CMCC Technology Vision

2020 Plus

White Paper

Content

1 Introduction

1.1 Scope

This white paper is issued by China Mobile and describes the vision about the technology developments in all aspects of the industry in 2020 and beyond. It includes views on the industry development trends, digitalized services for everything connected and the related technology developments. We hope the industry partners can communicate and cooperate with each other to realize this vision.

1.2 Trends

With the evolution of information industry from fixed to wireless networks, landline to mobile calling, Morse code to voice/SMS, and from just providing network capabilities to providing the mobile multimedia services (video services, social media, location services, converged communication etc.) with enhanced user experience, the future development of the information network will be driven by three main factors: new smart terminals, ultra wideband mobile internet and intelligent applications. What will be the new expectations of the customers towards the information and communication industry in 2020 and beyond? What are the trends of individual and enterprise customers and what will be the key industry innovations?

- **Convergence of Informationization and Industrialization**

In 2020, advanced interaction and display technology (e.g. Super audio-visual, 3D printing, augmented reality, 3D etc.) will enable the seamless connection between the digital world and the real world for the customers. When users are consuming massive information, they are gradually becoming "micro enterprises", and producing a large amount of personalized (iMade) digital information.

- **The virtualization of Enterprise**

The enterprise employees all over the world can work together through the virtual network collaboration. The outsourced IT services are all cloud-based. Massive enterprises interact and influence each other effectively and automatically.

- **Cross-industry innovation**

Ubiquitous mobile broadband network has triggered a new round of changes in various industries (i.e. financial, transportation, energy and power, education, medical and so on), and will create a new “e-industry”, such as: connected cars, e-medical, e-logistics etc.

According to the prediction of GSMA, the global data consumption will increase 11 times and the growth of the whole industry value will be $1.1 trillion in 2020. The minimum daily user data consumption is expected to be at least 1G bytes on the average, and the network capacity will need to grow at least 1000 times by 2020. The converged mobile communication business will penetrate into all industries, and the network innovations resulting from the cloud and big data will have to meet the user's personalized experience. Operators will face challenges in the following fields:

- During the fast growing period of the Internet, how to ensure the stable growth of the operator's revenue when they invest and construct their network continuously?
- As the customer experience becomes the key competitive distinction, how to ensure the consistency of the user experience in different scenarios and to provide personalized services to customers?

Business requirement is the driver of technology innovation, and technology innovation will also stimulate the growth of new businesses. The evolution and development of the information technology in 2020 will mainly cover the network system, the fundamental technology evolution, terminal technology revolution and the intelligent applications supported by new digital services.

1.3 Overall Statement

In 2020 and beyond, China Mobile will pursue the target of " More Than Connecting", establishing a high quality, intelligence network to realize the interconnection of all things, creating a first-class infrastructure to provide professional services to realize the connection between traditional industry and information for Internet +, and enabling unlimited innovation.

As an operator, China Mobile has always had the primary goal of providing communication services, and hopes to cooperate with all the partners in the industry to jointly realize the "More Than Connecting" vision in the year of 2020 and beyond.

2 Digital Services for Everything Connected

We will provide the digital services for everything that is connected. These include human, machine, enterprise and information, to which we will ensure they are connected and be able to communicate. The top ten digital services are as follows (shown as in figure 1),

- Future Communication services
- Content and Value-added Info services
- Enterprise Informationization services
- Industry Vertical services
- Data Ability Openness services
- Smart IoT services

- Smart Home and Family Care services
- Socialized IoT services
- Industry Informationization Services
- Data Assets Operation services

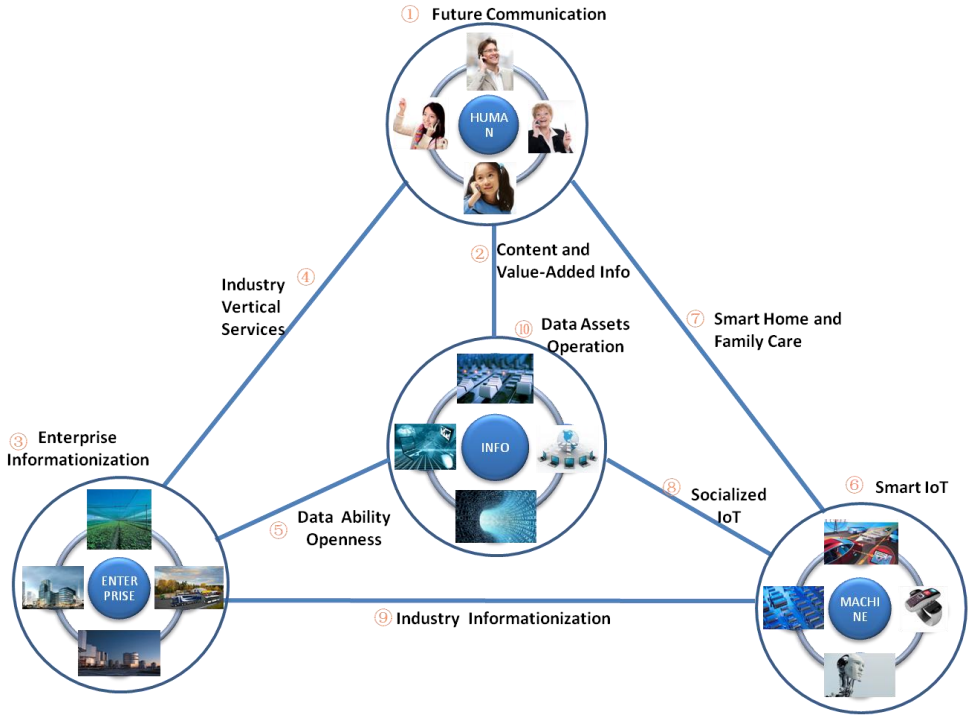

Figure 1：Top 10 digital services for everything connected

2.1 Human-human：Future Communication services

According to the prediction of a well-known institute, the global mobile data traffic will grow by 240 times from 2010 to 2020, and the number of mobile terminals around the world in 2020 will double from 2010 to 2020, reaching 10.7 billion. By the year 2025, there will be 2 to 3 billion people using social network applications. It is estimated that 5G will cover 60% of the globe in 2023. Big data traffic will be the norm with 30GB data consumption per user per month. The traditional SMS/MMS and voice calls will be replaced by multimedia message and high-definition video calls[1].

CMCC believes that operators will continue to build and operate the new generation communication network, to provide the "Enjoy what you want" communication services for its customers. As the expert of operations and service provider of ubiquitous, high-speed, secure and intelligent network, China Mobile will provide human communication service that is available anytime, anywhere, instant, efficient and with superior user experiences.

