on the empiric work at China Mobile Communication Cooperation during 2010. Many 3G technologies were researched and based on the theory, data transmission as the main subject was tested during the training. According to practical part, the 3G network in telemedicine was planned to be built in rural areas.

2. The third generation mobile communication technology (3G)

2.1 Background

The first generation of mobile communication system belongs to the analog communication system, which can only provide low quality voice transmission services. The second generation mobile communication system is using digital modulation techniques, based on the first generation to join the technology to support low-speed data services. In first generation period, because both the numbers of mobile users and business needs were increasing, technology manufacturers stacked a packet-based wireless interface in the GSM communication network which could reach the rate of 115 Kbit / s to achieve fast access to data networks using the GSM technology.[1] However, it was an ideal situation in digital rate. In practice, since many specific restrictions of external factors, the rate is generally around 20 Kbit / s, much slower than in the theory.

Pointing at this view, mobile technology providers began to develop a new generation of mobile communication technology, and then the 3G was implemented. After years of effort, the third generation mobile communication (3G) of the construction is in full swing. 3G also has changed from a theoretical term into a common term among people. This interpretation may be too boring, simply to say, 3G is actually a broadband wireless network. The significance of launching this wireless broadband network is that it can provide users with implementation of various new applications and a broader platform.

2.2 Definition of 3G

"3G" is the short for the third generation mobile communication technology. It is a kind of cellular mobile communication technology which can support high-speed data transmission [2]. 3G services can simultaneously transmit voice (call) and data information (e-mail, instant messaging, etc.). The speed is more than a few hundred

Kbps generally. The representative feature of 3G is to provide high-speed data services. Relative to the first generation analogue phones (1G) and the second generation GSM, CDMA and other digital phones (2G), generally, the third generation mobile (3G), refers to a new generation of mobile communication systems which combines wireless and multimedia communications with the Internet. [2] It can handle images, music, video and other media streaming including web browsing, conference calls, e-commerce and other information services [1]. In order to provide this service, wireless network must be able to support at least 2 MBps (MB / sec) data transfer speed in the indoor, outdoor and vehicular environments respectively.

2.3 Basic Features of 3G technology

An analysis of the current 3G indicates that, the network feature is mainly in the wireless interface technology. Cellular mobile communication system wireless technology includes cell multiplexing, multiple access / duplex mode, the application frequency, modulation, radio channel parameters, channel coding and error correction, frame structure, the physical channel structure, multiplexing mode and other aspects [2]. Throughout its evolution, 3G wireless technology does not completely abandon the 2G, but fully draws on the operator experience and mature application technology of 2G networks. On the other hand, under the IMT-2000 goals, 3G wireless technology would have the ability of high spectral efficiency, high quality of service to meet the multi-service environment. And it should have good network flexibility and ability of full-coverage.

Innovations of 3G wireless technology are mainly in the following areas: [2]

1. Use of high frequency spectrum
2. Use of broadband radio frequency channel to support high-speed services
3. Achieving multi-service and multi-rate transmission
4. Fast power control
5. Use of adaptive antennas and software radio technology

2.4 The four standards of 3G

The International Telecommunication Union (ITU) in May 2000 established W-CDMA, CDMA2000 and TD-SCDMA as the three mainstream air interface standards, which were written into the 3G technical guidance document "2000 International Mobile Communications Plan." On October 19, 2007, the International Telecommunication Union in Geneva held the wireless communications plenary session, after votes from most countries, WiMAX was approved as an official standard of 3G in the world following the WCDMA, CDMA2000 and TD-SCDMA. [1] [3]

CDMA is the abbreviation of Code Division Multiple Access, which is the basis of the third generation mobile communication systems technology. The first generation mobile communication system uses frequency division multiple access (FDMA) analog modulation. The main disadvantage of this system is that the spectrum utilization is low and signaling is interfering with voice services. The second generation mobile communication system mainly uses time division multiple access (TDMA) digital modulation methods to enhance the system capacity, and uses independent channels to send signals. It had improved the system performance greatly, but it is still limited for capacity of TDMA systems and handoff performance is still not perfect [1]. The CDMA system has the advantages of simple frequency planning, large system capacity, and high factors of frequency reuse, good anti-multipath capability, and good communication quality. Its own soft capacity and soft switching characteristics show great potential for development.
Here are brief introductions of four kinds of 3G standards: [3]

WCDMA

The full name of WCDMA is Wideband Code Division Multiple Access, also known as CDMA Direct Spread. It can support data rate ranging from 384Kbps to 2Mbps. In the fast-moving state, it still can provide 384Kbps transmission rate. In the low speed moving environment or indoor, it can transfer up to 2Mbps. WCDMA is supported by European manufacturers whose main product is the GSM system, and Japanese companies are more or less involved. The U.S. and European Ericsson, Alcatel Kata, Nokia, Lucent, Nortel and Japan's NTT, Fujitsu, Sharp and other manufacturers support it. This standard proposed the evolution strategy of GSM (2G)-GPRS-EDGE-WCDMA (3G). The system can be set up in the existing GSM network; this is easier for

system providers to transit. In Europe, the GSM system is quite popular which makes this standard more suitable to accept. Therefore, WCDMA has inherent advantages from the view of the market.

CDMA2000

CDMA2000 is an extension of 2G's CDMA, also known as CDMA Multi-Carrier. It is led by the North American Qualcomm. Motorola, Lucent and Samsung also participated in the technology. Now South Korea is the main leader of the standard.[3]

The system is derived from the digital standard of the narrowband CDMA One, which could be upgraded from the structure of the original CDMA One to 3G with low construction cost. However, the coverage is not so wide that the supporters of CDMA2000 are less than W-CDMA. But the development process of CDMA2000 standard is currently the fastest. This standard raised the evolution strategy as CDMA-IS95(2G)-CDMA2001x-CDMA2003x(3G).In this development process, CDMA2001x is called as 2.5 generation mobile communication technology. The main difference of CDMA2003x and CDMA2001x is on the application of multi-carrier technology. Through the use of three carriers to raise bandwidth, China is using this program to transit over 3G, and has built CDMA IS96 networks.

TD-SCDMA

The full name of TD-SCDMA is Time Division-Synchronous Code Division Multiple Access, a standard of wireless communication technology. It was first brought by China and on the basis of Radio Transmission Technology (RTT), with international cooperation China has completed the TD-SCDMA standard which becomes a member of the CDMA TDD standard [9]. TD-SDMA has the characteristics of low radiation, known as "green 3G" [9]. This standard will be integrated with intelligent wireless, synchronous CDMA, software radio technology and other leading technologies. And it has unique advantages of spectrum efficiency, flexibility of business support, cost and other aspects. In addition, because of the huge China market, the standard receives the attention of the major telecom equipment vendors. More than half of the world equipment manufacturers have announced support TD-SCDMA standard. The standard is raised without intermediate links of being 2.5 generation, directly to the 3G. It is very practical in the GSM system in the 3G upgrade. Moreover, communications network in military field is the core task for TD-SCDMA as well.

WiMax

WiMAX's full name is the Worldwide Interoperability for Microwave Access, also known as IEEE802.16 wireless metropolitan area network. This technology is combined with license or license-free microwave equipment, due to lower costs, which will expand the market of broadband wireless technology, improve awareness of enterprises and service providers. Because it is also a future part of 4G, so more details of WiMax will be introduced in 4G.

2.4.1 Evolution of different technical standards

The following figure shows the evolution history of different technologies. The GSM network must first upgrade to GPRS, then continue to upgrade to EDGE, or from GPRS then evolves to WCDMA or TD-SCDMA, to achieve the 3G standard. If it continues to evolve, it is along the HSDPA and HSUPA, then reaches over 4G standards. [2] In addition, Japanese PDC is through direct evolution to WCDMA, and then continues. The evolution line of CDMA is firstly to CDMA2000-1X, and then upgraded to 1XEV-DO, or 1XEV-DV, and next to CDMA2000-3X, at last moving to the 4G [2][9].

