Artificial Intelligence Applications of Telecom Operators White Paper

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1 Status and Trends of AI

1.1 Overview

Artificial Intelligence (AI) is an interdisciplinary frontier subject, and there is no uniform definition at present. Computer science defines AI research as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Colloquially, the term "artificial intelligence" is used to describe machines that mimic "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving".

AI began in the 1950s. Its development has been roughly divided into three stages. The first stage (1950s-1980s): birth of AI. The second stage (1980s-late 1990s): AI begins to enter industrialization. The third stage (2000-now): explosion of AI.

It is generally believed that the evolution of AI is in three stages: the Artificial Narrow Intelligence (ANI), the Artificial General Intelligence (AGI), and the Artificial Super Intelligence (ASI). ANI only focuses on specific tasks, such as the speech recognition, the image recognition and the translation. AGI belongs to the human-level AI which can think, play, solve problems, understand and learn complex concepts quickly. As for ASI, Nick Bostrom, a well-known AI thinker from Oxford University, argues that ASI is “much smarter than the smartest human brain in almost all fields, including the scientific innovation, the general knowledge and social skills”. At present, the research goal of AI is still in ANI. Few people undertake research in AGI, and ASI is still in the imaginary stage.

1.2 Status and Trends in AI Technology

The advancement of key algorithms, such as the deep learning, the knowledge graph, the Natural Language Processing (NLP), etc., the arrival of big data era, the increased computing power and the expansion of application scenarios, all have a profound impact on the development of the AI technology.

This section firstly introduces the status of the AI technology.

1) Data

Data is the cornerstone for the AI development. Recently progress of the AI

technology mainly benefits from the large data base. Massive data provide raw materials for training the AI models. However, massive data cannot directly drive AI applications. It needs to be processed to become AI data sets. At present, public AI data sets, which are mostly constructed by academic and research institutions, are constantly enriched and their quality is constantly improving. Some AI data sets are as follows.

Table 1-1 Common AI Open Data Sets

Type	Data Set Name	Explanation
NLP	WikiText	Wikipedia corpus
	SQuAD	Stanford University question and answer dataset
	Common Crawl	Petabytes of data collected since 2011
	Billion Words	The common language modeling database
Speech Recognition	VoxForge	An accented corpus
	TIMIT	An acoustic-phonemic continuous speech corpus
	CHIME	A speech recognition dataset containing environmental noise
Machine Vision	SVHN	Google street view house number dataset
	ImageNet	Common image datasets based on WordNet
	Labeled Faces in the Wild	A facial region image dataset for face recognition training

In addition, the AI data sets are closely integrated with industries, which are the core competitiveness of enterprises. Therefore, enterprises construct industrial AI datasets in a self-built way. The self-built AI data sets of enterprises have promoted the development of the data service industry. At present, the data service industry mainly includes the dataset construction, the data cleaning, the data annotation, and so on.

2) Algorithm

The machine learning algorithm and the deep learning algorithm are two hotspots in AI. The development of the deep learning algorithm rapidly drives the maturity of the speech recognition, the machine vision, NLP and other technologies. The open source AI algorithm framework is a driving force to promote the development of the

AI technology. It allows the public to use, copy and modify the source code. It has the characteristics of fast update and scalability. It can greatly reduce the cost of enterprises and customers. These frameworks are widely used by enterprises to accelerate the iteration and maturity of their own technology, and ultimately achieve the application of products. Some of the mainstream frameworks are as follows.

Table 1-2 Common AI Open Source Frameworks

Framework	Source	Programming Language	Brief Introduction
TensorFlow	Google	Python/C++/Go/...	An open source library of the neural network
Caffe	UC Berkeley	C++/Python	An open source framework for convolution neural networks
Paddlepaddle	Baidu	Python/C++	An open source platform for deep learning
CNTK	Microsoft	C++	A deep learning computational network toolkit
Torch	Facebook	Lua	An open source framework for machine learning algorithms
Keras	Google	Python	Modular neural network library APIs
Theano	University of Montreal	Python.	A deep learning library
DL4J	Skymind	Java/Scala	A distributed deep learning library
MXNet	DMLC community	C++/Python/R/..	An open source deep learning library

Open source AI algorithm frameworks have become the focus of technology giants. Google, Amazon, Facebook, Baidu, Alibaba, Tencent and other companies are accelerating the deployment of AI algorithm platforms. At present, there are more than 40 AI frameworks in the world.

3) Computing power

The implementation of AI algorithms needs support of the strong computing power, especially the large-scale use of deep learning algorithms, which puts forward higher requirements for the computing power. In recent years, the development of new high

performance AI chips has become the main driving force of the AI technology evolution.

According to the technical framework, AI chips can be divided into general purpose chips (CPU, GPU, FPGA), semi-customized chips based on FPGA, fully customized ASIC chips, brain-like computing chips (IBM TrueNorth). In addition, the main AI processors include DPU, BPU, NPU, EPU and other AI chips for different scenarios and functions.

From the development stage of AI chips, CPU, GPU and FPGA are the main chips in the AI field. ASIC chips for neural network algorithms are being introduced by Intel, Google, NVIDIA and many start-ups, and it is expected to replace the current general purpose chips in the next few years and to become the main force of AI chips. Brain-like chips are still at the stage of the laboratory research and development.

4) Application Scenario

The industry generally believes that application scenario is the fourth element of AI, and also the core element of industrial applications.

Next, the trends of the AI technology are introduced.

The development of the AI technology has remarkable characteristics in the following aspects, which reflect the AI trends.

1) Open Source AI Platform to AI Industry Ecology

An open source AI framework has made remarkable achievements in AI fields. It enables developers to use existing AI tools directly, reduce the secondary development, and promote the industry cooperation. The industrial giants have also realized that the establishment of an industrial ecology through the open source technology is an important means to seize the industrial commanding heights. Through the open source technology platform, we can expand the scale of technologies, integrate technologies and applications, and effectively lay out the whole AI industry chain. Leading enterprises such as Google and Baidu have laid out the open source AI ecosystem one after another. In the future, more software and hardware enterprises will participate in the open source ecosystem.

2) ANI to AGI

At present, AI can only deal with a single field of problems, such as the picture, the character, the speech, and so on, which is still in the stage of ANI. Since various fields are interacting with each other, ANI with a wide range is needed with the development of science and technology. AGI can perform general intelligent

behaviors. It can connect AI with human characteristics such as perception, knowledge, consciousness and intuition, reducing the dependence on knowledge of specific areas and improving the adaptability of processing tasks.

3) Perceptual Intelligence to Cognitive Intelligence

The development of AI mainly includes the operational intelligence, the perceptual intelligence and the cognitive intelligence, which is widely recognized by the industry. Presently AI is the perceptual intelligence, and machines have the perceptional abilities of vision, hearing and touch. In the future, AI advances to the era of the cognitive intelligence.

1.3 Status and Trends in AI Product

Characteristics of AI products are as follows. At present, AI products mainly focus on a single scenario to provide services for users. The user experience of AI products in complex scenarios is not good. So, the user experience needs to be further improved. Further, AI products concentrate on areas of voice, image and text where deep learning algorithms are good at. AI products in other areas are not rich enough.

Trends of AI products are summarized as follows. Intelligent products will support more single scenarios, and AI products of multi-scenario will gradually emerge. Improvement in the user experience will go ahead, such as the speech recognition accuracy and semantic understanding accuracy. The products for industry applications are gradually enriched since the demand for AI technology and products increases, including the fields of the industrial Internet, the manufacturing, the household, the finance, the education, the transportation, the security, the medical treatment and the logistics.

1.4 Status and Trends in AI Industry

As the core driving force of the new round of industrial change, AI will bring about new technologies, products and industries. Meanwhile, it will trigger major changes in economic structure and achieve the overall improvement of social productivity. McKinsey & Company predicts that the global AI application market will reach 127 billion US dollars by 2025, and AI will be the breakthrough point for the development of many intelligent industries.

According to the “Blue Book of World Artificial Intelligence Industry 2018” of

CAICT, the total number of AI enterprises in the world was 4925 by June 2018. American has 2028 AI enterprises, ranking first in the world. China has 1011 AI enterprises, ranking second in the world. Then, it was followed by Britain, Canada and India. In 2017, the global AI investment and financing scale reached 39.5 billion US dollars. Chinese investment and financing scale reached 27.7 billion US dollars, accounting for 70% of the total. China has become the world's largest capital-absorbing country in AI field.

Global AI enterprises mainly focus on the business (e.g., marketing and customer management), the medical health, and the financial fields. The AI technology is merging with the business of various industries, and AI will be the breakthrough point of many industries. The followings are some examples.

1) AI + Medical

The application of AI technology in the field of medical and health care can significantly improve the efficiency of medical institutions and personnel.

2) AI + Finance

Finance is one of the most data-dependent industries. Integration of the AI technology and the financial industry will deeply reconstruct the ecological pattern of the current financial industry and make the financial services (e.g., the bank and the insurance) more humanized and intelligent.

3) AI + Education

The application of AI technology in education can help teachers pay more attention to students' characteristics and improve the quality of teaching. The intelligent education covers the industry chain of "the teaching, the learning, examinations, evaluation and management for teachers". It plays an important role in various sub-tracks, such as the kindergarten education, K12, the higher education, the vocational education, the online education, etc.