The typical scenarios include:

- **Social communication by variety of means and channels:** with super Ultra High-Definition Audio/Video calls and multimedia message, interpersonal communication can become more intuitive and convenient.
- **Remote communication with almost real like feel**: with virtual reality, ultra-high-definition videos, and enhanced somatosensory (such as smell, touch) transmission equipments, people feel as if they are communicating face-to-face.
- **Communication for specific group**: with sensor equipments, such as some hearing, vision, and physical body sensing enhancement devices, disabled persons can easily communicate with others.
- **Communication in ultra-dense scenarios**: with proper technologies, a consistent service experience can be expected in ultra-dense scenarios, such as stadiums, open-air gatherings and concerts.
- **Communication by brain waves**: instead of traditional communication media like voices, movements and video, people can feel and understand what others are thinking with the advent new kind of communications equipment.

The scenarios above require:

- Network date speed needs to be at least 960Mbps in order to support transmission of 8K (3D) video
- Less than 10ms end to end network latency
- Consistent communications experience under harsh environments, such as high-speed mobility, crowded places, etc.
- In terms of energy efficiency, more than 100 times improvement on energy savings is required.

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Network Function Virtualization (NFV), Software Defined Networking (SDN), Software Defined Air Interface (SDAI), C-RAN, Next Generation Radio Interface (NGFI), Smart Energy-saving Network , Self-organization and self-management Network、Ultra Large Scale Antenna Systems, Smart Spectrum Access、Ultra-dense Networks、new Network Architecture ,etc.

2.2 Human-information: Content and Value-added Info services

According to a well-known consultant, from 2012 to 2017, the Compound Annual Growth Rate (CAGR) of mobile video will reach 75%.[2] And the CAGR of global game market from 2013 to 2017 will reach 8.1%, the market will reach $102.9 billion in 2016.[3] And in 2018, the global wearable devices market will reach $19 billion.[4] By the end of 2020, these trends will continue. It is estimated that about 90% of people will use mobile device to get information, such as music, text, game, video, etc. all over the world. Each person may have 3 to 5 mobile devices, of which 1 to 2 will be wearable devices. Also, in the future, from the family front, the configuration of Holographic projection and the Hi-Fi sound equipments will be common.

China Mobile aims to integrate the superior content resources and to make the ultra enjoyable user experience. As the expert of multimedia content integrator and digital content provider, China Mobile will provide fascinating, popular, multi-win and personalized digital entertainment services.

The typical scenarios include:

- **Holographic home theatre**：to provide the experience that one can be personally in the scene by using holographic projection and the Hi-Fi sound technology
- **Immersive gaming**：to provide the experience that people can play games socially and with immersive experience by using the technology of wearable devices and virtual reality
- **Specific content**：to provide specific content, such as interactive movies and novels to a consumer with his/her own ideas to direct the story
- **5D movies**：to provide the newly designed interactive movies that one can feel he/she is really in the scene of the drama

The scenarios above require:

- The new digital content technology, such as holographic, Hi-Fi, stereoscopic image, etc.
- Users can use wearable devices and the techniques of virtual reality or augmented reality to enhance their experience on digital content
- The operators are in charge of the content production and digital right management

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Next Generation Multimedia encoding/decoding, Ultra-fast optical transmission systems, Intuitive and natural user interface, Natural Language Interaction, Somatosensory and Gesture Control, Virtual Reality, Augmented Reality, Data Privacy Protection and Wearable devices, etc.

2.3 Enterprise-enterprise: Enterprise Informationization services

Enterprise is the main component of the market and is always the key customer for the operators. With the new wave of informationization of the world, the companies in various industries, especially the small companies are eager to promote their working efficiency. According to the prediction by famous consultant entity, the market of cloud for enterprise will keep the rate of increase of 15% and will reach $244 billion by 2017.[5] Using the cloud and other ICT techniques, traditional businesses will sell their internal capabilities as services that are separate and distinct from their regular business offering.

China Mobile aims to build the ecosystem of mobile ICT and help the small enterprise to reform for innovation. As the products and solutions provider of enterprise informationization, China Mobile will provide secure, highly-efficient, low cost and flexible ICT services at the enterprise-level.

The typical scenarios include:

- **Office work socialization**： employees could perform any cooperative work and information sharing by using the mobile internet technologies, thus the working efficiency can be significantly improved
- **Working Virtualization:** help enterprise to realize work automation and high efficient cooperation by using the virtualization technologies, such as the virtual environment, virtual teamwork, etc.

The scenarios above require:

- Enable the enterprises to deploy centralized information management, storage and computation.
- Enable the enterprises to realize office intranet, internal coordination and communication based on the mobile internet

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Open and Customized network security services, Data Knowledgization, Data Privacy Protection, etc.

2.4 Enterprise-human: Industry Vertical services

Due to the merging of the industry chain, it will happen not only between the fixed and mobile communication suppliers but also the mobile internet industry, and common communication supplier and other related fields. In the meantime network operators would also be involved in the competition of vertical service providers. According to the estimation of some organizations, until 2017 mobile payment market is going to increase to $720 billion [6], and national online education market will expand to 120 million users and $28 billion [7]. In 2020 more than 50 percent people will have health related wearable devices and services. And during the time, medical services (including mobile medical services), online retailers, public services and smart automobiles will occupy 85 percent of the whole Internet of things.

China Mobile hopes to lead the convergence of mobile internet related industries and cultivate innovative ecosystem for the civil livelihood. As a service and platform provider of mobile internet education, mobile internet medical service and mobile internet financial platform, China Mobile will exert great efforts to provide more convenient, affordable and open vertical services.

The typical scenarios include:

- **Chronic disease management:** by collecting and analyzing the data from wearable medical devices or home level monitors, people can conduct professional medical service management, especially for patients with hypertension, diabetics or cardiovascular disease.

- **Health management:** by recording and uploading the sports data, sleep status, diet schedule, mood change, social behavior, and some other lifestyle actions from mobile or wearable devices, people would get professional and customized advices from service provider.
- **Customized education:** people can get "For your own style" learning material and courses through online education platform and people can also use high definition video devices to make learning customized and smart.
- **Smart classroom:** with the help of intelligent education devices, students can ask and answer questions, take tests and vote in the remote classroom. The virtual classroom is very lively and vivid.
- **Mobile internet finance:** Based on the big data analysis, people can get customized and professional investment advice, personal financial consult and insurance services. In relation to the traditional financial industry there is no threshold for the public to receive these services.

The scenarios above require:

- Monitoring the condition of patients with chronic illness and normal people, providing fitness and medical suggestions.
- Data should be transmitted between medical sensors and server platforms within milliseconds.
- Providing personalized and entertaining online education.

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Wearable Medical Devices, Ultra High Speed Optical transmission system, Quantum Secure Communication, Real-time Big Data Processing, Augmented Reality, the New Generation of Multimedia codec, Intelligent Perception of Services and Users.