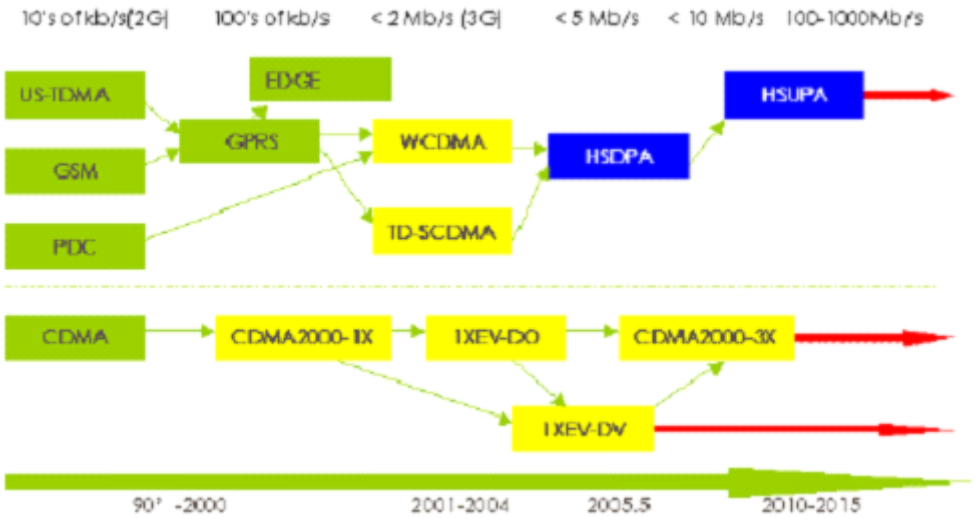

Figure1. Evolution of different technical standards [2]

According to three steps development plan of 3G market, 3G multimedia services will enter the third stage of development in less than 10 years. Nowadays the global coverage of the 3G network has been basically completed and more than 25% of the global population using third generation mobile communication systems. In developed countries, 3G services have penetrated more than 80% of the markets. Then there is the need of a new generation of systems to further improve service quality.

3. Basic test and project

3.1 Background for the project

First of all, on the account of the coming 3G, we have experienced various applications by it. It has deeply changed our life with wireless communication, video calls, mobile shopping, and mobile online games. And it also went into other fields such as education, financial area, medical care, and monitoring systems and so on. From its feature of high-speed data transmission and real time, we could achieve a lot of technology innovation, for example, 3G applications in telemedicine in rural areas.

Telemedicine is a medical service which combines the traditional medicine and modern communication technology [15]. It refers to improving medical standards, reducing health care costs, and meeting the health needs of the masses [16]. And rural areas usually have more need to reduce the waiting time of diagnosis because of far-away distant location and lack of medical facilities. From this point of view, it is necessary to adapt this service into rural areas. Even in rural areas, it is still possible to have medical diagnosis with telemedicine. People in villages can have chance to communicate with experts in the city. With telemedicine, it is possible to share medical resources and ease the pressure on hospital outpatient centers, so that people in the village could enjoy the city medical diagnostic technology, as well [17].

Nowadays, with the fast development of communication technology, telemedicine steps onto a new and more convenient stage. Currently, telemedicine has developed from the original television monitoring, telephone remote diagnosis to using high-speed network to achieve real-time voice communication and high-definition images transmission. But LAN (Local Area Networks) or the second generation mobile communication technology cannot meet these needs anymore because of the platforms but also the transmission speed [16]. And in the transmission process, there have been problems with security and definition of information. However, 3G, whose basic feature is fast data transmission and security, could achieve real-time

communication. With the advantages of technology, we can set telemedicine network in rural areas in a 3G environment.

3.2 Objectives

The aims of this project are to model the system of 3G telemedicine in rural areas and evaluate the usability of 3G in telemedicine. In this thesis, according to construer of the network, the medicine conditions are the basis of 3G telemedicine which improves nowadays the medical technology. Compared with before telemedicine, using 3G technology could bring great advantages of information updating in time. People do not need to wait for so long time and it help to reduce medical and human resources. With the process, we want to have the possibility of building the 3G telemedicine network in rural areas. And it is needed for introducing terminals which people could use to display the video, how does 3G play a role in the process of network and Internet communication. At last we could reach the logical management and high efficient use of data according to these objectives.

3.3 Methods

To able to see the framework of the project, we need to take a closer look on data transmission. First of all, the author chose to do the test in image and video aspects for different standards of 3G in China, which is to be taken as a sample, to get relative realistic results. Statistics and analysis of the practical data could prove our point that 3G has obvious advantages in video and web browsing. On the basis of the test, this thesis shows the author's own concept of configuration 3G network in telemedicine after reading literatures. In addition, this thesis is the first step to module the construction of telemedicine. With the proposed network combining 3G and telemedicine, the thesis includes devices structures, implementation of technologies for idea. And then from the module, we will evaluate the usability of 3G in this network [17]. We will discuss the possibility for building up the telemedicine in 3G environment.

In this thesis, the main work been done is setting 3G network parameters in the rural areas by combining with the current construction of 3G network. Computer online software can be used to test the data transmission from two parts which are video and

web browsing. Obtained from different environments, data speed results which we received need statistics and quantification analyses. At the same time, compared to the theory data speed of different standards in 3G, the result shows that in the era of 3G, video, images and other data transmission have great efficiency and real-time advantages. On this basis, the author made the module concept of 3G in telemedicine and evaluated the usability from scopes, remote communication quality and efficiency, system compatibility etc. The establishment of 3G communication system on rural telemedicine could bring many kinds of advantages.

3.4 Project process

3.4.1 Test of data transmission

First, from the literature and book of data speed of 3G, the author still wanted to do the test to obtain the practical results of its loading video and web browsing situations which are the most used technologies to support the telemedicine basically. In my opinion, the module needs more specified results than theory. And on the basis of work placement in the Network Department of China Mobile Communication Cooperation before, here the author planned to do the real-time test of 3G according to the 3G knowledge learnt before and chose the 3G situation in a relatively remote city in China as the sample of our test.

There are now three standards of 3G in China. They are WCDMA, CDMA2000 and TD-SCDMA provided by three different companies. The WiMax has no channel and applications in China. So the test is of the above mentioned these three standards to get the practical experience. Does the 3G really change a lot for us with the speed as it advertises? Could it support the video and image transmission really? With these questions in mind, the test project was started.

Table 1. Three standards parameters and the equipment used in the test.

Standards	**WCDMA**	**CDMA2000**	**TD-CDMA**
Brand	HUAWEI	HUAWEI	ZTE
Model Number	E1750 (Internet Access Card)	EC169 (Internet Access Card)	MU350 (Internet Access Card)
Enlarged Memory	4G	Null	64M expansion card, support 2G MicroSD card
Interface Type	USB2.0 Interface	USB2.0 Interface	USB2.0 Interface
Feature and Functions	HSPDA7.2downlink/ HSUPA5.76uplink;High-speed Internet Access; Text Message; Phonebook; Automatic installation / start	Downlink3.1Mbps, Uplink 1.8Mbps; High-speed Internet Access; Text Messaging; Phonebook; Automatic installation / start	Downlink 2.8Mbps, Uplink 386Kbps; High-speed Internet Access; Text Messaging; Phonebook; Automatic installation / start; Compatible with 2G networks
3G Internet Access Card Type	WCDMA Specified 3G Card of China Unicom Company	CDMAEVDO Specified 3G Card of China Telecom Company	Specified Usim3G Card of China Mobile Communication Cooperation
Software of Test	HUAWEI(Mobile Partner);China Unicom Testing software	HUAWEI(Mobile Partner) ; NetPerSec	ZTE testing software by CMCC
Platform and Environment of Test	Lenovo Ideapad Y450; Windows XP Professional SP3		
City and Area	Yicheng, Hubei Province, China		
Place of Test	First floor of business hall of China Unicom Company	Network Center of China Telecom	Experience Center of China Mobile Communications Corporation

Result of Web Browsing test in three standards

The first test was Web Browsing so we went to different operator companies to process the test. Three 3G Internet Access cards were connected and the online data detection software was used on different standards. The web pages were opened to check the data transmission. When the data were stable, sectional drawing was started.