4) AI + Home

The application of AI technology in the field of the home makes the household life safer, more comfortable, energy-saving, efficient and convenient. In the future, the smart home will gradually achieve the adaptive learning and control functions to meet the individual needs of different families.

From the perspective of the development process of the AI industry, AI is triggering the fourth industrial revolution. The following trends are emerging.

1) Increment in AI Industry Scale

Statisticians predict that the global AI market will grow at an average annual rate of 50.7% in next 10 years. According to Chinese “New Generation of AI Development Plan”, the scale of the AI core industry in China will exceed 400 billion yuan by 2025, driving the scale of related industries to exceed 5 trillion yuan. By 2030, the scale of the AI core industry in China will exceed 1 trillion yuan, driving the scale of related industries to exceed 10 trillion yuan.

2) Adaptability to multiple scenarios

The application fields of AI are mostly for one scenario, such as the face recognition, the video surveillance, the speech recognition, and so on. The coverage is limited, and the degree of industrialization needs to be improved. In the future, AI is adaptable to multiple and complex scenarios with the introduction of new AI products like that of the smart home and the intelligent logistics.

3) Shortage of AI Talents

The gap of AI talents will be further expanded. The demand for AI talents will change from IT to AI. The shortage of AI talents won’t improve in next few years.

2 AI + Telecom Operators

While AI is sweeping the world and promoting development of all industries, telecom operators are using AI to enhance the network intelligence, improve the user experience, and expand vertical industries.

2.1 Networks

The Internet of Things (IoT), the Software Defined Network (SDN), the Network Function Virtualization (NFV) and 5G are the potential directions for the network evolution. However, the number of network devices and data in IoT are growing rapidly. The video, the Augmented Reality (AR), the Virtual Reality (VR) and other services causing large traffic are emerging. These lead to a great increase in the network equipment and traffic. Network architecture reconfiguration based on SDN/NFV/Cloud enjoys the flexibility, but it gives rise to management and control complexity in new dimensions. While 5G network brings great progress in performance and flexibility, its complexity also increases significantly.

Integration of the AI technology and the telecom network provides potential solutions to the above problems. Specifically, the powerful capabilities of AI in aspects of analysis, judgment and prediction can make the network intelligent.

For the current network, AI can empowers the network with capabilities of analysis, judgement and prediction, promoting the development of the network planning, the network construction, and the network operation and optimization.

For the future network such as SDN/NF and 5G, AI provides training and inference capabilities in the infrastructure layer, the network and business layer, and the management and orchestration layer.

2.2 Services

Some basic AI capabilities, like the speech recognition and the Natural Language Processing (NLP), are gradually used in various scenarios of services of telecom operators. In particular, the typical applications are the intelligent customer service and the smart home. In the smart home, telecom operators have launched virtual assistants and household products that have the capabilities of the intelligent control and interaction. In the intelligent customer service, virtual assistants and customer

service robots have been able to replace much of the work done by customer service staff.

2.3 Industries

As a general enabling technology, AI can serve all industries so AI can help telecom operators to achieve the digital transformation to expand service capabilities and business channels for industries.

Now, AI technologies, such as the computer vision, the speech and semantic recognition and NLP, have already been successful in commercial use. They can quickly integrate with the business capabilities of telecom operators to achieve composition of services of multiple industries to open up new market areas and to increase revenue.

With the help of AI, telecom operators are no longer confined to services of the traditional network communication. They can expand their business areas to multiple vertical industries. On the one hand, telecom operators are improving their technological innovation ability and building an AI platform that integrates their own network with various industries. On the other hand, telecom operators are improving their business innovation ability, deeply cooperating with many manufacturers of the AI technology, and launching a number of services for vertical industries including the smart cities, the smart government, the smart agriculture, and so on.

3 AI Applications in Telecom Operators

3.1 China Mobile

China Mobile Communications Corporation (CMCC) was established on April 20, 2000. It is the telecommunication operator with the largest network, the largest number of customers and the highest market capitalization in China. China Mobile mainly operates mobile voice, data, broadband, IP telephony and multimedia services.

1) Intelligent networks

In 2018, China Mobile developed independently three products for network optimization and operation: the Autonomous Coverage Optimization System (ACOS), the Autonomous Parameter Optimization System (APOS) and AI for IT Operations (AIOps). ACOS based on deep learning can intelligently analyze cellular coverage and provide suggestions for network optimization. APOS supports optimization in complex network environment with sufficient AI algorithms. AIOps can provide operation functions such as failure predictions, device information statistics and unstructured data extraction.

In 2018, China Mobile partnered with AT&T, Deutsche Telekom, NTT DoCoMo, and Orange to set up the Ohrand Alliance for promoting the development of open-source and intelligent network.

On June 27, 2018, China Mobile collaborated with 12 telecom operators from all over the world such as AT&T, SKT&T, NTT to establish the O-RAN Alliance. The alliance is committed to introducing AI and SDN to wireless network.

2) Intelligent services

Intelligent Customer Services

In 2016, China Mobile launched an intelligent robot for customer service called “Yiwa”. “Yiwa” is an intelligent interactive system for customers, supporting both text and voice interaction. It has more than 200 million interactions monthly, which are equivalent to the workload of 1000 staff of the customer service, saving more than 100 million yuan in labor costs.

Smart Home

In 2016, China Mobile created China Mobile Digital Home Alliance (CMDHA)

with the smart home companies, promoting innovation of smart home products and developing home devices such as smart headphones and smart watches.

In 2016, China Mobile released a protocol for smart home called “Andlink”. The protocol is to facilitate connections among multiple smart home devices.

3) Intelligent industries

Platform

On November 24, 2017, China Mobile launched an AI platform called “Jiu Tian”. “Jiu Tian” focuses on the market operations, networks, services and other application areas of telecom operators. It provides end-to-end AI application solutions for the vertical industry. The platform consists of three layers. The top layer is about the product application, which contains smart operation, smart connection, and smart service. The middle layer is the core ability, which includes speech and language, image and video, and structured data. The bottom layer is the deep learning platform based on GPU and other infrastructures.

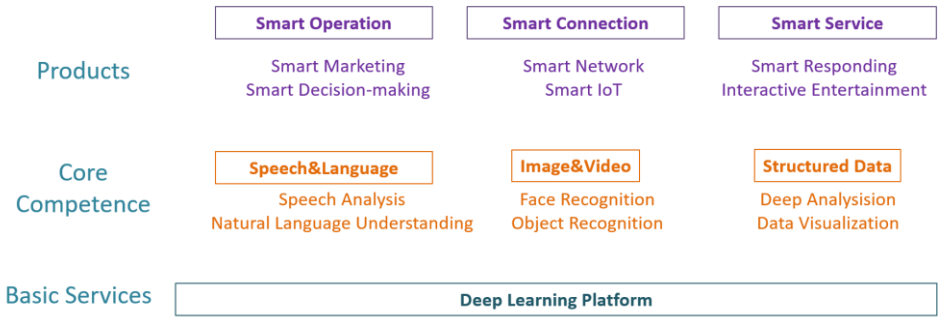

Figure 3-1 Architecture of Jiu Tian

On 2017, the Open Networking Automation Platform (ONAP), as a merger of AT&T's ECOMP project and China Mobile’s Open-Orchestrator project, was formed. And the project began under the aegis of the Linux Foundation with China Mobile, Huawei and ZTE as leading contributors. ONAP provides a platform for real-time, policy-driven orchestration and automation of physical and virtual network functions that will enable software, network, IT and cloud providers and AI developers to rapidly deploy new services and support complete lifecycle management.

Smart City

In December 2018, China Mobile released the “Super-brain” plan to promote the construction of smart city in Xiongan based on its core capabilities such as 5G networks, Edge Computing and AI.

Intelligent Transportation

In September 2019, China Mobile created an alliance with automobile manufacturers and colleges for research on auto-drive. China Mobile also released Chinese first test road for auto-drive cars. A smart vehicle terminal called “Helutong” was released one month later, it integrates voice recognition and interaction, ETC and other intelligent functions.

3.2 China Unicom

China United Network Communications Corporation Limited (China Unicom) was officially established on January 6, 2009 by merging former China Netcom and former China Unicom. It is the only Chinese telecom operator listed on the stock exchanges of New York, Hong Kong, and Shanghai. It has been a Fortune 500 company for many years and was ranked at No. 273 in Fortune 500 in 2018. China Unicom operates a wide range of services, including fixed communication services, mobile communication services, domestic and international communication facilities services, the satellite International Private Lease (IPL) service, data communication services, network access services, telecom value-added services, and system integration services related to information and communication.

1) Intelligent networks

China Unicom has started researches and applications related to AI on the network planning, the network design, the network maintenance, the network optimization, the security, SDN/NFV, 5G, the edge computing and IoT. It is also planning for the network brain project. At present, China Unicom has implemented many intelligent network applications.