2.5 Enterprise-information: Data Ability Openness services

Facing the massive data generated from mobile internet and internet of things, there are increasing demands for information from the Enterprises. No matter big or small companies, either in traditional or emerging industries, almost all of them desire to be capable of mining and analyzing the data. They expect to own their cross-industry big data platform, which can provide them cross-boundary information guidance. According to the statistics, the market of big data will reach $50 billion by 2017, with CAGR up to 31 percent for the next 5 years. Furthermore, the market will grow to $112.4 billion by 2020. [11] At that time, not only will the technology and application of the big data be individually used by the enterprises, but also it will become open and profitable. With the enriched environment of data technology, service and applications will evolve by then.

China Mobile will drive a collaborative and a win-win open data hierarchy system which provides value-added data service. As an expert of big data platform operation and

information processing of data, China Mobile will also provide the open data service which is characterized by full open, fine-tuned, customized and real-time.

The typical scenarios include:

- **Cross-industry data service**: Provision of big data analytical service, by means of user data acquisition from the smart pipe, terminals and services platform etc. and in combination with service convergence with other vertical industries.
- **Accurate advertisement delivery**: Provision of timely and precise service recommendation and advertisement delivery, by means of user data analytics.
- **Network optimization of big data:** Network operations surveillance and provision of customized and optimized solutions, by means of data collection (both control and user plane) from key network entities, real-time data analysis and data mining.
- **Data credit**: Support the financial sector and government regulators to build social credit systems and also credit databases for individuals and enterprises, by means of analyzing subscriber data in operators' data pipe, e.g. location, user behavior and financial records.

The scenarios above require:

- The scale of data storage is above 1EB (1024PB).
- The response time of data processing node (transaction and query) is less than 1ms.
- The cost of data processing is less than 1 US cent per GB per month.
- The integration of cross-industry data (medical, education, financial).

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Big Data Storage and Processing, Data Knowledgeable Intelligence, Data Integration in various channels, Machine Learning and Mobile medical information processing.

2.6 Machine-machine: Smart IoT services

IoT (Internet of Things) is becoming the second network infrastructure for mobile operators. With the proliferation of low-cost sensors and the rapid increase in the number of connected devices, networks demand more intelligence to transmit and process colossal amount of data, while ensuring the service safety and the provision of more friendly services. According to industry estimation, global IoT terminals will reach 26 billion by 2020, with the sales revenue reaching $300 billion, and the leveraged economy will exceed $1.9 trillion. [7] By 2020, more than 80% machines will be connected via network and are capable of communication. Also IOV (Internet of Vehicle) will grow explosively. In 2013, IoT terminals are only half of the traditional internet equipments such as the smart phones and computers; however by 2020 this number will be two times the traditional internet equipments.

China Mobile will build and operate IoT network, provide intelligent M2M services. As the secure, efficient and intelligent IoT expert of operations, IoT infrastructure platform and

services, China Mobile will provide the world ubiquitous, omnipotent, automatic, low-cost M2M services.

The typical scenarios include:

- **Smart Grid:** A modernized and robust electricity grid that uses sensor and communications technology to gather and act on information, such as the behavior of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics and sustainability of the production and distribution of electricity.
- **Intelligent building:** A safer, more comfortable and energy-efficient building utilizes IoT to monitor and coordinate internal and external environment and facilities.
- **Collision avoidance:** Vehicles can automatically warn the drivers of a paternal accident including situations such as car to car, car to non-motor vehicle, and car to pedestrian.
- **Intelligent transport:** Based on V2X communication, a new generation of IOV network environment will be realized, including intelligent traffic signal control systems, traffic information service systems, traffic steering guidance systems and priority support systems for emergency vehicles.

The scenarios above require:

- The security and accuracy of the IoT data transmission, to protect data from manipulation and eavesdropping.
- The real-time performance in IOV network of millisecond transmission delay.
- Autonomous driving technology which can measure the distance and automatically avoid obstacle
- Vehicle terminals will become another form of smart devices. During driving, drivers can use the functions of the smart terminal and the IOV special functions
- Intelligent driving needs to acquire and process real-time traffic information and the environment.

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Real-time Data Processing, Opening and customizing of network security services, Intelligent Spectrum Access, Natural Language processing, V2X Communication, Vehicle Terminal Operating System, etc.

2.7 Machine-human: Smart Home and family Care services

Family is a major part of everyone’s life. IoT based family service requires stronger individualism, more human-object interaction, more complex terminal formality, etc. Based on the family broadband access, personalized IoT household service as the main scenario provided by service providers to help improve the quality of people's lives. According to the market estimation, the global market scale of smart home is $33 billion in 2013 and it to reach $71 billion in 2018[9]. In 2018, global shipment volume of wearable devices is expected to reach 485 million, corresponding to $19 billion sales volume [4]. By 2020, wearable devices are expected to enter the

stage of explosive growth and more than 50% of the global population will have 1 or 2 wearable devices connected to a mobile phone and/or a computer.

China Mobile hopes to provide attentive human-machine interaction service and make great efforts to fulfill the vision of "Mobile Changes Life". As a provider of smart home & wearable devices products and solutions, China Mobile will provide friendly, convenient, personalized and intelligent human-machine interaction services.

The typical scenarios include:

- **Family security:** By the real-time monitoring of household intelligent sensors, people can remotely monitor the home at any time and can receive security alarms.
- **Personal assistant:** The intelligent robots at home will have the ability of language, reasoning and abstract thinking, and help people make planning, scheduling and the decisions of the family business.
- **Energy saving:** People can realize intelligent monitoring and energy-saving management of the household facilities such as the utilization of water, electricity, natural gas and other energy, and get real-time status information.
- **Care of Independent Aging Population:** People can pay close attention to the living status of the old people who live alone through wearable devices and the built-in sensors in the furniture and household items.
- **Children guardianship:** Through wearable or implantable sensors, people can pay close attention to children's location and environmental conditions in real-time, and get notification of any abnormal events in a timely manner.

The scenarios above require:

- Remote monitoring, automatic alarm generation and automatic disaster recovery for the family security needs
- The functions of remote control, programmable, energy saving, low power consumption, connection and location for smart home needs.
- The functions of programmable, regular data collection and automatic response to emergencies for family robot needs.

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Precision Micro Sensors, Safety Authentication on Characteristic Behaviors, Direct Equipment Communication (D2D) and Wearable equipment, etc.

2.8 Machine-information: Socialized IoT services

There will be more and more human properties for the objects in the future, including identity, intelligence, communication, etc. With the growth of the IoT technologies development, object itself will have a social life, building up the interconnection of all things in the future world (Internet of Everything) of social networking. By 2020, 50 billion devices will be connected to

IoT network around the world.[10] Definition of a social network is no longer limited to just people, but also includes human to machine as well as machine to machine with increasing scope of the larger social networks where they detect and communicate with others.