WCDMA

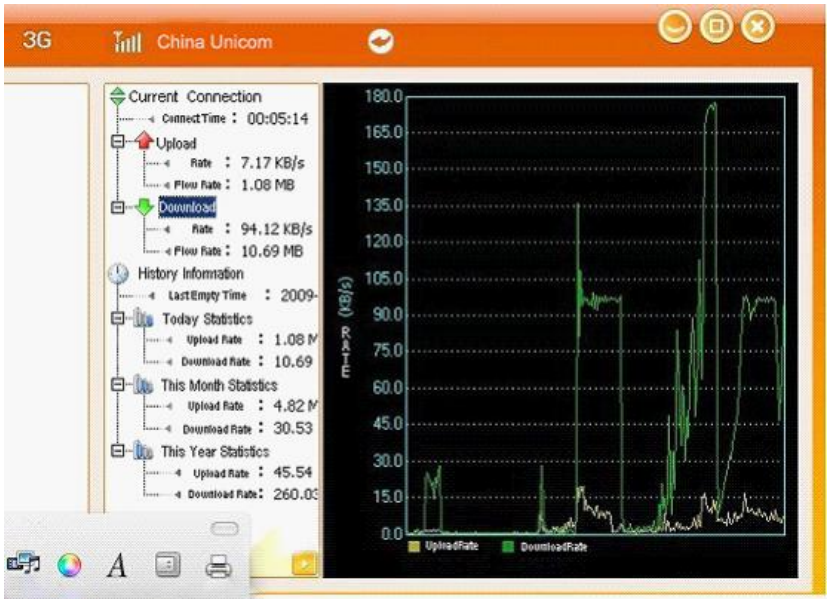

Figure2. Date details the test software in 3G WCDMA

In Figure1, the higher speed part is refreshing pages whose rate is above 80 kb/s. There should be no difficulties with refreshing the basic WebPages. The speed saves waiting for the web browsing.

CDMA2000

First of all, the signal strength was checked using the software by HUAWEI (Mobile Partner) which could test the speed and strength. At the same time, it checks the connection.

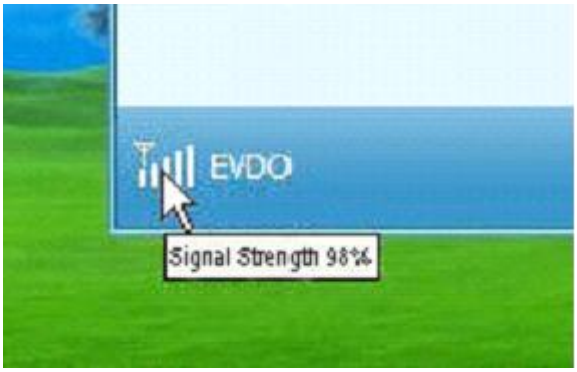

Figure3. Signal Strength of 3G in environment CDMA2000 by *China Telecom*

Figure4. Connection of 3G in environment CDMA2000 by *China Telecom*

Then the network speed was tested in the notebook by using the NetPerSec software. It is a kind of software which can help users to understand the connection speed in real time; users can monitor all incoming and sent TCP / IP events to the Internet or other network, and to graphically display the communication speed (Figure 4). We can see that the average speed is 376.1 Kbits/s, which is around 0.4 Mbps. It could support fluent web browsing even on foreign web pages.

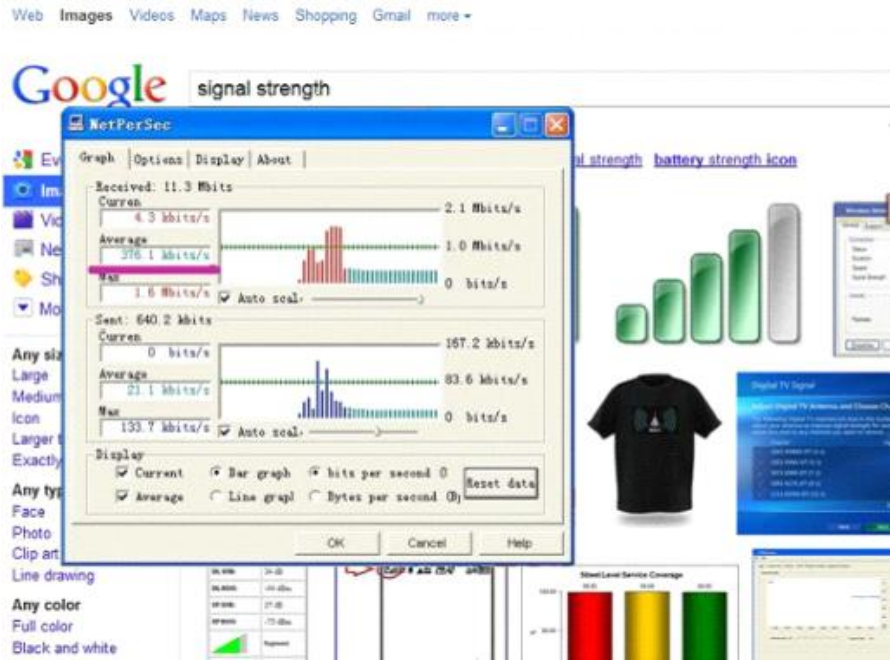

Figure5. Data details of visiting a webpage in 3G CDMA2000 NetPerSec

TD-SCDMA

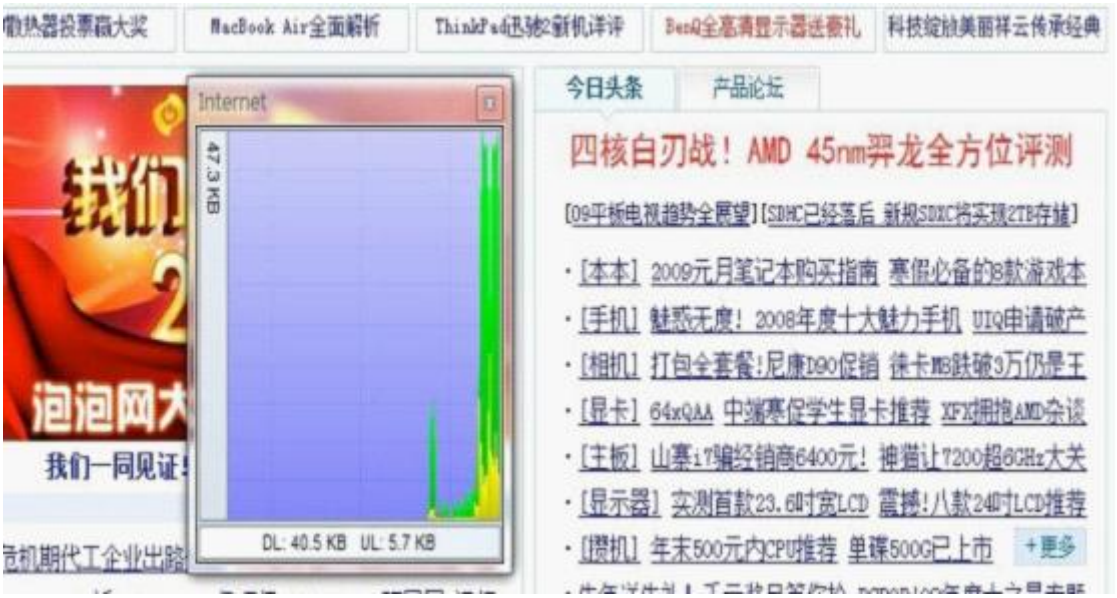

Figure6. Data details of visiting a webpage in 3G TD-SCDMA

In web browsing, the effect of normal web browser is general; some images have a loading problem. Speed is stabilized at 45 KB/S, but it could be felt a bit slow when refreshing pictures. But switching network often appears in the process of data test. We can see that TD-SCDAM is not stable enough (Figure 5, 6).