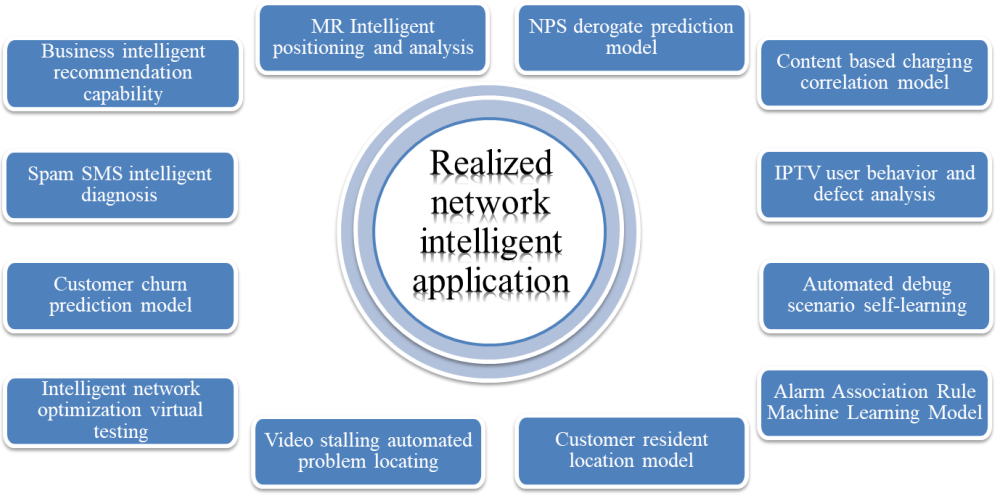

Figure 3-2 Intelligent network applications

CUBE-Net2.0+

China Unicom announced the launch of CUBE-Net2.0+ network architecture to build a new generation of an AI enabled intelligent network at the 5G and network transformation conference in June 2018.

AR Intelligent Operation and Maintenance System

China Unicom exhibited the "AR Intelligent Operation and Maintenance System" at the PT/EXPO China 2017 held in Beijing. The system runs through the whole work flow of frontline inspectors, including the precise intelligent detection, the remote maintenance and guidance by experts, the fault discovery for base stations, the worksheet upload, the transmission of the real scene, etc.

Network Security Situation Awareness Analysis System

China Unicom Network Security Situation Awareness Analysis System is a key innovation achievement. The system uses the AI and big data technology to collect and compare logs of multiple security systems. It fulfills the comprehensive analysis and unified presentation of multi-dimensional security situation of the existing network, and enables operators to grasp the security situation of the network.

Origin of Network Alarm

China Unicom applies AI technology to trace the origin of alarm in IPRAN network, filter the alarm, obtain the alarm information worthy of attention, and form a more efficient alarm processing method.

Network Information Platform

China Unicom launched a cloud platform "Tian Gong". The platform builds an efficient IT ecosystem with the "platform + applications" mode that integrates

open-source technologies and commercialization capability.

China Unicom launched a research management platform “Tian Ti” based on agile development. The platform supports the entire procedures of project management including the demand analysis, the research & development, the test and the launch.

China Unicom also launched a monitoring system “Tian Yan” to monitor platforms and applications in 7×24 hours.

Network Information Plan

China Unicom has stepped up overall planning to bolster the network information in the Management Support System (MSS), the Business Support System (BSS), the Operation Support System (OSS) and the Decision Support System (DSS).

In MSS, China Unicom integrates the access to professional applications and office applications, applies clouds and micro services to MSS, designs and develops various management applications for the intelligent finance, manpower, e-mall, etc.

In BSS, China Unicom seizes the opportunity of the mixed-ownership reform, and launches the “Operation 2.0” strategy to develop cross-border cooperation and the Internet operation in fields such as the new retail, the client applications and the billing system.

In OSS, China Unicom focuses on the construction of the basic capabilities, open platforms and core applications. It launches OSS 2.0 which contains seven core functions that are the data collection, the resource management, the electronic operation maintenance, the intelligent monitoring, the customers service support, the mobile business assurance and the innovation platform. In 2018, China Unicom developed the Open Network Service (ONS) based on OSS 2.0, enhancing the operation support for innovative network and business such as SDN, 5G and NB-IoT.

In DSS, China Unicom launches a big data platform based on Oracle, Hadoop, Spark, Storm, etc., enhancing the capability of access, process, integration and standardization for massive offline and online data. The platform provides China Unicom with centralized, unified and visual data management and scheduling capability.

Network Management System

China Unicom launched a network management system based on AI. The system introduces machine learning algorithms to build a prediction model for network traffic flow, providing abnormal situation alarm and intelligent troubleshooting.

Intelligent NFV Operation and Maintenance Platform

China Unicom launched an intelligent NFV operation and maintenance platform based on Open Web SA (OWS). The platform contains the fault experience base and the fault location function to support the internal work and external business.

Private Line Service

China Unicom launched the high-quality private line service by applying network flow prediction algorithms. With the capability of big data and AI, the service is able to actively perceive and predict customers' demands.

Customer Departure Forecast Algorithm

China Unicom develops a departure forecast algorithm for government and enterprise customers based on Spark, the deep learning and other big data and AI technologies. The algorithm builds customers' characteristic portrait by analyzing habits of using the network to provide services adapted to the customer's needs.

Net Promoter Score Prediction and Improvement

Telecom operators introduce Net Promoter Score (NPS) to evaluate customers' satisfaction. China Unicom analyses characteristics of unsatisfied customers and build prediction model. This model help China Unicom find the reason why customers give low score.

Intelligent Operation and Maintenance Platform

The intelligent operation and maintenance platform developed by China Unicom uses AI analytical ability and intelligent choreographer technology to manage hidden troubles and faults in network elements. For network elements in the core layer, the platform detects and assesses the hidden troubles. For network elements in access layer, the platform fulfills the intelligent troubleshooting and automatic self-healing.

2) Intelligent services

Smart Home

China Unicom's smart home products based on the voice interaction and gesture interaction includes the smart speakers, the IPTV set-top boxes, the AR/VR/MR and other products.

China Unicom and China Telecom lead the project of AI Devices Guidelines standard in GSMA TSG.

China Unicom has launched smart home platform "Steward of Wo Jia" to fulfill the interactions among smart home terminals.

Intelligent Customer Service System

China Unicom has launched the intelligent online customer service robot “Wobao” to solve various business problems in business hall and mobile phone business hall client.

China Unicom has launched an Intelligent Voice Customer Service System, which uses AI technologies such as the speech recognition, the speech synthesis and NPL to fulfill voice dialogue between the intelligent system and customers and solve business problems for users.

Intelligent Call Center

China Unicom introduced an intelligent voice outcall service system, which uses machine instead of human to fulfill automatic outcall function, reduced the cost of customer maintenance, and enhanced the marketing ability of new business.

China Unicom cooperates with Baidu, Ali and other AI enterprises to export intelligent call center cloud solutions to the whole industry, enhances customer perception and reduces enterprise operating costs.

3) Intelligent industries

Smart City

China Unicom is the overall responsible unit of Xiong’an digital project. It provides smart city solution for Xiong’an and uses AI technology to perform the construction of the smart city infrastructure. China Unicom is building an intelligent digital infrastructure with characters of high speed and security, and an urban big data platform with the core of open and share. Meanwhile, it plans to build a city cloud brain which can enjoy the intelligent data analysis, and a new ecological system of a government-led intelligent city.

On January 24, 2018, the standard project “Reference Architecture of Artificial Intelligence Service Exposure for Smart Sustainable Cities” led by China Unicom and FiberHome Technologies Group became the first AI project of ITU SG20.

Intelligent Government Enterprises

China Unicom actively introduces AI technology into "XueLiang Project". It combines the face recognition, the license plate comparison, the big data analysis, the comprehensive layout control and other technologies with the construction of a county, a town and a village to provide precautionary measure to citizens.

Intelligent Transportation

In June 2017, China Unicom cooperated with other companies to explore the

integration of the intelligent driving and the communication technology. China Unicom demonstrated the application scheme of the cellular vehicle-to-everything (C-V2X) technology that supports multi-scene fusion through the real vehicle test at the National Intelligent Network United Automobile Test Base (Shanghai). At the Mobile World Congress (MWC) Shanghai June 2017, China Unicom cooperated with other companies to demonstrate the 5G ultra-long-distance intelligent driving for the first time in the industry.

Intelligent Medical

China Unicom launched telemedicine workstations and 5G intelligent respirator with Tencent, also launched a self-developed and pioneered "5G respirator medical networking clinical decision-making analysis system".

China Unicom has cooperated with Tencent to launch cloud solutions for medical image application scenarios by using the image recognition and the deep learning technology to automatically recognize medical images such as CT and MRI of patients. It helps doctors to improve the diagnosis efficiency.

Intelligent Environmental Protection

China Unicom and Chinese Central Meteorological Station have built a "Smart Blue Sky" air pollution prevention and control platform. The platform integrates the desensitized communication data with the atmospheric environment data, achieves fine air pollution prevention and control, intellectualizes enterprise environmental protection monitoring, and helps "Green Winter Olympics" and "Smart Winter Olympics".

China Unicom applies the computer vision technology to the intelligent river length solution to achieve intelligent video surveillance for rivers, reservoirs, sewage outlets and other key areas.

Intelligent Education

China Unicom and South China Normal University cooperated to set up the "Artificial Intelligence + Teachers' Ability Development Joint Laboratory". The two sides carried out relevant cooperative research and product development around evaluation of teachers' ability development, AI technology in education industry, platforms of the education industry, etc.