China Mobile hopes to provide the socialized IoT platform and launch the era of socialization of everything. As the service provider of socialized IoT platform, China Mobile will provide an active interest, dynamic, automatic communication and social networking services

The typical scenarios include:

- **Ambulance evasive pass:** Based on the location, speed and model etc. reported by vehicle terminals, the Social Networking Platform, through the intelligent analysis, automatic identification of vehicles associated with ambulance traffic and traffic lights, and information related to vehicle notifies an ambulance to avoiding congestion, as well as by adjusting traffic signals to ensure speedy passage of the ambulance.
- **Home Networking:** Refrigerators, air conditioners, windows, TVs, oven and other mutual objects share information to realize intelligent temperature control, dietary advice, shopping recommendations, sharing of recipes, and other functions.
- **High-risk collaboration:** In high-risk scenarios such as fire fighting, disaster relief, exploration, high-temperature and high risk environment enable collaboration of intelligent robots.

The scenarios above require:

- Self communication, and automatic discovery of objects
- Collaboration between objects, information communication, and status query

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Micro Programmable Sensors, IoT Identification, Environmental Energy Gathering and Machine Learning.

2.9 Machine-enterprise: Industry Informationization services

With speedy integration of informationization and industrialization, product integration, business integration, derivatives are unstoppable trends in the traditional industries, resource allocation to different industrial sectors and companies proportional to continuous optimization, production and supply structure and industrial quality and continuously improve existing business models and production models will be changed, so as to promote the industry as a whole to adapt to the new trends in the information society.

China Mobile hopes to promote integration of Informationization and industrialization, and to help the reconstruction of traditional industry. As the industry upgrades services and solutions,

China Mobile will provide a safe, low-cost, large-scale, flexible and customized industry information service.

The typical scenarios include:

- **Smart factory:** Automation of industrial processes through the Internet of Things technologies and with the equipment resource scheduling and monitoring technologies to achieve full synergy, reduce manual intervention in the process, and build energy-efficient, green and comfortable environment of the human planet.
- **Intelligent production:** IOT technologies adjust the operation of the production process and environment control, through a simulated practice environment, affect the use of equipment during the manufacturing process test the functionality and performance of a variety of factors, enhance product.
- **Smart logistics:** Through the Internet of Things consolidation and logistics resources, for shipment, transport, sorting, process automation, and greatly increase efficiency.

The scenarios above require:

- To help the traditional industry carry out informatization upgrade, and promote industrial modernization by informationization.
- To help realize intelligent production, contributing to accelerating the pace of evolution.

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: Industrial Sensors, Big Data Security, Situational awareness and open and customized network security service.

2.10 Information-information: Data Assets Operation services

With the advent of the big data era, global big data industry has become increasingly active, data providers have emerged, including data owners and data distribution platforms. Communication operators are also active participants in the industry. With a wealth of data they could obtain and massive user resources, data analysis and mining, as well as the use of data for further business development will become a new value growth opportunity. Enterprise's own data, transaction data between companies or the public data released by third parties / platforms, the rational uses of the data is likely to bring huge economic benefits for the enterprise. This data will be monetized assets, which can be traded and operated. There are several influential data transaction platforms like Microsoft Azure Data Marketplace，BlueKai Purchased by Oracle，and DataMarket, Factual, Infochimps, DataSift and so on. In China, ZhongGuanCun Big Data Transactions Industry Alliance was founded in February 2014. Traditional IT vendors accelerate the pace of transition of the big data solution providers, cloud service providers become the subject of big data processing service providers, big data resource providers emerge.

Meanwhile, the combination of large data and artificial intelligence, digitalization of the knowledge and large number of knowledge-based digital services; knowledge will become the data assets of important components and performance. Traditional ICT service provider or

enterprise software will be the largest data cognitive restructuring, the era will be enormous changes have taken place.

China Mobile hopes to provide data asset operation and open new era of cognitive computing. As a knowledge service provider and data assets operator, China Mobile will provide complete, accurate real-time knowledge services and data asset operation services。

The typical scenarios include:

- **Data Transaction:** By processing the raw data (removing the useless information, desensitization, etc.) and analysis of operation data as an asset, available for use within the enterprise but also by making it available to external companies to achieve realization of assets or capital appreciation.
- **Intelligent Customer Service:** Intelligent Customer Service can provide intelligent voice customer service; understand the questions rose by users and respond in real time, support cross-business enhanced human-computer interaction by the form of voice, text, animation, and video and so on.
- **Knowledge Quiz:** Build the self-replicating, self-aware, self-healing, self-intelligent information and knowledge platform (similar to IBM Watson).

The scenarios above require:

- Transactions by large data centre for data storage, processing, analysis and provision of data applications, requires the ability for data pricing, data assets are traded
- Automatic call answer coverage should reach 80%, the correct rate should be over 90%
- The knowledge quiz covers daily uses and most professional fields.
- The data can be monetized, visualized and in safe privacy.

In order to meet such requirements, China Mobile looks forward to conducting research and cooperation in the following technologies: High Performance of Big Data Storage and Processing, Machine Learning, Data Pricing, Data Privacy Protection, Data Visualization etc.

3 Technology Vision

In order to support the objective of "More Than Connecting" vision and meet the needs of the digital service areas for technology, relying on China Mobile's existing network capacity, we need to strengthen the research and cooperation on some techniques in the three aspects of terminal, network and applications, and put forward the Technology Vision 2020 of application, terminal and network parts. We hope to express our perspective of the technology development and application through this Vision 2020.

From the technical evolution, in 2020 and beyond, the network will show the cloud trend, and the industries will be deeply integrated with ICT. Terminals will be wearable and will be friendlier. The application will be more intelligent and open.