Figure7a. Automatic tips by ZTE software

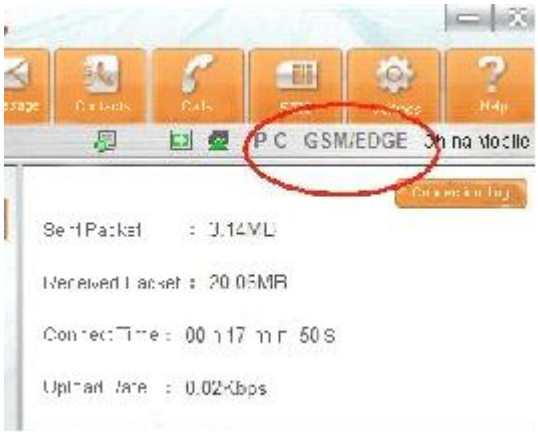

Figure7b. The network has often been switched during the test of TD-SCDMA

Results of loading online video test in three standards

The second test also used different testing software to detect data transmission. A 360P online video was loaded and tested by the software. With the situation of cache bar, let's see the results in different standard environments.

WCDMA

In situations of visiting Web Pages, even online videos, the speed of 3G could be achieved. Figure 8 illustrates the loading conditions of a 360P resolution video as an example. It supports video online in smooth processing. We can watch the whole video without interruptions.

Figure8. Loading condition of video by in 3G WCDMA

CDMA2000

The author selected youku.com, the best domestic server support and online video website in China as a test site. In the following figure, the 360p resolution video is without the slightest pause, and there is fast rise in the cache bar. When watching the video, the maximum speed is almost 1.5 Mbps, an average of 600Kbps (70KB / s) around. CDMA2000 showed an unexpected performance.

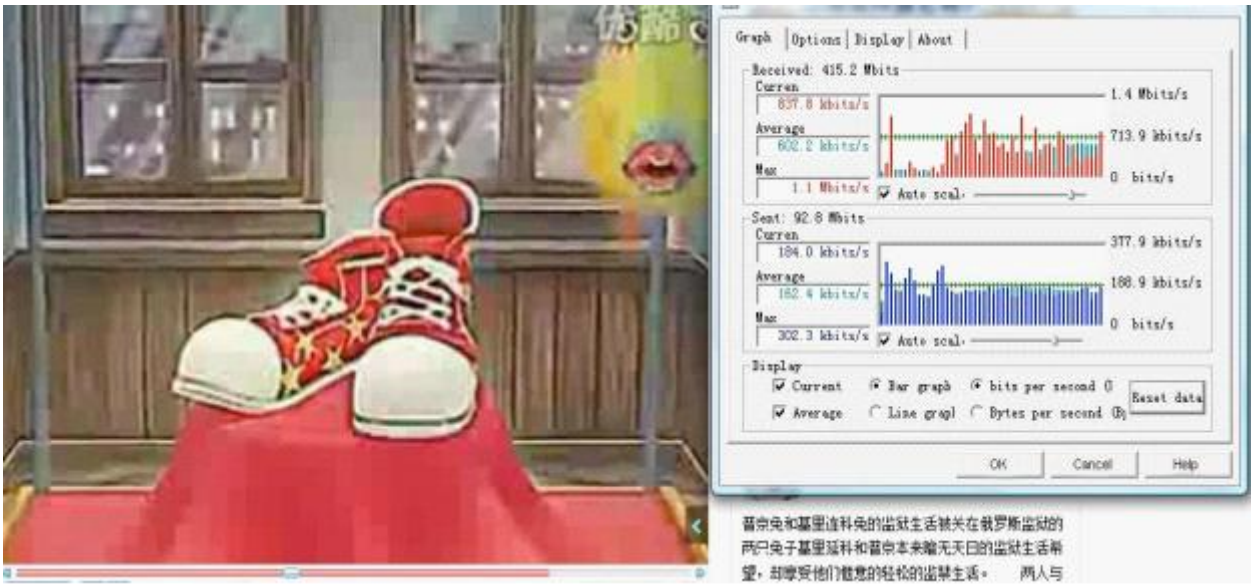

Figure9. Status of testing loading a video in 3G CDMA2000

TD-SCDMA

Finally, when the network was stable the loading speed test of video in TD-SCDMA environment was tested. Figure 9 shows that the video which was more than 360p could not play smoothly. A relatively low resolution of the video can still cope. (Figure 14) Note the valued video loading progress bar when playing stable video at speed 45kb / s or more.

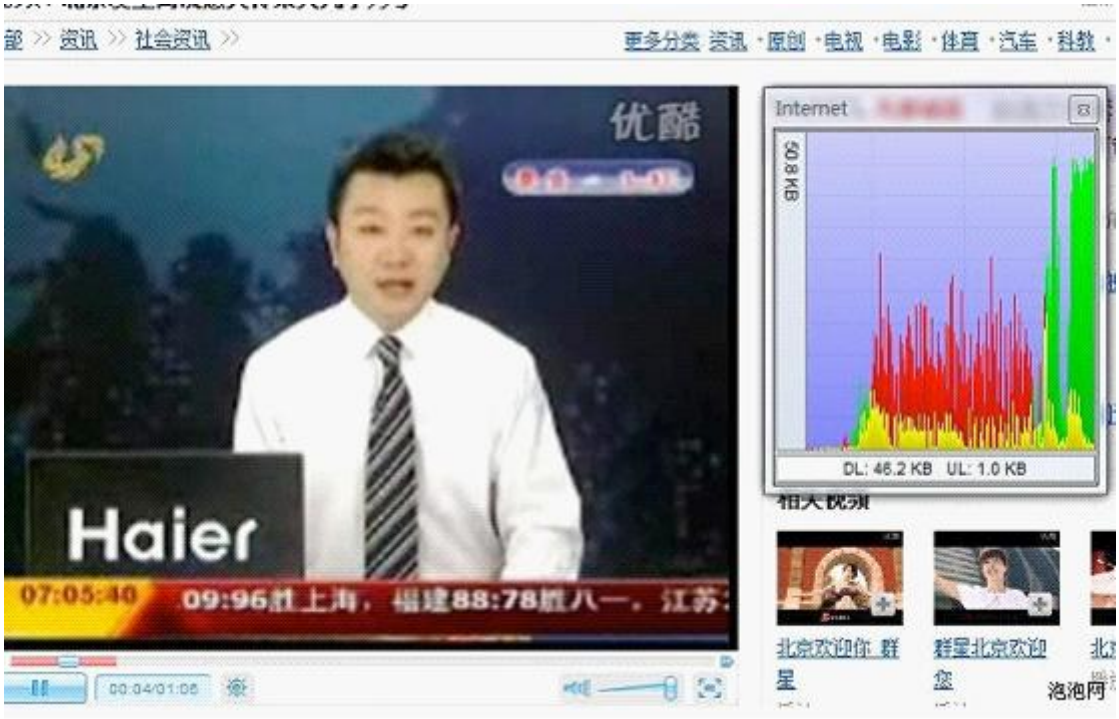

Figure10. Loading video more than 360 pt in 3G TD-SCDMA

After the testing and data analysis, we can obtain the summary results and then summarize them into a table.