Intelligent UAV

In March 2018, China Unicom has completed the world's first 4G network based flight measurement and control test of a long-distance high-altitude industrial UAV. It

successfully achieved the oversight flight of UAVs in highland and mountain areas by using the network of telecom operators.

China Unicom, in conjunction with other companies, has launched 5G UAV intelligent security products. The face recognition technology is used to analyze monitoring pictures in real time. Combined with geographic map and historical data in background database, the automatic identification of suspicious people is implemented and the monitoring efficiency is improved.

Intelligent networked UAV low-altitude communication system is an integrated and intelligent low-altitude communication network aiming at solving the problems of difficult UAV supervision. This system combines the edge computing, the 5G network evolution, big data technology, etc., and can provide basic communication services and customized value-added network services for UAV.

3.3 China Telecom

China Telecommunications Group Corporation Limited ("China Telecom") is an integrated information service provider, and is one of the listed companies of state-owned China telecom corporations. China Telecom provides wireline and mobile telecommunications services, Internet access services, information services and other value-added telecommunications services.

1) Intelligent networks

In 2016, China Telecom released the CTNet2025 network architecture white paper, starting the intelligent network reconstruction.

In February 2017, China Telecom and HUAWEI established ENI, the first global intelligent network standard working group in ETSI.

In April 2018, China Telecom participated in issuing the Network Application of Artificial Intelligence White Paper. It introduces firstly the definition, typical application scenarios and future network framework of intelligence network.

In May 2018, China Telecom issued 5G technical white paper, becoming the first telecom operator to explain the overall strategy of 5G. The white paper states that the operation of 5G will be more intelligent by means of data-driven AI technologies.

2) Intelligent services

Smart Home

China Telecom cooperates with intelligent terminal manufacturers to develop a smart speaker (Xiaoyi), a smart gateway, a smart set-top box and other smart home products. China Telecom develops customized mobile clients and open platform to provide smart living solutions for users.

Intelligent Customer Services

China Telecom's intelligent customer service robot “Xiaozhi” applies AI technologies such as the neural network, the deep learning, the voice recognition, NLP, and the context scene interaction to provide the intelligent response service for users through human-computer interaction in 24*7 hours.

China Telecom builds a cloud platform for intelligent customer services with the intelligent voice and semantic identification.

3) Intelligent industries

Platform

On January 26th, 2018, China Telecom launched an AI open platform named “Deng Ta”. “Deng Ta” consists of three layers: the top layer is the application layer including the security finance, the self-driving, the smart city, the smart speaker, the smart livestock and the medical image diagnosis. The middle layer is the capability layer including the image, the video, the phonetic and NLP. The bottom layer is the foundation layer including the deep learning platform “DTaas”.

Smart City

China Telecom has signed strategic cooperation agreements with 236 domestic cities, cooperating in the aspects of the e-government, security, the environmental protection, the health care, the education and the tourism. China Telecom also plans to construct a smart city management platform.

Smart Government

In 2016, China Telecom launches a communication platform called “Ma Shang Ban” for enterprises, promoting the development of smart office and expanding enterprise market with the advantages of integration of the Internet and communication.

On May 2018, China Telecom established “Tianyi Cloud Security Ecological Alliance” that provides more secure and credible cloud services for government and enterprise customers.

China Telecom independently developed an intelligent system called “Zhi Cha” based on AI technologies and big data for assisting police to discover clues, analyze

potential threats and deploy forces.

Energy-Saving

China Telecom Tianyi Cloud Company applies the cloud computing and AI technologies to build an energy-saving system in Inner Mongolia resource pool, saving about 34 percent of the electricity consumption and 121518 yuan per year.

Smart Agriculture

By integrating AI and block chain, China Telecom launched an intelligent agricultural platform for agricultural product tracking. The grazing cattle and sheep's birth identity information, grassland information and quarantine information are uploaded to the platform in real time to monitor livestock growth and meat quality.

Intelligent Transportation

China Telecom builds an intelligent traffic management information system to combine traffic signal, cameras, weather information together, achieving real-time interaction among people, vehicles and roads.

In 2018, China Telecom collaborated with BAIDU, achieving the technical test of driverless cars based on 5G in Xiongan.

Telecom Fraud Prevention

In January 2018, China Telecom built an AI joint laboratory with SpeakIn, committing the intelligent voice recognition in telecom fraud prevention.

AI Terminal

In May 2018, China Telecom issued the AI Terminal White Paper. This white paper presents the understanding and demands of China telecom for AI mobile terminals, and regularly defines smartphone in terms of AI computing power and applications.

3.4 AT&T

American Telephone & Telegraph (AT&T) is the world's largest telecommunications company, the second largest provider of mobile telephone services, and the largest provider of fixed telephone services in the United States.

1) Intelligent networks

AT&T released a software framework called Disaggregated Network Operating System (dNOS) hosted by the Linux Foundation to accelerate the adoption of network white boxes. The dNOS project will provide a software framework to speed up the use of white boxes in service providers' infrastructure to meet requirements of

customers.

AT&T designs an open hardware platform called universal Customer Premise Equipment (uCPE) on which AT&T delivers applications and services to manage enterprise networks in businesses. With this platform AT&T works with developer communities to help the entire industry in the SDN field.

In July 2016, AT&T launched a security intelligence platform called Threat Intellect. The core is an analytics and machine learning program. The analytics part watches everything happening in the network and determines if an unusual activity is worth flagging. The machine learning part means that Threat Intellect is always improving its understanding of what activity is normal.

In 2018, AT&T partnered with China Mobile, Deutsche Telekom, NTT DOCOMO, and Orange to set up the Ohrand Alliance to promote the development of open-source and intelligent network.

On June 27, 2018, AT&T collaborated with 12 telecom operators from all over the world such as China Mobile, SK Telecom, NTT to establish the O-RAN Alliance. The alliance introduces AI and SDN to achieve the intelligent wireless network based on big data.

2) Intelligent services

Smart Home

AT&T launched a smart home product called Digital Life which is designed to meet the demands of the home automation. Digital Life gives users automated control over four features.

- Locks. Users can setup custom passcodes, lock or unlock doors remotely.
- Surveillance. Users can receive notifications whenever someone approaches their home through motion detectors and sensors.
- Energy. Users can control lighting and thermostats to regulate energy usage.
- Water. Digital Life can detect water leaks and automatically shut off pipes.

Call Center

AT&T provides customized call center solutions from AI chatbots and emails to phone calls, IoT and the social media, helping businesses to improve customer relationships and discover new ways of revenue.

3) Intelligent industries

Platform

In 2017, AT&T cooperated with Tech Mahindra to build an open-source AI platform, Acumos, hosted by the Linux Foundation. It makes it easy to build, share and deploy AI applications. The platform provides a marketplace for accessing, using and enhancing those applications.

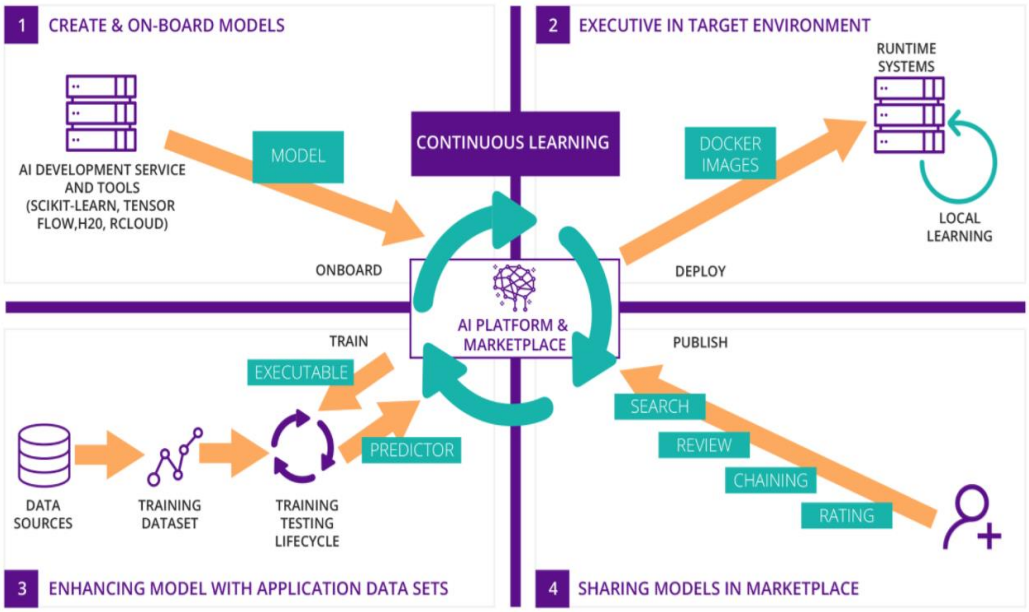

Figure 3-3 Four Stages of AI Development Supported by Acumos

On 2017, the Open Networking Automation Platform (ONAP), as a merger of AT&T's ECOMP project and China Mobile's Open-Orchestrator project, was formed. And the project began under the aegis of the Linux Foundation with China Mobile, Huawei and ZTE as leading contributors. ONAP provides a platform for real-time, policy-driven orchestration and automation of physical and virtual network functions that will enable software, network, IT and cloud providers and AI developers to rapidly deploy new services and support complete lifecycle management.