The relationship with different technologies and the technology Vision 2020 plus of China

Mobile and the overall architecture is shown in figure 2-:

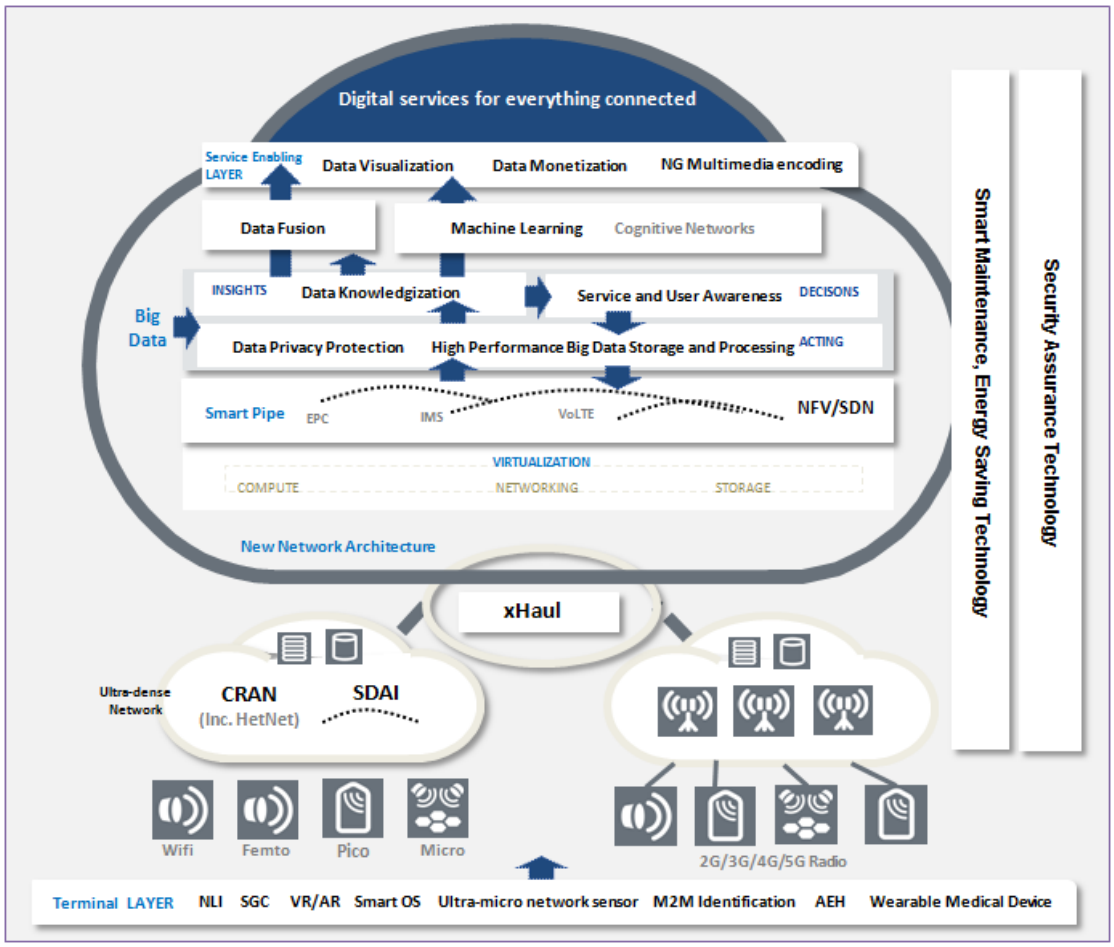

Figure 2: The architecture of CMCC Technology Vision 2020+

3.1 Terminal 2020

3.1.1 Intuitive and Natural User Interface

HCI (Human computer interaction) is an important part of the terminal field nowadays along with the chips and the rapid development of network technology, HCI technology towards the naturalizing closer to the human beings in natural exchange of forms. Users do not need to learn and adapt, just use natural means of communication, such as touch, voice, gesture, etc will be able to interact with the computer.

On the one hand natural user interface will have a very strong sense of authenticity, such as virtual reality technology to build highly realistic virtual environment, so that people have the feeling of immersion, The Augmented Reality technology for the real world of digital convergence, the HCI across the entire environment, people, machines, natural harmony and unity. HCI technology enables the terminal has a more intuitive and natural, barrier-free and machine communication.

China Mobile with the world's largest number subscribers, committed to give users the best user experience, and will promote development of Terminal HCI technology, drive the generation of innovative applications.

- **Natural Language Interaction**

Interactions rely on speech recognition, natural language semantic understanding of natural and artificial intelligence technologies to human nature, is at a phase of certain use scale, but does not completely meet the needs of the people. After 2020, speech input in noisy environments and different accents will be possible with matured problem solving semantic models of mass data enabling anywhere directly accept commands of complex language rather than the simple instructions as today. Terminal will act as private individual intelligent assistants.

- **Somatosensory & Gesture Control**

Somatosensory, gesture recognition using optical sensors, motion sensors, such as access to human, morphology and movement of the finger, at present at the stage of further innovation beyond just the larger but lower accuracy or equipment as before. After 2020, chip miniaturization and increased recognition accuracy, somatosensory, and gesture will be widely used. One can separate the empty control gestures, and body movements to control the user interface, control the game action figures, remote medical and surgical operations, somatosensory 1:1 remote controlled robots.

- **Virtual Reality**

Novel virtual reality interactive devices such as head-mounted displays will be used to build dynamic real-time three-dimensional modeling, virtual environments and graphics, human motion capture are at an early stage of development. Beyond 2020, with graphics capability, lower equipment prices, user actions and view capture problem-solving, high bandwidth and low-latency internet, online gaming and social networking will surge in popularity. People in virtual scenarios through wearable device with sensing equipment can immersive in an online game with a friend far away as if in a face-to-face communication in a virtual environment.

- **Augmented Reality**

With augmented reality using visual search, refactoring and personalized recommendations based on the metadata tool assistance the user can perceive the real world. This type of product is still in the exploratory stage in the market. After 2020, with the image and sound feature extraction, data compression, and other maturing key technologies such as object recognition and information transmission efficiency, lower network delay, the simple one screen communication can integrate themselves with the surrounding space and objects. Augmented reality game associated with it virtual, remote communications, remote tourism guides and other products will be further applications in the market.

3.1.2 Mobile-embedded Everything

Future terminal will not only realize the multi-dimensional interaction in the future, with important features such as morphological diversity and application of intelligent in order to satisfy the refined needs of industry and individual users, applied to every aspect of life, brings convenient, multi-purpose product experience.

China Mobile will continue to promote the development of terminals with multiple forms, and strengthen the perception of the terminal's efficiency. China Mobile will realize the ability of identifying people and objects with efficient identification technology, smart sensing and information extraction through diversified sensor technology, overall management through intelligent operating systems, long battery life through ambient energy harvest technology, and develop multi-form and intelligent terminals as wearable and implantable devices.

- **New Intelligent Terminal Operating System**

Smart terminal operating system is the core of the terminal overall software. Today, problems of smart OS consist of incompatible platforms, insufficient portability, lack of security and stability. By 2020, smart terminal operating system will have compatible platforms, high portability and high security. Deeply integrated with operator's network, smart OS will be widely used in domains with requirements of higher reliability and security such as intelligent robots, intelligent transportation, and smart grids, etc.

- **Ultra-micro Network Sensor**

Sensors for precise perception of environmental information have become the basic components of all kinds of automation systems. In the future, sensors will be further diversified, networked and miniaturized. By 2020, it is expected that more than 90% of sensors with a population of billions will have communication functions and become an essential part of intelligent IoT.