Table 2: Summary of the test

Standards	**WCDMA**	**CDMA2000**	**TD-SCDMA**
Bandwidth in Theory	7.2Mbps downlink /5.76Mbps uplink	3.1Mbps downlink /1.8Mbps uplink	2.8Mbpsdownlink /386kbps uplink
Visiting Websites	80kb/s	47kb/s	45kb/s
Loading Online Videos	85kb/s	70kb/s	45kb/s
Download Rate	70kb/s(Maybe with the reason of sources)	160kb/s	45-50kb/s

According to the statistics of actual test data result, considering the efficiency of data processing for equipment, the complexity of the wireless environment, data resource

availability and other factors, 3G speed is about 1.5 Mb / s as the home broadband. Although this did not reach the maximum theoretical 7.2 Mb / S in HSDPA, it is enough to meet the needs of current users of web browsing, video playing and downloading. There are differences between the bandwidth under the three different standards, which is the main factor affecting data transmission. In addition, the web browsing test may be interfered by elements in the website, connecting nodes and other factors so causing some delay in the test. In short, opening a web page could meet the 2.8 Mbps download speed performance, without experiencing significant delay.

3G has the advantages of playing high-quality online video, according to the theoretical bandwidth; 3G video transmission can reach performance of playing multiple concurrent videos. The fluency of dynamic picture and sound quality can initially reach the practical level. Convergence of video and audio part could be referred to as perfect; the phenomenon of unsynchronized audio and video does not occur. Compared to cable networks, 3G could get the access of current data transfer speed, which should have been enough for video communication.

Based on the practical test of data transmission of 3G, we can boldly imagine that using 3G into telemedicine could succeed in theory and reality. From the discussion and summary of the data test, the author continues the second part of my project.

3.4.2 Model structure of 3G telemedicine network

Based on topological knowledge in Cisco courses and materials of telemedicine, the author constructs a basic 3G network for telemedicine in rural areas. The applications of the new telemedicine are the basic ones. With the latest telemedicine technology, we could have more and better performance.

We can see from Figure 11 that this 3G network could be divided into three parts. The telemedicine application server, the FTP server, the database server and real-time communication server constitute the core part of telemedicine service platform [17]. Because of the existing firewall which protects security of hospital database, we can gather information and data needed from various hospitals. At the same time, the

platform control all schedules and implementation of remote medical activities. The second part is the internal structure of hospital in cities. Hospital primary databases, host computers and internet make up the data mountain of hospitals regardless of them being in rural areas or cities. The firewall here is to project the LAN in hospital from attacks outside the network. It includes access permission, IP control, Network isolation, port shield, virus prevention [16]. The last part consists of two main aspects, 3G environment provided by operators and telemedicine applications in 3G. It includes base situations, 3G gateway server and other basic equipment.

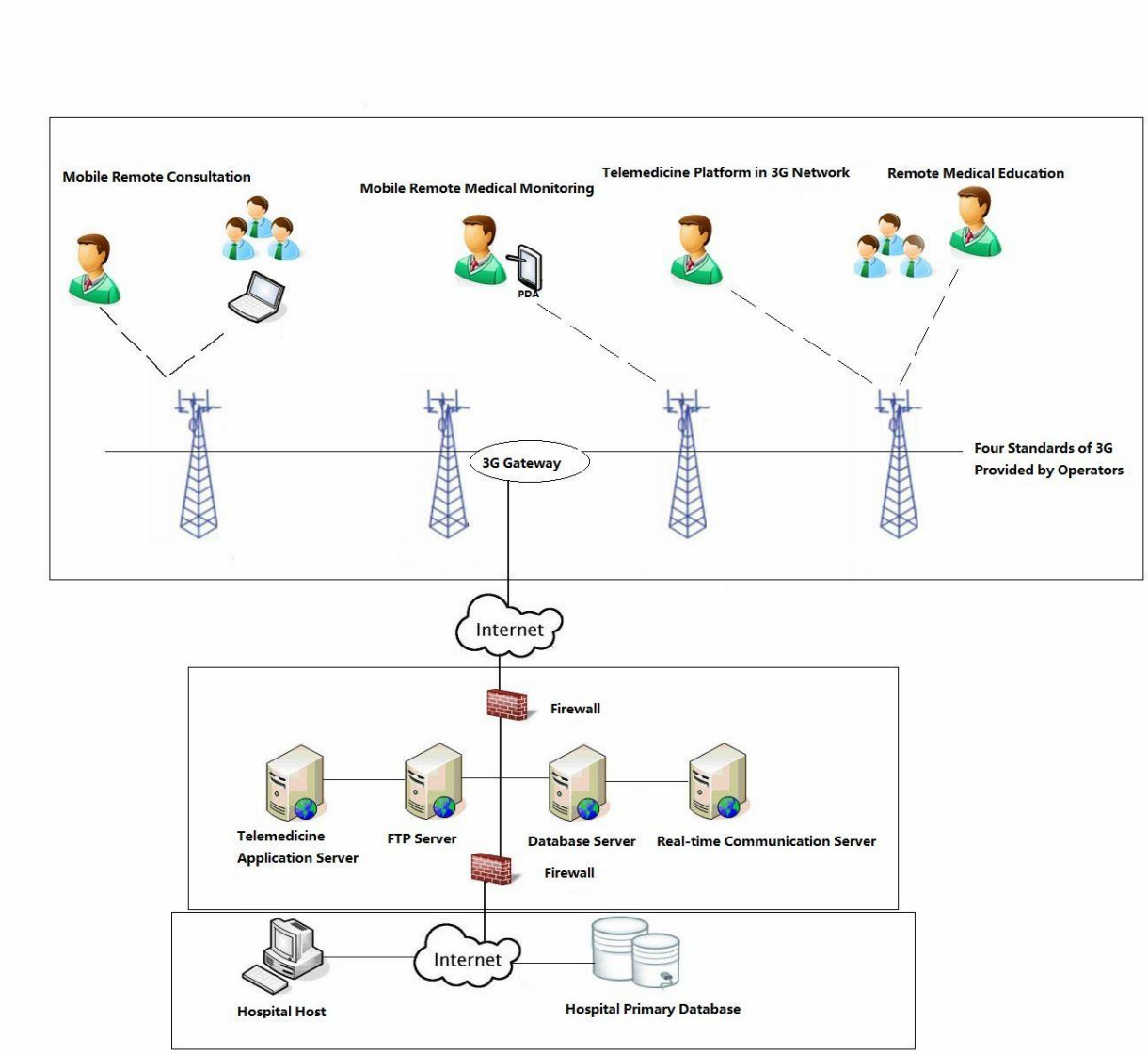

Figure11. Topological diagram of 3G telemedicine network [15]

Using 3G mobile communication through shared broadcast and a multicast transmission link could achieve high performance mobile communications, to meet the needs of mobile telemedicine activities. Mobile telemedicine terminals use smart phones or laptops with mobile communications to access the Internet through a 3G network.[15] Mobile remote consultation, remote medical monitoring, telemedicine and teaching activities could all come true in terminals in a 3G environment.

3G mobile telemedicine systems in rural areas is an application system which is integrating a set of multiple technologies. It is based on 3G technology as the core network architecture. 3G technology ensures high-speed data transmission for telemedicine, and can achieve efficient exchange of information which is conducive to real-time telemedicine. After the entire system would be implemented, the patients could get the help from mobile remote medicine [17]. Using audio and video reduces problems caused by only voice description in traditional telemedicine. It is possible to provide rapid and effective emergency plan in a really short time. Doctors and medical resources make a breakthrough of their limits in geographical scope, which enables rural remote areas to access more advanced medical care. The 3G network provides different types of medical care in the same platform, sharing audio and video information to patients to receive better guidance and help. Patients could receive help in the system automatically from an e-expert in a few minutes. It is the most basic emergency plan. Then based on 3G data center handling, according to the real situations reflecting via audio and video, the system will give a preliminary analysis and then continue to switch into sub-sections [16].