In February 2018, Akraino Edge Stack, a complete software platform for edge computing systems and applications hosted by the Linux Foundation, was launched. In the project, AT&T has designed carrier-scale edge computing applications running in virtual machines and containers to support reliability and performance requirements.

Smart City

In 2016, AT&T launched a smart cities framework and formed the Smart City Alliance with Cisco, Deloitte, Ericsson, GE, IBM, Intel, and Qualcomm Technologies,

aiming at developing solutions that could help cities address critical issues like high energy costs, transportation, aging infrastructure and public safety.

Smart Medical

In 2018, AT&T developed smart glasses and the “Hey Chloe” medical platform for people with poor vision to read important text such as labels on medication bottles. The platform can help people to correctly identify prescriptions and over-the-counter medications, reducing their reliance on human agents for text recognition tasks.

UAV

AT&T partners with major technological companies including Intel and Qualcomm to bring drones, the machine learning and video analytics together for the cell tower inspections, as well as exploring other drone capabilities. In cell tower inspections, AT&T has a deep learning based algorithm that analyzes video footage and shows promise in detecting defects and anomalies.

IoT

AT&T and CarForce collaborated in the fields of AI and IoT for car dealerships. AT&T's IoT platforms combined with CarForce’s AI and machine learning to help car dealerships better manage car maintenance like predicting car issues before they happen.

3.5 Verizon

Verizon Wireless is an American telecommunications company which offers wireless products and services. It is the largest wireless telecommunications provider in the United States.

1) Intelligent networks

Verizon monitors network stability by using AI-driven technology and responds promptly to faults affecting customer experience in its fiber optic broadband service. The predictive analytics algorithms monitor the streaming from millions of network interfaces from customers’ routers to an array of sensors.

In 2018, Verizon launched a software-defined wireless local area network (SD-WLAN) service which manages both the corporate WiFi network as well as Bluetooth-enabled devices connected to the network. The service is based on Mist Systems’ technologies that include AI and machine learning capabilities. The new SD-WLAN service can automatically monitor and analyze the wireless network and

user data in real time to achieve the network fault prevention and self-healing, as well as to prevent unauthorized terminal to access networks.

2) Intelligent services

On January 15, 2019, Verizon launched an end-to-end management service called Digital Customer Experience (CX) that blends human and AI to enhance the customer engagement experience. Through Digital CX, customers will receive personalized experiences based on their past interactions.

3) Intelligent industries

Platform

On February 23, 2017, Verizon launched the Exponent, a portfolio of platforms providing a broad range of business and technical benefits to carriers. It includes the big data and AI Platform, IoT Platform, the media services platform, the Internet services delivery platform and the cloud computing and storage platform. Exponent's platforms are designed to integrate the flexibility and openness of the Internet technologies with the consistency of carrier-grade solutions in order to leverage the open source software, the comprehensive APIs and micro-services architectures.

Smart City

In 2018, Verizon collaborated with NVIDIA to attach the latter’s Jetson-powered smart camera arrays to street lights in cities. The camera arrays which Verizon calls video nodes use the deep learning to analyze multiple streams of video to look for ways to increase traffic flow and enhance pedestrian safety, making cities safer and smarter.

3.6 NTT

Nippon Telegraph & Telephone (NTT) was founded in 1952. It’s a leading telecom operator in Japan that mainly provides the phone, the video phone, i-Mode, and mail services.

1) Intelligent networks

NTT collaborated with 12 telecom operators all over the world such as AT&T, SK Telecom and China Mobile to establish the O-RAN Alliance. The alliance introduces AI and SDN to achieve an intelligent wireless network based on the big data.

2) Intelligent services

Smart Robot

NTT DOCOMO launched OHaNAS in 2015 that is an interactive voice-activated robot and can engage in interactions by voice in Japanese. The device connects wirelessly smartphones to the natural language platform based on clouds whose proprietary is owned by NTT DOCOMO.

NTT West launched the service robot called “Sota” in December 2016 that interacts with people in English and Chinese. “Sota” is connected to NTT AI platform “Corevo” to get customers’ information such as their nationality and intention. “Sota” also can provide care services for old people.

3) Intelligent industries

Platform

NTT Group launched the “Corevo” AI platform in 2016, which mainly focuses on four directions: “Agent-AI”, “Heart-Touching-AI”, “Ambient-AI” and “Network-AI”. “Agent-AI” is used to understand the intentions and emotions in the information sent by human and interact with people. “Heart-Touching-AI” is used to analyze and understand people's deep psyche, intellect and instincts. “Ambient-AI” is used to analyze and understand the world, and predict some situations. “Network-AI” is used to evaluate and optimize the social system with AI technologies.

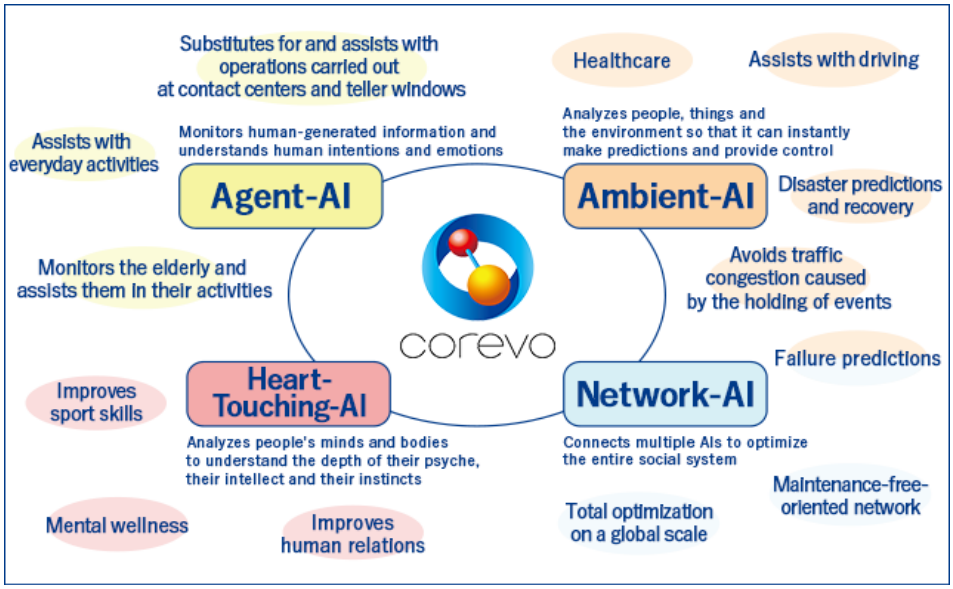

Figure 3-4 Functions of the AI platform “Corevo”

NTT DOCOMO launched its new AI Agent Open Partner Initiative on June 2017 to

facilitate collaborative development for speech interfaces of the service-agnostic and the device-agnostic functions. NTT DOCOMO expects to create an open environment for diverse services that use AI technology.

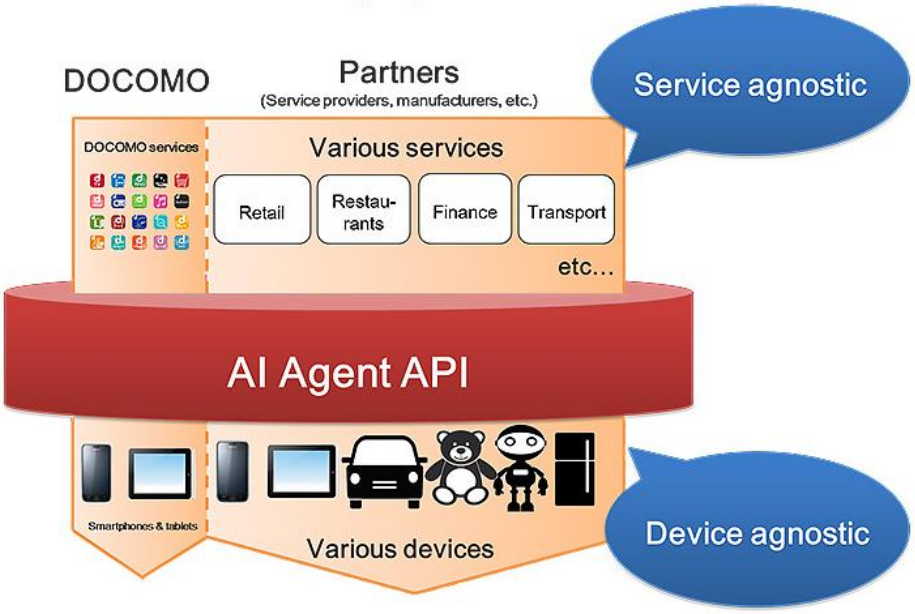

Figure 3-5 Architecture of AI Agent

Smart City

NTT Group expanded its partnership with Dell Technologies to launch the smart city initiatives in 2018. The proof of concept with the Las Vegas is first performed as part of its digital transformation.

Intelligent Security

In 2018, NTT East partnered with the startup Earth Eyes Corp to release a security camera called “AI Guardsman”. It is based on machine learning techniques and gives CCTV cameras the ability to spot troubling behaviors without human supervision. The camera uses open source technology to scan live video streams and estimate the poses of any bodies it can capture and then tries to match this pose data to look for suspicious behaviors.