- **M2M Identification**

Nowadays, people mainly use RFID, fingerprints and password to realize identification. By 2020, as the development of the intelligent data analysis technologies, such as images and sounds, more than 80% of the terminals will realize identification via more diverse biological and electronic features such as face, voice and eye balls to enhance the safety and convenience.

- **Wearable Medical Device**

The mHealth wearable segment can be broken into two sections: fitness and wellness focused which have gained widespread popularity, and medical wearable still in an early stage of development. In terms of medical wearable devices, key technologies include nano-devices, nano-fabrication, low power technology, embedded real-time and intelligent processing, and human body communication using human body as a reliable transmission medium. By 2020, medical wearable devices and body-implanted devices, such as micro devices running biochemical

tests, implantable nano sensors and smart pills with sensors embedded, will can be worn long on different parts outside or remain inside the body, continuously collecting psychological and physiological data. Through further aggregation and analysis of the collected data, personalized healthcare services are delivered to end users.

- **Ambient Energy Harvest**

At present, in terms of IoT terminal power supply, ambient energy harvest can collect light, thermal gradient, vibration or radio waves to produce electricity. However, the technology still has some limitations such as low conversion efficiency and bigger size terminals, etc. By 2020, with the improvement of energy acquisition and conversion efficiency, more than 50% of the IoT sensors are expected to do long-term work without power supply, and achieve free lifecycle maintenance. The sensors will be widely used in bridge inspection, environmental monitoring, intelligent agriculture and other areas, gradually forming ultra-large scale Internet of things.

3.2 Network 2020

3.2.1 Customized Network

Future networks will be able to adaptively configure network resources in accordance with end users' location, service type variation, etc, to achieve seamless and high efficient network convergence. They can provide consistent experience for users in network access, data rate, latency and reliability. Furthermore, future networks can deploy and utilize the network resources according to the diverse demands of users, provide customized, personalized and diversified services, by analyzing the user behavior and the service attribute. They will be leveraging the development and evolution of network intellectualization, big data fusion, mobile cloud computing and other aspects.

In order to make the vision of "Best experience following you and customized services everywhere" into reality, new technologies of large-scale antenna arrays, smart spectrum access, Device to Device, ultra-dense network and ultra-fast optical transmission systems will be implemented in order to increase network transmission efficiency and to enhance access and transmission capacity, and finally to meet requirements of consistent experience. Other technologies such as new network architecture, vehicle-to-X transmission and service and user awareness will enable the launch of the customized services.

- **Ultra Large-Scale Antenna System**

Large Scale antenna system deployment can greatly improve the spectrum efficiency by exploiting the beam forming gain and multi-user multiplexing gain. Currently, most of manufacturers and operators are researching on relevant technologies and making contribution into the global standardization. It is expected that standardization in 3GPP on large scale antenna systems in low band and high band frequency will likely be accomplished by the end of 2015 and early in 2018 respectively, with its ecosystem will be taking off then based on this achievement. At

the same time, as the trends of product development of large scale Antenna are going to miniaturized, integrated, nearly invisible and achieving higher bandwidths. Now, the integrated pre-commercial base station with 128 antennas and the active antenna “SmarTile” with high level of integration have been developed, which can meet the demand of high rise and in-depth coverage in the future, improve the system capacity and suppress the interference.

- **Smart Spectrum Access**

Achieving fiber-speed wireless data access will cost more spectrum resources. Currently, low frequency bands are widely used in wireless communication system, but research on higher frequency band and unlicensed band is in progress together with the research of multi-band cooperative transmission. By 2020, high dater rate transmission will be carried out in higher bands, lower bands will provide seamless network coverage, in conjunction with the use of Licensed Spectrum Access to increase data speed and improve recourse allocation agilities in order to reduce the cost.

- **D2D：Device to Device Communication**

D2D provides operator network controlled discovery services and direct communications for UEs that are in proximity utilizing the cellular resources. It will enable public-security-oriented communications in emergency; provide UEs’ discovery capability for higher capacity and speed and reduce the network load through network controlled direct communication among devices. Relevant technologies are being discussed within 3GPP, and it is predicted that first D2D devices is to be released in 2017 for public security. D2D can be used to improve user experience for commercial services through proximal device discovery and to reduce network load through direct communication in the future.

- **Ultra-Dense Network**

Ultra-dense network (UDN) could increase volume density and user perceived throughput by increasing small cell deployment density. Meanwhile, UDN will also introduce more challenges on interference management, cost control, mobility management, backhaul enhancement, and so on. At present, many manufacturers and operators regard UDN as a key technical way to satisfy the requirement of 500-1000 times mobile data traffic growth in 5G, and actively solve various problems and challenges in UDN. Looking ahead to the year 2020 and beyond, UDN will be widely deployed in hot spot scenarios with ultra-dense users such as dense blocks, office and so on.

- **Ultra-Fast Optical Transmission Systems**

Optical transport networks are essential in telecommunications. At present, 100Gbit/s transmission systems have been widely deployed in optical transport networks. Major system vendors have been making significant investment in R&D of 400G~1Tbit/s transmission systems in order to increase the transmission capacity and lower the cost and power consumption per bit. As industry going to mature and technology going to standardize, 400Gbit/s and 1Tbit/s

transmission systems will be widely deployed around 2017 and 2020 respectively. Meanwhile, major fiber manufacturers are investing actively in ultra low loss fiber optic which can double the transmission distance. As with standardization in progress and cost decreasing, ultra low loss it is predicted that the fiber optic will succeed in the backbone transport networks before 2020.

- **New Network Architecture**

The new network architecture will systematically improve the entire network efficiency. Such a newly designed architecture enhances the corporative control, optimize traffic steering, support multi-RAT convergence and multiple connections and support dynamic network topology configuration. Introducing the new architecture also enables openness capability, improve the performance and optimize user experience together with the services. Designing such new network architecture is one important task of the industry. It is expected in 2020, we can achieve new network architecture by introducing technologies such as flat network function design, control and forwarding separation, and dynamic network setup per service requirements. In this way, operators could generate flexible networks according to different QoS and the overall efficiency improves dramatically.

- **V2X：Vehicle-to-X Communication**

Core technologies supporting V2X is facing key challenging issues, such as collision between multi-users, low reliability in dense road, etc. It is predicted that high reliability and low latency V2X network will be widely adopted in 2020 with applications equipped with, anti-collision, intelligent traffic management, interaction between vehicle and pedestrian and automatic driving, etc.