In Figures 12 and 13, the topological pictures show the process of medical consultation services via a medical Imaging transmission. These are the main applications for telemedicine. The joining technology 3G gives more advantages for both products.

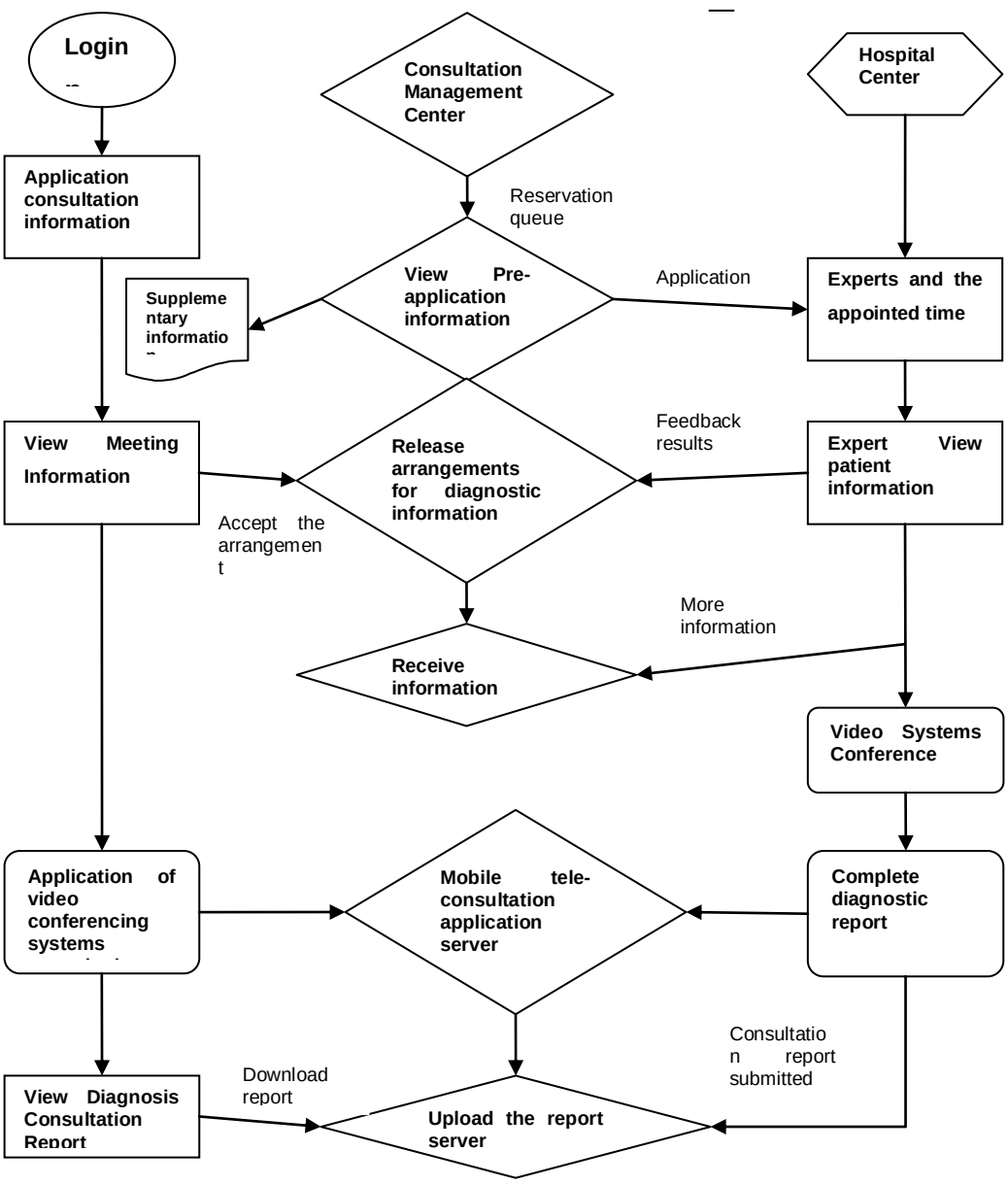

Figure12. Medical consultation service platform process in 3G telemedicine [16]

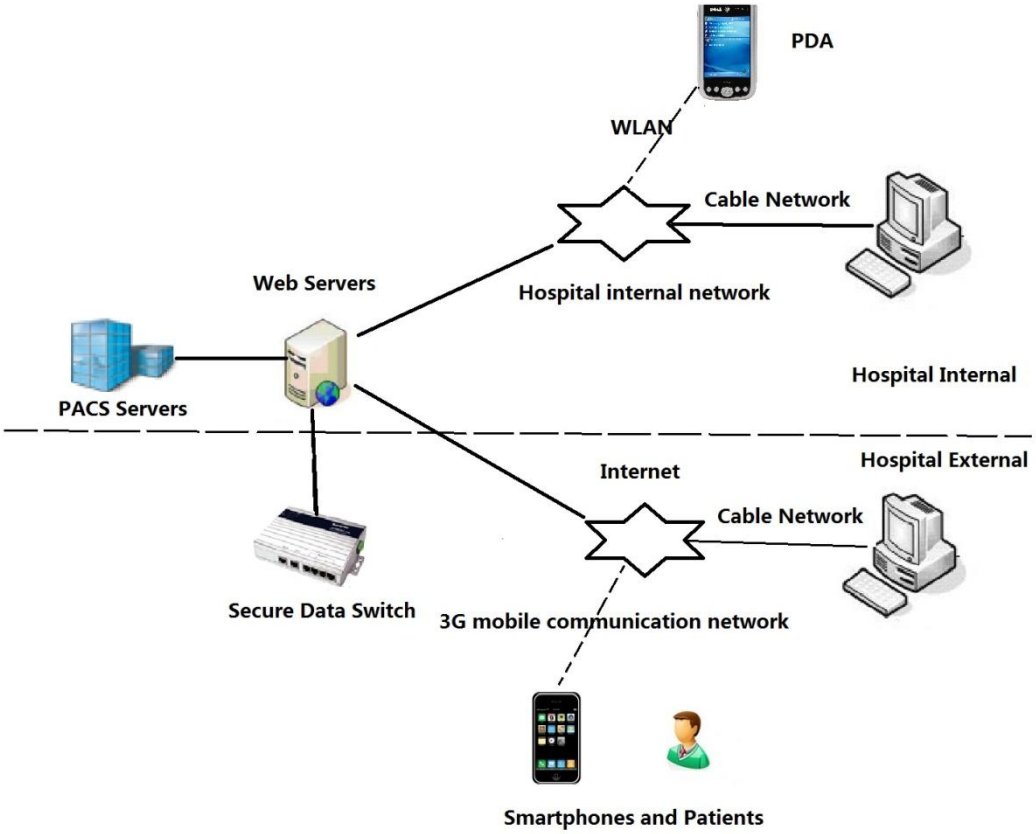

Figure13. The medical Imaging transmission system in 3G telemedicine [17]

3.4.3 Evaluation of the usability of 3G in telemedicine

At the same time, in a hazardous environment and disaster like scene, we can use the positioning map system to quickly find the patient asking for help. Then we contact the nearest appropriate medical institution. Good management and distribution of emergency medical services of rural areas is an efficient way to improve rural emergency health conditions [15]. A seamless 3G network is the premise to popularize and extend the use of telemedicine in rural areas. From the system model, the medical institutions in rural areas could take the advantages of data, experts fast connection of video conferencing, remote video assisted surgery which all help to improve the chances of survival for patients without emergency medical treatment. Here is Table 3 evaluates the usability of 3G. The research results are summarized into Table3.