Intelligent Transportation

NTT collaborated with Toyota Motor on high-speed wireless technology to commercialize safer self-driving vehicles in 2017. The two companies jointly developed technologies for cars utilizing 5G networks.

Smart Retail

In March 2018, NTT DOCOMO launched an AI engine that accurately analyzes shelf allocations in stores and warehouses with photos taken by smartphones and

other common devices. Image recognition and object detection technologies are applied in the engine. It is expected to be used widely in the distribution and retail industries for product-shelf management and sales analysis.

3.7 SoftBank

SoftBank is a Japanese telecom operator and venture capital firm whose businesses mainly include the broadband, the fixed line telephony, the e-commerce and the Internet. Since SoftBank launched the Yahoo! BB service to provide the broadband ADSL services in 2001, it had officially entered the telecom field and become a leading telecom company in Japanese.

1) Intelligent networks

SoftBank partnered with Ericsson to improve the RAN design by using a network automation service in 2018. The technology applies the machine learning and big data analytics to enable automation. Two companies conducted the analysis on the radio network, which includes the cell coverage overlap, the signal strength and the receiving diversity.

SoftBank launched a vacuum robot Called “Whiz” in November 2018 that is powered by AI and is regarded by the company as a potential remedy to Japan's labor shortage

2) Intelligent services

Smart robot

In 2014, SoftBank launched a semi-humanoid robot called “Pepper”. It is designed to interact with customers by analyzing expressions and voice tones with the ability to detect emotions. On August 2018, SoftBank announced that “Pepper” started to use the emotion recognition from a technology company named Affectiva to interpret and respond to human activities.

3) Intelligent industries

Intelligent Transportation

In 2017, SoftBank partnered with Honda launched an electric car called “NeuV”. The car is able to gauge the driver’s emotions and engage in conversations by cameras and sensors in it.

IoT

In December 2017, SoftBank and startup Inuitive Ltd. announced the collaboration on AI and IoT. The collaboration focuses on the pioneering applications of 3D sensor, validating the performance of sensor chips developed newly by Inuitive, and testing solutions that combine Inuitive's AI chips and SoftBank's IoT platforms.

3.8 SK Telecom

SK Telecom, founded in 1984, is the South Korean’s largest wireless telecommunication operator. It is part of the SK Group, one of the country's largest chaebols. SK Telecom is the world’s first operator to implement 3G mobile networks. SK Telecom is also the world’s first operator to commercialize 5G mobile networks.

1) Intelligent networks

In 2017, SK Telecom announced that the company expanded the application of the “T Advanced Next Generation Operational Supporting System”, known as TANGO, to all telecommunications networks of the company. TANGO is an AI-assisted network operation system with big data analytics and machine learning capabilities. The system delivers the automated detection of issues on the network, the troubleshooting of problems, and the performance optimization.

2) Intelligent services

Smart Voice Assistant

In 2016, SK Telecom launched its AI based voice assist service called “NUGU”, which is the first virtual home assistant service that understands and processes the Korean language. Consumers can interact with the device to give it commands such as controlling mobile applications and query information on the Internet.

SK Telecom launched several products based on NUGU like the NUGU mini and BTV×NUGU. BTV×NUGU integrates IPTV set-top boxes and the AI platform NUGU together to control other intelligent devices in home.

SK Telecom with Xilinx Inc. announced that SK Telecom had deployed Xilinx’s FPGAs as their AI accelerators in its data center on August 2018. The FPGAs accelerate the automatic speech-recognition application of NUGU.

Smart Home

SK Telecom launched GiGA Genie in 2017 that is a smart set-top box and can manage IPTV, the Internet phone, IoT and other smart devices.

3) Intelligent industries

Intelligent Transportation

SK Telecom launched an in-car virtual assistant called “T Map×NUGU” in 2017. The AI-based vehicle navigation system enables drivers to access existing navigation functions and real-time traffic information by voice, and to use the voice command to adjust the volume, end the service, close the applications, etc.

3.9 Vodafone

Vodafone Group plc headquartered in London, is a British transnational mobile phone operator. Vodafone is one of the largest mobile communication network corporations, and makes investment around 27 countries. Vodafone collaborates with other 14 countries’ local mobile phone operators on mobile phone network service. The name of Vodafone means Voice, Data, and Phone, which is also its global strategy.

1) Intelligent networks

Vodafone Germany and Huawei trialed the Centralized Self-Organizing Network (C-SON) to identify the optimal settings to deliver voice over LTE services across 450 mobile cells chosen at random. Vodafone Ireland and Cisco use the machine-learning algorithms in C-SON to predict locations where 3G traffic will peak in the following hour. The program predicts the network traffic behavior based on data processing and pattern recognition. The predictions enable the network to configure itself automatically, balance the traffic load among neighboring cells, and improve the customer experience.

Vodafone uses the AI technology from Ericsson and Huawei to reduce incidents, improve fault management, and improve user experience by ensuring the system to automatically choose the best frequency or node for each mobile connection.

2) Intelligent services

Smart Home

V-Home, an intelligent home IoT service, is Vodafone's latest smart home value-added business solution under the premise of the development of the IoT. V-Home aims to let customers know what is happening at home anytime and anywhere.

Intelligent Customer Service System

Vodafone UK has launched an AI chatbot named TOBi. Users can download My Vodafone app or login to Vodafone's website to use TOBi. TOBi is powered by IBM Watson and LivePerson. TOBi can help deal with customer services such as the phone maintenance, the account usage queries, and the order tracking. Vodafone revealed that TOBi can achieve seamless handover. It helps Vodafone to reduce the cost and improve customer service by shortening the responding time of questions.

Vodafone launched a virtual agent "Hani" that uses the intelligent chatbot technology to support and enhance the consumer digital service. Hani answers 80,000 enquiries per month. The staffs in call center use Hani to get accurate and up-to-date information of Vodafone products and services.

Vodafone Italy officially launched "Vodafone Bot", an AI system that provides real-time answers to simple questions of clients.

Intelligent Interview

Vodafone uses AI to interview more than 50,000 applicants for its call center and customer service jobs. After potential applicants recorded their responses in videos to standardized questions, robots analyzed videos based on 15,000 factors. These factors include the body language, facial expressions, and the tone of voice. If applicants pass the AI test, they will be invited to an interview of a real person. Vodafone said that the recruitment time is cut in half and hired people have better "attitude".

3) Intelligent industries

Intelligent UAV

Vodafone developed the world's first Radio Positioning System (RPS) for UAVs. Vodafone's RPS, combined with the AI algorithm developed by itself, can track and monitor a large number of UAVs remotely. A series of experiments were conducted in 2017 and 2018 with the aim of the commercial use in 2019.

Smart City

Vodafone proposes the Ready City project to lay out the global smart city business. On the one hand, Vodafone actively develops its own vertical industry solutions, including the waste management, the smart energy, the smart transportation, and so on. Taking the waste management as an example, Vodafone embedded its M2M SIM card into the garbage bin to help garbage classification and detect whether the garbage bin is full. On the other hand, Vodafone also provides services through the strategic

cooperation with partners, including the smart street lights, the smart water management, the smart parking, and so on.

3.10 Telefonica

Telefonica is a Spanish telecom operator. Telefonica provides services of the fix communication line, the mobile phone, the Internet, the cable TV, and so on. Telefonica has a strong influence in countries that speak Spanish and Portugal.

1) Intelligent networks

Telefonica collaborated with Juniper Networks to develop the Self-Driving Network. The collaboration aims to transform the network infrastructure provided by Telefonica into an automated network that is capable of the automatic discovery, the automatic analysis, the automatic tuning and the automatic correction. Hence, the business development will be accelerated with lowering the operating cost and enhancing security and flexibility.

2) Intelligent services

Intelligent Virtual Assistant

Telefonica announced the launch of Aura that is an AI-powered digital assistant and will transform the way customers interact with Telefonica on February 25th 2018 in MWC Barcelona. Aura will be firstly used in Argentina, Brazil, Chile, Germany, Spain and the United Kingdom.

Smart Home

Telefonica announced the launch of the smart home equipment on February 25th 2018 in MWC Barcelona, Movistar Home, which will integrate Aura’s intelligence into all its services. Movistar Home aims to become a hub where users can connect and manage all the devices in houses.

Smart Notifications

Telefonica launched Smart Notifications on February 9, 2018, an AI or machine learning solution for mobile applications to optimize the delivery of notifications to users. The solution aims to intelligently select the best moment during a day to send notifications when users are most receptive to interactions.

Fourth Platform

Telefonica announced the launch of the ‘Fourth Platform’ at MWC 2017.

Telefonica’s fourth platform is a determined move towards positioning itself as a ‘smart telco’ instead of a ‘dumb pipe’.

3) Intelligent industries

Smart Energy

Telefonica launched the smart energy business. The smart energy offers solutions that enable Telefonica‘s customers to monitor their energy consumption and apply specific savings measures.

Smart Retail

Telefonica launched the smart retail business. It encompasses a set of technological solutions enabling the convention from a conventional physical store into an interactive point of sale, which meets the digital revolution. It also provides retailers with the necessary tools to obtain detailed information of their business and customers, increasing their sales and operating processes.