- **Service and user Awareness**

Smart traffic & user awareness mainly targets a smart pipeline providing end-to-end fine & diverse network connectivity, traffic & content differentiation, through the introduction of more elaborated traffic &user differentiation mechanism, as well as auto-configuration of air interface technology and system parameters, etc., which is done with accordance to the traffic scenario, UE capability, user preference, and network capability. Currently, traffic awareness based on DPI and QCI is gradually evolving to fine granularity awareness technology as per the traffic type, APP and application provider, content attribute, etc. It is expected that by 2020, adaptive air interface access & management, as well as end-to-end fine & diverse traffic & content differentiation are to be realized in mobile communication networks, based on the capability of traffic &user estimation, analysis, reaction and processing. It can provide more accurate and complete user personalization & customized resource allocation and network services, which will meet diverse user &traffic requirements, while ensuring high quality and consistent user experience.

3.2.2 Soft-defined, Flexible and Green Network

Network not only requires providing high speed and high quality of service, it should cope

with diverse service demands and cost issues as well, i.e. requires flexible and customized network architecture. The target goal is to reduce 1000 times in cost and with an efficiency increase of 100 times in the future network construction.

China Mobile drives the network evolution of a common hardware platform, resource allocation in virtualization, software realized functions, flat architecture, etc. It will leverage NFV and SDN technology to construct its own mobile infrastructure in common and customizable platform, employ the principle of separation in control plane and forward plane function, deploy C-RAN and SDAI technologies to design more flexible and efficient network architecture, introduce the end to end intelligent management to achieve to goal of network energy saving, and create the low cost, high efficient and green network.

- **NFV**

NFV (Network Function Virtualization) takes the advantage of virtualization technology to transform the traditional network functions into the resource pools as APPs, decouple from the hardware, the virtualization layer and the software, and also let the deployment and management of the current network become flexible. So far, the NFV standardization is still in progress; open source organizations are established to promote the SW openness and maturity of the NFV industry; several operators are also planning NFV to trial and pre-commercial deployments. In 2020, as predicted, NFV will be ready with carrier grade stability and availability which will be based on open source release, operators will be able to integrate their own NFV platforms so as to completely decouple the network and significantly increase the flexibility and efficiency while reducing the cost.

- **SDN**

SDN（Software Defined Network）is designed for centralized control and path-calculation through separation of data plane and control plane. IP and Transport areas are more mature than the mobile core networks in the SDN industry development. It is predicted according the industry, from 2020, the commercial network of SDN will be deployed on a large scale; most elements of mobile core network will have centralized control function and flexible service chain function; based on user, network and service information, the operator will be able to provide custom-defined virtualized network services, including flexible traffic Engineering, service chaining and etc.

- **SDAI**

SDAI (Software defined air interface) is envisioned to provide a scalable and configurable mechanism to customize air interface design to support different services and applications under different transmitting and receiving conditions, via protocol stack reconstruction and adaptation of the fundamental building blocks, such as frame structure, bandwidth, duplex mode, multiple access scheme, waveform, modulation and coding, etc. Currently, SDAI is being actively studied by both industry and academia. It is expected that around 2020, SDAI will be able to provide favorable solutions for 5G air interface to support the network operation for all foreseen services

and scenarios.

- **C-RAN**

Featuring centralization, collaboration, Cloud and Green aspects, Cloud RAN (C-RAN) centralizes the baseband processing units and virtualizes them into resource pool which can be dynamically allocated and managed on demand. C-RAN provides the advantages such as TCO reduction, quicker network deployment and so on. Technology feasibility of C-RAN has been verified through extensive field trials. It is foreseen that C-RAN could be commercialized ~~in~~ around 2020. As one of the key RAN architectures, C-RAN could facilitate the application of 5G technologies including UDN, CoMP, Multi-RAN and No More Cell and so on.

- **NGFI**

Next-generation Fronthaul Interface (NGFI) is a new fronthaul interface between BBU and RRU which features variable bandwidth, multipoint-to-multipoint connection and packet-based transmission. So far several projects have been set up in CCSA and IEEE 1904.3 for the topic. It is foreseen that NGFI would become one of the basic components for future 5G networking solutions around 2020. NGFI would facilitate the deployment of C-RAN, indoor coverage and UDN networks. It also fulfills the requirements of dynamic routing, reduced bandwidth, packet switching and so on.

- **Smart Energy-saving Network**

As the network is becoming more software oriented, efficient End to End Energy Saving (E2E ES) technologies turns to popular issues, such as the network resources and capacity reallocation, equipment powered on demand and so on. These technologies are devoted to precisely match the network energy cost with traffic load so as to minimize the consumption of network resources. At present, network energy saving technologies has been preliminarily standardized in 3GPP. It is estimated that around 2020, E2E ES will provide a solution for the 5G network energy saving, contribute to low-cost operation of network, meanwhile ICT services will greatly help to reduce the carbon emission for the entire society.

3.2.3 Secure, Reliable and Intelligent Operation and Maintenance

With the continuous developments in mobile Internet services and the surge in the number of customers, network and information security will become the greatest challenge faced by operators. The next generation network should be more secure and reliable. Moreover it should be able to provide individualized, multi-level security services for users. To solve the increasingly serious security challenges, China Mobile will actively apply security IntelliSense and big data analysis technologies to achieve real-time warning of security risks and precise control of abnormal behaviors, creating a secure and reliable digital mobile service environment.

In order to provide users with high-quality mobile communications services, a customized network should be provided. On the one hand, global planning and configuration can be done automatically due to the versatility of the devices and easy configuration management. Construction costs are thus substantially reduced. This better supports the flexible autonomy of the network, i.e. plug and play capabilities of network devices. On the other hand, it is required that network parameters can be adjusted effectively and quickly through automatic optimization, in order to optimize the allocation of resources and to adapt to the requirements of customers and services. The network has to have more advanced self-management and intelligent optimization capabilities. The combination of both can further save labor costs, and achieve a low-cost, automated precise operation and maintenance.

- **Security Situation Awareness based on Big Data**

By adopting technologies such as assets discovery, vulnerability awareness, abnormity monitoring, incident awareness and big data analysis, security situation awareness can increase the warning speed of security risks up to one hundred times, and can achieve automated warning and self-protection capabilities. It will be widely implemented by 2020 in network information systems as a measure of risk warning and protection, and serves to enable the sustainable and healthy operation of networks.

- **Behavior-based security authentication**

Secure authentication technology based on characteristic behavior using the key hidden in the representation, and authentication system reproduces the key according to the characteristic behavior to authenticate the user. At present the technology has been in the stage of scale validation. It is expected that in 2020 the technology will become the mainstream technology of access security authentication, solving the problem of key leakage caused by key storage in improper way.

- **Openness and Customization of Network Security Service**

An open network security service platform can be constructed based on a comprehensive utilization of technologies regarding smart terminal devices, cloud computing, and big data analysis. This platform is capable of performing fine-grained anti-attack security protection and privacy preservation. It is also capable of providing security services catering for the personalized/individualized need of the customers. It is anticipated that main-stream carriers/operators will all provide fine-grained multi-level protection and personalized/individualized security services based on this kind of platform by the year of 2020.