Table 3: Evaluation of usability of 3G from the point of technology

Comparison	**Data Transmission**	**Ability of Handling Data**	**Information Security**	**Standards**
3G Telemedicine System	An average of 100kb / s or more	Multithreading, Two-way information processing, Sharing all the data at the same platform	Real-name system, Unified data management, Central database, Information security, Authentication access for terminals	Four interoperable Standards, Unified video coding standard, Good compatibility
Traditional Telemedicine System	Generally lower than 60kb / s	Single-threaded processing, One-way data processing, Low level of information sharing	Cross-regional information storage, A great chance of disclose, No authentication of any terminal access	Different communication protocols, Protocol conversion needed in connection, Relatively poor compatibility

From the data transmission, information processing, information security and technology standard aspects, a comparison was made of 3G telemedicine system with the traditional remote medical system in a rural one. The advantages of 3G technology are obvious in communication. Following the trend of integrating communications, medical and other aspects of life, video high-speed transmission is a prominent feature of a new generation of communication. The network in this model also displays the feature that doctors and patients can experience a better exchange of information, while ensuring the accurate classification of each person's information, not to be disclosed [16]. 3G for rural telemedicine is suitable for extensively carrying out, and the cost for establishing the system is lower than that of the traditional remote medical system as the following comparison of the table demonstrates:

In contrast, we can find that, whether from the point of the technology or the market demanding, 3G played an important role in this model. Building a 3G network in rural areas leads the telemedicine to a new stage. The supporting technology of 3G solves the problems in telemedicine fundamentally. Therefore, in rural and other remote areas, 3G telemedicine is truly the best way to share medical resources.

Table 4: Evaluation of usability of 3G from the point of foundation

Comparison	Network Platform Compatibility	Core Equipment and Terminal	Total cost	Profit model
3G Telemedicine System	Unified 3G gateways, access to internet, Transceiver using the same antenna No compatible problems of geographical access	Common 3G core equipment, central database, rich selection of the terminals, two-way voice and video in high speed, mobile ability	Only need to add 3G Equipment into former telemedicine network, wide coverage, low cost	High-standardized information sharing models, avoiding a number of charges, help to achieve standardized charges, huge market with development potential
Traditional Telemedicine System	No effective compatibility in Satellite, Telephone, Network, ISDN and ATM communication, regional differences affecting the use	Old core equipment, Complex maintenance, Redundant equipment deployment, Simplex selections of terminals, simple functions, not conducive to the sharing of different signals	Large area laying different standards equipment, High cost	Information is not real-name, integrity is low, different charging systems, market spread, the small profit margins

3.4 Summary of project

In this project, we test the data transmission of 3G and set the module of 3G telemedicine in rural areas. The test result shows that 3G has obvious advantages in image and web browsing which could achieve mobile remote medical monitoring and mobile remote consultation in 3G which are the typical products of 3G high speed.

The high-speed data transmission services are brought by 3G, not only to achieve better normal voice communications, but also to improve the efficiency of information processing. Through the theory test examination, we can assume that in the social aspects, there will be similar successful applications like 3G telemedicine. The applications could provide better services, achieve a more advanced technology. We can imagine that, when the 3G terminal equipment is available to everyone, no matter when and where one is, they can enjoy convenient, efficient and secure information services.

4. The future communication technology

4. 1 4G mobile communication system

When the 3rd generation communication technology is in the making, the more advanced technology has been in process in the laboratory [4]. Therefore, people look forward to the third generation mobile communication systems, while the concept of the latest technology is coming into life quietly. So at last what is 4G communications?

4G is an abbreviation for the fourth generation mobile communication and technology. It combines 3G and WLAN in one and is able to transmit high quality video images whose image transmission quality is pretty even to high-definition television [6]. The 4G system is able to provide 100 Mbps download speed, 2000 times faster than dial-up Internet access, and the upload speed can reach 20 Mbps. It can meet almost all users' requirements for wireless services.

4G communications technology is not derived out of the previous communication technologies; instead, it is based on the traditional communication technology, and uses a number of new communication technologies to continuously improve the efficiency of wireless communication networks and functions. If 3G can provide people

with a high-speed transmission of wireless communication environment, then the 4G communication is an ultra high-speed wireless network, which is a super internet highway without cables. This new network allows phone users to connect to wireless and three-dimensional virtual reality.

Price is definitely most concerned in any business. 4G and fixed broadband networks are about the same in price, and billing methods will be more flexible. Users can determine their services according to the necessary requirements by themselves. In addition, 4G could be deployed covering the areas in which there are no DSL and cable modems and then extend to the entire region [6]. Obviously, 4G has unparalleled advantages.

4G communications technology is once again the evolution of wireless communication technology after the third generation. The development has more clear objectives: to improve the wireless Internet access speed of mobile devices [7]. The International Telecommunications Union has completed the assessment of six 4G mobile wireless broadband candidate standards for the official IMT-Advanced designation that will deliver interoperable, 100 Mbps (mobile) broadband speeds as an official international 4G standard. Two technologies, “LTE-Advanced1” (based on cellular’s LTE standard) and “WirelessMAN-Advanced2” (based on the WiMAX 802.16m standard), have been accorded the official designation of IMT-Advanced, qualifying them as true 4G technologies [13].

Currently, the 4G system is still at the preliminary building stage with no formatting a unified network structure. It is the processing period of this new technology. The trend of blending the network can be a basic analysis of the 4G network:

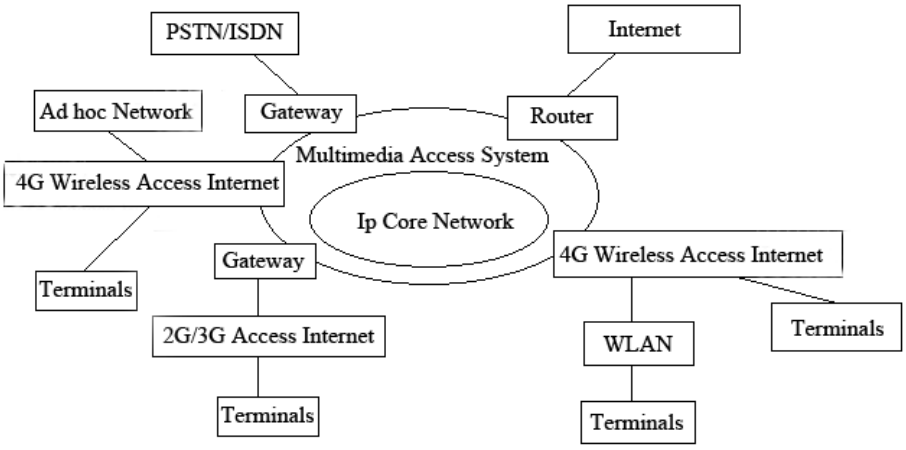

Figure14. The trend of basic structure of 4G network [17]

It can be seen from the figure above that the fourth generation mobile communication system is the mobile communication system of an integrated multi-functional broadband form. It is the first time in the history of mobile communications that a high quality three-dimensional image transmission is achieved. Different wireless users could communicate in three-dimensional virtual reality. As all of networks have their own network structure, the 4G network architecture could be divided into three layers: the physical layer, the middle layer of the environment, the application network layer. To improve scalability which helps increase the new business, interfaces in each layer of this network structure are open, thereby, increasing the 4G application value in practice.

4. 1.1 Comparison of technical indicators

Different organizations in the world give different definitions of 4G, but all of them agree that the 4G is high-speed cellular mobile network basing IP protocol, evolution from the existing 3G [12]. We could see the details in following table.