Smart Transportation

Telefonica launched the smart transportation business, Smart Mobility. Smart Mobility includes solutions for the fleet management, the asset tracking, the car connection, etc., making the transportation of goods and people more efficient and safe.

Smart City

Telefonica launched the smart city business. The smart cities platforms can gather information from different sources such as sensors, city council's systems or citizen's smartphones. It contributes to the development of a sustainable city by improvements in environmental and economic efficiency.

3.11 Orange

Orange is headquartered in Paris. It is the first mobile operator in Britain and France, and one of the largest telecom operators in Europe. The main services are the mobile, the landline, the Internet and IPTV.

1) Intelligent networks

Orange revealed an AI research project in detail with IBM and Nokia that could predict demand patterns in future for 5G networks and avoid the "overprovisioning" of network resources.

Orange is actively promoting the digital transformation of network. It involves the improvement of the quality of the network services by introducing AI technology in the network optimization and SDN/NFV, and the process of the video content with AI technology.

Orange launched a security and anti-fraud solution that consists of four steps: statistics, detection, protection, and notification. The statistical step provides an in-depth analysis report on potential or known vulnerabilities. The detection step is to monitor threats in real time. The protection step intervenes and intercepts cheating in real time. The notification step is to send a security report to users.

2) Intelligent services

Smart Home

Orange France launched Homelive, a smart home solution that combines its own smart home product, Livebox, to form a small but rich ecological closed loop.

In spring 2019, Orange will launch the “Connected Home” service in France. This service will make it possible to directly connect objects to Livebox and manage them remotely through a single application accessible via a smartphone or a TV.

Intelligent Virtual Assistant

Djingo is the intelligent assistant from Orange that can be controlled by voice or text. It offers an easy and intuitive way for users to watch the Orange TV, manage connected devices, make a call, etc.

Smart Speaker

Orange developed a smart speaker with Deutsche Telekom based on Djingo. The smart speaker is voice-controlled and is the interface for all Orange services. So, it becomes a telephone to make hands-free calls at home and it can be used to interact with Orange TV and to control all the “Connected Home” services.

3) Intelligent industries

Smart Agriculture

Researchers of Orange Labs are working on a business AI solution in collaboration with pig farmers in Brittany to digitize the farming data, aiming to help farmers produce better quality meat at a lower cost.

Orange Business Services, which is a subsidiary of Orange and specializes in IT solutions services, applies Huawei's AI technology to wineries. The vineyards are

managed intelligently by monitoring pests and diseases with data from satellites, cameras and sensors on agricultural machinery.

VR/AR

Orange with partners launched the AR/VR product called Holotenins. It provides an immersive experience for people equipped with VR headsets.

Orange launched a virtual tour service called Look Around. It offer users a touring experience of virtual immersion with technologies of AI, the 360-degree immersion, the big data, and so on. It is also a smart assistant able to answer visitor's questions about the destination.

3.12 Deutsche Telekom

Deutsche Telekom, headquartered in Bonn Germany, is the largest telecom operator in Europe and the fifth largest in the world. “T” is the brand sign of Deutsche Telekom and other global subsidiaries such as the famous T-Mobile and T-system.

1) Intelligent networks

Deutsche Telekom is breaking new ground in its fiber optic roll-out, becoming the first network operator in Europe to plan a pilot project using AI. The pilot will be carried out with the help of a special vehicle that gathers precise data about the environments via various sensors and laser-scanning technology. The data will be translated into georeferenced 3D image data. The system learns to recognize landscape features, such as houses, grass, trees. The system is also able to incorporate available reference data such as street maps. As a result, it can rapidly produce precise proposals for ideal routes for subterranean cables. The project is being carried out in cooperation with Fraunhofer.

Deutsche Telekom unveiled an application names CONNECT to find the best available Internet connection. There are various ways to connect to the Internet, 3G, 4G, hotspots or Wi-Fi with different price, thus, it is not easy for users to choose the best way of the Internet connection. Although some users do not care the way to connect the Internet, the majority of users are affected by price, the network speed and security. Manually changing connections is inconvenient. The CONNECT app uses the machine learning technology to help users choose the “Best connection” or the “WiFi preferred”, as well as gives customers a full control of the high speed and cost. It provides a fast access to the Internet with high security. An integrated VPN

encryption enhances the data privacy when the public Wi-Fi networks are chosen.

2) Intelligent services

Smart Home

Deutsche Telekom has launched a smart home business platform, Qivicon. It mainly provides back-end solutions, including smart home terminals for users and the integrated software development and maintenance platform for enterprises.

Intelligent Virtual Assistant

Deutsche Telekom launched a chatbot acting like a virtual employee, Tinka, aiming to assist customers in Austria at any time of a day. Tinka is an icon of a young woman with long hairs. She has learned over 1,500 answers. If she can’t answer the questions, she will forward it to a customer service agent. Connecting customers to customer service agents is one of her strengths. If the agent is not available right now, she will recommend customers send emails to the agent. Besides, the company owns other virtual assistants including the Sophie and Vanda.

Smart Speaker

Deutsche Telekom plans to begin offering its customers the Smart Speaker, an intelligent personal digital assistant. The Smart Speaker is able to manage all connected devices in users' home by voice commands, including Deutsche Telekom's EntertainTV and the Magenta Smart Home applications. Therefore, operations like changing channels, dimming lights and adjusting room temperature can be done through voice.

Intelligent Recruitment System

Deutsche Telekom uses the hub:bot, an AI-supported chatbot designed by its startup incubator Hub:raum, to improve job seekers’ experience and efficiency in the interview. The hub:bot can answer applicants’ questions immediately and is available 24*7. It saves applicants’ time on making appointments and waiting for the responds. The hub:bot also enhances the efficiency of recruiters by help them weed out applicants who are completely unfit for the job.

3) Intelligent industries

Smart City

Deutsche Telekom unveiled a new smart city app and announced a new smart city platform. The platform will facilitate residents to access data about the city, including

sightseeing opportunities, the location of Wi-Fi hotspots and taxi stands, as well as the waste collection time.

3.13 Singtel

Singapore telecommunications limited, abbreviated as Singtel, is the Singapore's largest telecom operator which has 640 million users. Singtel provides the network service (SingNet), the IPTV service (Singtel TV), the mobile phone networks (Singtel Mobile) and the fixed line telephony services.

1) Intelligent networks

On June 27, 2018, Singtel collaborated with 12 telecom operators from all over the world such as China Mobile, SKT&T, NTT to establish the O-RAN alliance. The alliance introduces AI and SDN to fulfill the intelligent wireless network based on big data.

2) Intelligent services

Smart home

In August 2018, Singtel showcased technologies for the smart home which include the home system controlled voice and IoT for consumers. All functions are managed seamlessly through Singtel's smart platform FIC.

3) Intelligent industries

Platform

In August 2018, Singtel launched its FutureNow Innovation Center (FIC) platform to support the government and enterprise's digital transformation. FIC applies AI, SDN, data analytics and other emerging technologies, and serves as a platform for technology partners to perform collaboration and innovation.

Smart Retail

In August 2018, Singtel established an innovation center with Chinese smart retailer Comma Smart, expanding the smart retail market in Singapore with the help of AI technologies.

Others

In December 2017, Singtel collaborated with Nanyang Technological University and Singapore's National Research Foundation to set up Singtel Cognitive and Artificial Intelligence Lab for Enterprises (SCALE), which focuses on the research of

AI technologies, big data and IoT. The lab also develops industrial applications such as the pubic security, the transportation, and the health care in next five years.

In December 2017, Singtel signed a five-year Master Research Collaboration Agreement with Singapore Agency for Science, Technology and Research. The agreement announces that both will jointly research smart buildings, robots and IoT applications. Singtel also will test these new technologies in scenarios of 5G and NB-IoT in its Advanced Remanufacturing and Technology Centre.

On June 29, 2018, Singtel signed the memoranda of understanding (MOU) with National Supercomputing Center (NSCC) Singapore, Nanyang Technological University and Chinese corporation SenseTime. The collaboration aims to promote AI technologies and research solutions for the demand of the industrial development in Asia.

Singtel is the largest telecom operator that participates in Singapore National Research Foundation (NRF)'s AI project called "AI.SG", aiming to promote the development of domestic AI technologies. The project gathers AI research institutions, technology firms and industry companies together to build AI knowledge base, develop advanced products and cultivate AI talents. In August 2018, AI.SG introduced two AI plans, "AI for Everyone" (AI4E) and "AI for Industry" (AI4I), to energize industries with AI technologies.

3.14 Bharti Airtel

Bharti Airtel limited, an Indian company of telecom services, is the largest local mobile network operator in India and the third largest in the world in the aspect of subscriber count. The company's products include 2G, 3G and 4G wireless services, the mobile commerce, the fixed line services, the high speed home broadband, DTH and enterprise services.

1) Intelligent networks

In September 2017, Bharti Airtel announced that they start to expand TANGO, an AI-assisted network operation system with big data analytics and machine learning capabilities developed by SK Telecom on mobile networks to improve the customer experience.

2) Intelligent services

On November 8, 2017, Bharti Airtel announced a strategic partnership with software solutions provider Amdocs to bring AI-based services to its customers in India. Both partners will apply the machine learning and advanced AI-based technologies across Bharti Airtel's businesses. It helps Bharti Airtel to deal with the self-healing operations and introduce smart chatbots.