- **Quantum Private Communication**

Quantum Private Communication will fundamentally solve the problem of communication security, where quantum state is the information carrier and communication process is realized based on the theory of quantum entanglement. At the present time quantum communication already moves towards the deployment in practice. Quantum communication technology is

anticipated to grow up into a new communications industry by 2020. China Mobile will monitor the maturity of this technology.

- **Self-organization and Self-management Network**

The network can perform automatic network planning according to the requirement of network capacity, throughput, coverage, and etc, in order to support intelligent network topology configuration, to realize automatic network deployment, to reduce labor costs and complexity, and to achieve self-management, self-maintenance, self-collaboration, self-optimizing, network self-testing and network self-healing. It is predicted that in 2020, the function and type of network nodes will be changed. The network equipment with module function, universal interface, automatic configuration, and self-running will be widely used for direct installation on a universal data interface, which can realize self-testing, self-starting, self-configuration and self-running, and can support plug-and-play, configuration and reconfiguration, self-management and self-maintenance. In addition, the network can dynamically optimize and adjust its deployment and parameters according to pre-configured policies or target, which can increase network performance and efficiency. The network can also realize problem self-shooting and self-solving, and automatic parameter self- checking and updating, which can dynamically adapt to the changes of network environment and traffic load, achieve precise network operation and maintenance, and significantly improve the efficiency and greatly reduce the costs.

3.3 Application 2020

3.3.1 User-specific Value-added Application

China Mobile has plenty of data form machine, communication and Social networks. We will not only take full advantage of own data to maximize the data value, but also devote to integrate data from various industries. In order to make the data valuable, we will help the user to experience the new interactive multimedia with 3D and enhanced the mobile medical services, by the means of technologies such as deep data mining, intelligent data knowledgization，massive media content compression mHealth Information processing and so on. All of these will bring big changes to industries and individuals and make our life Smarter.

- **High performance big data storage and processing**

Distributed big data storage and processing is a kind of technology which uses the ability of compute nodes on network for simultaneously storage and data processing, it is gradually replacing the traditional centralized data processing mode nowadays. By 2020,enterprise-class platform for big data will storage Exabyte data. Along with the memory cost reducing, Online-Data will completely be stored in memory. The data processing technology of Real-time streaming can deal with million recorders per second and the latency is less than millisecond.

- **Data Knowledgization**

Data Knowledgization is a technology that transforms unstructured heterogeneous data from multiple sources, such as texts, audios, videos and etc., into a machine understandable and reasonable structured knowledge system or a semi-structured knowledge system. The knowledge system is useful for Big Data business. Nowadays, data knowledgization is mainly applied on rule engine products. By 2020, mainstream operators will have finished the construction of Knowledge Graph by referring to ontology-based Knowledge Base products. The Knowledge Graph will assist not only enterprises but also industries in building more complete and efficient knowledge applications, which will further provide basic support for big data intelligent applications of enterprises.

- **Data Fusion**

Data Fusion is a technology that correlated merges multisource data across business sections of enterprises and industries into a uniform data vision with a full view by referring to certain associated reference elements. Such a technology is still at the stage of pioneering research on both theories and realizations. The technology that merges data from various channels with regard to users' authentication will have become mature until 2020. It will be used widely in the associations of operator's, Internet's and social identity's user data, in order to enhance the completeness and precision of data. It will further support user insight, perception and enterprises' decisions comprehensively.

- **Machine Learning**

Machine Learning is an important technology frame of knowledge acquisition that performs prediction according to available data. Currently, its applications of Graph Recognition, Audio Recognition and Natural Language Processing have become mature. These applications are used in product services such as, Intelligent Home, Intelligent City Transportation and etc. By 2020, a set of machine learning technologies like Incremental Learning and Deep Learning, which are more suitable for processing Big Data and simulating human being's intelligence will have been utilized in more business fields. For example, these learning methods can help predict, prevent, diagnose and cure diseases by learning data models from multi-modal health or medical treatment in the health care field.

- **Next Generation Multimedia encoding/decoding**

A new generation of video coding technology with H.265, EVS, Opus as the representative, is to further improve the compression ratio, enhance the perceived quality, reduce the computational complexity, and implement low power mobile codec chips. By 2020, audio and video coding performance is expected to more than double. Multi-view coding in 3D and interactivities, 4K Ultra HD coding will be widely applied in mobile terminals, home entertainment devices and vehicles.

- **mHealth Information Processing**

Mobile healthcare information processing is a multidisciplinary field, which involves the techniques of feature extraction, modeling, machine learning and data mining on the vital signs

and behavioral data monitored anytime, anywhere in the daily life. Currently, the adoption of this technology is still in the exploratory stage. By the future year 2020, the technology of mobile healthcare information processing will make it happen that enables comprehensive personal health management including exercise, diet, sleep and psychological and other aspects by taking advantage of the techniques of multi-modal parameters fusion, spatial-temporal model and etc., helps analyze the risk factors of the disease and identifies the high-risk populations by the regression technique, predicts the time of disease onset and progression using the method of extreme statistics, achieves the goal of personalized precision medicine through assisting diagnosis and determining the causes by utilizing the techniques of genetic analytics and mining of massive datasets.

3.3.2 Open Big Data

More and more data providers emerge in the Big Data era. From data content opening, data processing and analysis platform opening to the capability of data value extraction opening, all of which form an open multi-dimensional big data system. It will connect data from all kinds of platforms, provide EB-class data storage capabilities and value-added data services, and achieve monetization of data assets in 2020.

China Mobile is committed to be the open big data platform and data assets operator, protecting users' personal data privacy, providing data visualization capabilities and pricing data.

- **Data Privacy Protection**

Data privacy protection uses encryption, access control and other technologies to provide data privacy hierarchical management capabilities. It is not yet fully achieved analyzing open data without divulging any personal privacy. Open data will be removed identifier or differential privacy to make data desensitization or added noise to protect data privacy without disturbing the analysis of data. It will used in analyzing the character of users and providing targeted services without exposing user identity in 2020.

- **Data Visualization**

Data visualization uses graphical tools, turning data sets to data images like plots, tree charts, maps etc. By 2020, the form of data visualization will significantly expand, such as interactive images, audio, video, taking advantage of human visual, auditory, tactile and other senses to make a more dimensional display of data content. Operators will provide data visualization APIs of open data to enterprises and users, while providing a panoramic view of data support for its own operations.

- **Data Quantization**

Data pricing gives different values to data of different categories and different content.

There is no fully monetized value of data and no uniform data pricing rules. By 2020, most of the operators will price data according to the utility and scarcity, and trade the priced data.

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