Table 5. Comparison of 3G and 4G communication technologies

Technical indicators	**3G Communication Technology**	**4G Communication Technology**
Service Features	Voice and data services	Integration of data and VoIP
Network Structure	Cellular area	A hybrid structure, including Bluetooth, wifi etc.
Frequency range	1.6GHz ~ 2.5GHz	2GHz ~ 8GHz
Bandwidth	5MHz ~ 20MHz	100MHz
Speed	385kbit / s ~ 2Mbit / s	20Mbit / s ~ 100Mbit / s
Access methods	WCDMA/CDMA2000 TD_SCDMA etc.	MC-CDMA/OFDM
Switching methods	A circuit switched / packet switching	A packet switching
Mobile features	200Kmph	200Kmph
IP performance	A multi-version IP	Full IP

4. 1.2 Comparison of technical aspects

1) The core technology is mainly CDMA in 3G, while 4G uses OFDM as the main technology. OFDM can improve the spectrum efficiency which can overcome the problem of signal interference increasing during the high-speed transition in CDMA.

2) In terms of software radio, 4G upgrades radio technology of 3G to meet the requirements of various radio accesses of 4G. It solves the problem of unified radio access standards in 3G.

At the same time, 4G is based on software radio technology in 3G by adding the appropriate hardware module, upgrading the corresponding software to combine the

soft switching and hard switching to form a written uniform standard which achieves a variety of needs [11][12].

3) 3G network mainly uses cellular networking, but 4G uses all-digital, all IP technology to support packet switching which integrates the WLAN, Bluetooth, and LAN into the WAN. It increases the out speed of smart antenna and efficiency in 4G. Based on the smart antenna of TD-CDMA, the related software and algorithms will be upgraded to increase interface protocols to meet the requirements of 4G [10].

4) The 4G system also uses many new technologies, including hyperlinks and the specific wireless network technology, intelligent dynamic allocation of spectrum technology and software radio technology and so on [5].

5) At the point of the power control, 4G requirements are more stringent than 3G. The purpose of 4G is to satisfy the requirements of high-speed communications. Not only do resources limit the transmission frequency of signal rate for mobile users but also the power of base stations and terminals [5]. In 3G, using switching technology could reduce interference to improve voice quality; in 4G, switch technology will be more extensive, and towards the direction to integration of the soft switching and hard switching.

4. 2 Overview of "The Internet of Things"

This concept was first proposed in the 90s of the 20th century. The original propose of this concept was to achieve mutual communication from people to objects and from objects to objects, a similar communication between human and the transmission of information. Technically, the definition of Internet of Things is very simple things that are combining the radio frequency identification (RFID) devices, infrared sensors, global positioning system (GPS), laser scanners, and other information sensing devices to form a large network. And then all of "items" in daily life are gathered into this network to achieve intelligent identification and management [4].

"The Internet of Things" getting "articles" information (including the location of items, labels and other related information) is collected by sensor devices, through the Internet and information technology management center database to exchange information [6]. Unlike the "Internet" whose terminals are people, in the "Internet of Things", the material (goods) become into the terminal. It is a pan-established network

on the Internet. The important foundation and core technology is still the Internet in this new concept, through a variety of wired and wireless networks and Internet convergence, to pass out real-time accurate information of the objects. Because sensors in it collecting information need to regularly transmit over the Internet, and because of its extremely large numbers, they will form a mass of information. During transmission, in order to protect the accuracy and timeliness of data, the network in "The Internet of Things “must adapt to a variety of heterogeneous networks and protocols [6]. "The Internet of Things" has wide range of uses such as intelligent transportation, environmental protection, and public safety and so on. People could use various terminals to achieve communication with objects.

When mentioning the use of mobile phones, many people immediately think of phone calls, sending text messages, searching the Internet. But the future uses of mobile phone can be far more than these [6]. For example, it can be "fingers" classroom, banks, cinemas, or provide location-based services, even achieve remote control of washing machines and microwave ovens, as cars, refrigerators, microwave ovens, etc [7]. It can be that embedded SIM cards are terminals of the mobile communication network. About the locate function on the phone, some experts pointed that, it cannot be limited to conventional satellite navigation functions, but it can also send the user's location and record the user's whereabouts. When the user arrives at their destination, it could provide users with more services. For example, if a user uses ordinary navigation to arrive at the shopping center, the phone can provide real-time information of each floor and each counter automatically. The user can go directly to the counter for purchase.

With the era of the “Internet of things” coming, a large number of medical devices will be embedded with SIM cards, the phone will be widely used in health care fields. The Global System for Mobile Communications Association announced that it will enter the field of health care [12]. Applications will embed mobile technologies, for remote diagnosis, health monitoring and alarm. The Association predicted that this feature has become widespread which will save 175 to 200 billion U.S. dollars annually even only for in the field of chronic disease prevention and control which is provided by OECD and BRIC countries [7][3]. It is predicted that at the end of 2012, there will be 3.6 billion people worldwide using mobile payment capabilities. About 30 million adults in 2014 would pay through the mobile communications and Internet e-money transactions. Mobile payment system will mean tremendous business opportunities.

In addition, the use of mobile phones will also involve education, industry, entertainment, advertising and other fields. Many experts believe that mobile phones are no more than just a communication tool; they have gone deep into the daily work and life to change the way in which people work and live.

5. Discussion

As the 3G era is coming, modern communication has entered a golden period of development. This thesis fully describes the development and applications of 3G technology, which has a profound significance of the new generation of high-speed data transmission. With the training experience in the Network Department of China Mobile Communication Cooperation (CMCC), based on the understanding of 3G, using the relevant knowledge of 3G, useful exploration of 3G video transmission applications have been done. Referring to a large number of international studies and various disciplines, the thesis makes objective predictions of the latest communication technology trend.

In the study, first of all, my research started from the concept of summary of its 3G core technology, the four standard formats, the basic situation of evolution, so that readers understand the full range of 3G technology. Then according to the existing 3G communication equipment, under different standards, a whole test of the speed of web browsing, video playback, and file download was carried out. Applications such as online comparison test have been done. Using statistics and the contrast analysis, the author handled the actual test data; the data reflects the advantage of information of 3G technologies exchange efficiency and security. This potential becomes a powerful guarantee to promote the rich multimedia applications. Finally, I propose the introduction of new communication technologies which will greatly change our life.

This thesis is based on theoretical research and practical test for the background, the establishment of a 3G model of telemedicine system in rural areas, using a variety of analytical methods in 3G high speed data transmission study, so that making the original single theory more practical. It reflects the real characteristics of the 3G network to enrich the research content and expand the research significance. This thesis is limited by time and space constraints; there are many issues worthy of further research. Further research may focus on how to ensure stability in the wider region of data transmission, and how to achieve global seamless connectivity and standardization, the realization of applications compatible with various platforms. The rapid development of 3G technology and a smooth transition to 4G technology will achieve to improve high-speed data communications comprehensively.

6. Conclusion

This thesis produced that 3G meets the requirements of telemedicine. The traditional telemedicine is founded on the basis of combining wired network and medicine technology. Though it has improved the level of medical treatment for people even from long distances, the moving mode and high-speed data transmission of 3G could implement the telemedicine network more efficiently to help more patients.

The results give new opportunities to develop the telemedicine technology. The structure of 3G telemedicine network has been proposed in the thesis. While establishing a 3G model of telemedicine system in rural areas, the thesis also evaluates the model device configuration, the actual operation and development prospects, highlighting 3G's great potential in high-speed video data transmission. From the thesis, we can see that because of high speed data transmission, 3G could offer a lot of advantages to support the telemedicine technology.

With the test of the project, the capacity measurements could implement the old capacity. Compared with the traditional telemedicine, the 2G and wireless network technology no longer meet the needs of modern medicine. The 3G communication system is coming into the traditional technology to support the applications. Joining with new technology will be a huge step into services and business for rural areas.

This thesis was limited since the architecture of the network needed to be implemented. It is a large process to set the traditional devices and modern equipment. The work which has been done in this study was the concept but with possibilities. The results of this work could be used into building and modeling of the 3G telemedicine network as a draft in the future. Moreover, there is a need to develop the 3G telemedicine concept from the real foundation in a new thesis.

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