On October 3, 2018, Bharti Airtel acquired the intellectual proprietary rights for the Callup AI and the Fintech OCR, two flagship solutions developed by a Bengaluru-based start-up AuthMe ID. The Callup AI is a voice/chat assistant that uses AI to resolve customer queries over emails, chats and phone calls. The Fintech OCR is designed for processing financial documents.

3) Intelligent industries

On July 10, 2017, Bharti Airtel launched "Project Next". This project is a digital innovation program, aiming at transforming customer experience across all of its services and touchpoints. Bharti Airtel also set up a digital innovation lab in Bengaluru to work on emerging technologies such as AI, IoT, AR/VR as part of its broader strategy to develop technology capabilities.

4 Discussions about AI Applications in Telecom Operators

4.1 Intelligent networks

The typical researches and results of telecom operators in the intelligent network are as follows.

Table 4-1 Typical Researches and Results in Intelligent Networks

Classification	Telecom Operators	Typical Researches and Results
Current network	China Mobile	ACOS, APOS, AIOps.
	China Unicom	AR intelligent operation and maintenance system
		Awareness & Analysis system for network situational
		AI applied in Roots-tracing of Network Alarm
	AT&T	disaggregated Network Operating System (dNOS)
		universal Customer Premise Equipment (uCPE)
		Threat Intellect platform for network security
	Verizon	SD-WLAN service based on AI system Mist
	SK Telecom, Bharti Airtel	T Advanced Next Generation Operational Supporting System (TANGO)
	Vodafone	Analysis and prediction for Centralised Self-Organising Network (C-SON)
	Orange, Deutsche telekom	AI in network optimization, fault detection, etc.
Future network	China Mobile	NovoNet network architecture
	China Unicom	CUBE-Net 2.0+ network architecture
	China Telecom	CTNet2025 network architecture
	Orange	AI in SDN/NFV and 5G network resource allocation
	Deutsche telekom	AI in SDN/NFV
Alliance	China Mobile,	O-RAN

	AT&T, SK Telecom and 9 more operators	
	China Mobile, AT&T, Deutsche Telekom, NTT , Orange	Ohrand

The use cases above show that the intelligence is more and more urgent for the development of network. Following this tendency, operators conduct researches and cooperation to make networks intelligent.

Regarding applications of AI in the current network, operators' concentrations mainly are the intelligent operation and maintenance, and the intelligent optimization. AI technologies have helped operators to monitor the network status in real time and enabled the network to adapt to different business scenarios through self-regulation.

The exploration for application of applying AI in the future networks such as SDN/NFV and 5G is under way. At present, SDN/NFV is being deployed, and 5G will be in commercial use. The introduction of AI will probably solve many problems for the future networks like reconfiguration.

Telecom operators also cooperate to take their own advantages, and form numbers of alliances or groups to research the intelligent network. For example, the O-RAN Alliance established by China Mobile, AT&T and 10 other operators, introduces AI and SDN to make the wireless network intelligent. The Ohrand Alliance established by NTT, Orange and 3 other operators, promotes the development of the open-source and intelligent network.

4.2 Intelligent Services

The typical researches and results of telecom operators in intelligent services are as follows.

Table 4-2 Typical Researches and Results in Intelligent Services

Intelligent Services	Telecom Operators	Typical Researches and Products
Smart Home	China Mobile	China Mobile Digital Home Alliance (CMDA)
	China Unicom	Smart speakers, IPTV set-top boxes based on

		the voice and gesture interaction
	China Telecom	The smart speaker “Xiaoyi”
	AT&T	The smart home product “Digital Life”
	Vodafone	The intelligent home IoT service “V-Home”
	Telefonica	The smart home equipment “Movistar Home”
	Orange	The smart home solution “Homelive”
	Deutsche Telekom	The smart home platform “Qivicon”
Customer Services	China Mobile	The interactive robot “Yiwa”
	China Unicom	The business-driven adaptive network The energy-saving system based AI for data centers
	China Telecom	The intelligent customer service robot “Xiaozhi”
	Verizon	The end-to-end service Digital Customer Experience (CX)
	NTT	The service robot “Sota”, the interactive robot “OHaNAS”
	Softbank	The interactive robot “Pepper”
	SK Telecom	The voice assist service speaker “NUGU”
	Vodafone	The intelligent customer service robot “TOBi”, ”Hani”, and “Vodafone Bot”
	Telefonica	The intelligent assistant “Aura”
	Orange	The intelligent assistant “Djingo”
	Deutsche Telekom	The intelligent assistant “Tinka”, “Sophie” and ”Vanda”
Call Center	China Unicom	An intelligent voice outcall service system
	AT&T	AI chatbots

The use cases above shows that operators are actively promoting intelligent services. The researches and products mainly focus on the smart home and the intelligent customer service.

For smart home, operators develop and promote smart terminals based on AI technologies since they have advantages of accessing home customers. The products

such as the smart speaker and the smart set-top box are considered as the entrance of the smart home for telecom operators.

For the intelligent customer service, telecom operators use AI technologies such as the speech recognition and the natural language processing to develop the voice assistant, achieving the interaction between customers and chatbots. The voice assistant saves a great deal of labor costs.

4.3 Intelligent industries

The typical researches and results of telecom operators in the intelligent industries are as follows.

Table 4-3 Typical Researches and Results in Intelligent Industries

Intelligent Industries	Telecom Operators	Typical Researches and Products
Platform	China Mobile	The AI platform “Jiu Tian”
	China Mobile , AT&T	ONAP
	China Telecom	The AI platform “Deng Ta”
	AT&T	The open source AI platform “Acumos”
		The edge computing platform “Akraino Edge Stack”
	Verizon	A portfolio of platforms “Exponent”
	NTT	The AI platform “Corevo”
		The AI Agent Open Partner Initiative
	Singtel	The AI platform “FutureNow Innovation Center (FIC)”
Smart City	China Mobile	The “Super-brain” plan for Xiong’an city
	China Unicom	The overall responsibility for the smart Xiong’an project
	Verizon	Video nodes for the smart city
	Vodafone	The “Ready City” project
	Deutsche Telekom	The One Smart City App (OSCA)
Smart Government	China Unicom	The “XueLiang Project”

	China Telecom	The nterprises platforms “Ma Shang Ban” and “Zhi Cha”
Smart Agriculture	China Telecom	The smart agriculture platform for tracing agricultural products
	Orange	The AI solution for pig farms and wineries
Intelligent Transportation	China Mobile	The smart vehicle terminal “Helutong”
	Softbank	The electric concept car “NeuV”
	SK Telecom	The in-car virtual assistant “T Map×NUGU”
	Telefonica	The transportation service “Smart Mobility”
Smart Retail	NTT	The AI engine for the shelf allocation analysis
Intelligent Security	NTT	The security camera “AI Guardsman”
Intelligent UAV	China Unicom	The world’s first UAV testing flight based on 4G
	AT&T	UAV for cell tower inspections
	Vodafone	The world's first radio positioning system (RPS) for UAVs.
Intelligent Medical	China Unicom	The Internet of the medical and clinical decision-making system based on 5G

The use cases above show that telecom operators are using the AI technology to expand businesses in vertical industries. On the one hand, telecom operators develop AI platforms to integrate the network capability and the AI applications in order to comprehensively enhance the management ability and the service ability. On the other hand, telecom operators set to develop core technologies of AI and extend their business fields to vertical industries. The results show that telecom operators are providing the integrated digital services to customers in the fields of agriculture, transportation, retail, security and medical treatment.

5 Suggestions for Applying AI to Telecom Operators

At present, applications of AI technology in telecom operators are only in its infancy, but it has bright prospects in many fields. It is a great opportunity for telecom operators to deploy AI in platforms, networks, services and industries.

1) Build an Open Platform with AI Capabilities

Telecom operators should integrate their data with computing capabilities and introduce AI technologies to build an open platform with AI capabilities and form an integrated service capability.

2) Develop an Intelligent Network

Telecom operators should make full use of the powerful capabilities in analysis, judgment and prediction provided by AI algorithms to enable network elements, networks and business systems. For 3G, 4G and other existing communication networks, the AI technology is applied to the aspects of the planning, the design, the construction, the maintenance, and the optimization for networks in order to improve efficiency and reduce cost. In future networks such as 5G, SDN/NFV and the edge cloud, the AI technology is applied to the network management to meet the challenge of the increased network complexity.

3) Improve Service Quality

Telecom operators should take their advantages of data and AI technology to develop the intelligent customer service system, the smart business hall, the smart home and other service applications, enhancing customer service quality, reducing labor costs and improving the user experience.

4) Expand Diversified Industries

Telecom operators should pay attention to scenario-driven applications, explore AI applications in the medical industry, the financial industry, the retail industry, the education industry, the home industry, the manufacturing industry and other industries, launch AI solutions in various fields, and enhance business competitiveness.

In summary, the development of applications of AI technology to telecom operators will progress in both internal and external directions. The internal application of the AI technology aims to improve the network quality and achieve reduction in cost and increment in efficiency. Regarding the external aspect, building the AI industry chain by cooperation between businesses becomes the focus for telecom operators.

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