Building all-scenario intelligence with our partners
Intelligent Twins
Won the Prize for World Leading Technology at 2020 World Internet Conference

Intelligent Twins, the industry's first systematic reference architecture for the intelligent upgrade of governments and enterprises. Won the Prize for World Leading Technology at 2020 World Internet Conference. This is the fifth consecutive year Huawei has been awarded the prize.
In 2020, the first wave of high-speed, low-latency 5G networks were deployed. Mature cloud computing capabilities made computing power and AI capabilities as accessible as water and electricity. And the integration of massive amounts of AI-powered data, computing power, and industry know-how forged new service experiences, industry applications, and industry types.

Synergy and innovation across five tech domains – 5G, cloud, AI, computing, and applications – have made all-scenario intelligence possible and accelerated the deployment of intelligence by businesses and industries.

Huawei is working with its partners to build all-scenario intelligence in city, enterprise, and industry scenarios. Integrating technologies such as 5G, cloud, AI, and computing with industry expertise will power a range of smart applications for improving urban governance, quality of life, and business efficiency and innovation.

All-scenario intelligence will perceive every corner of cities, enabling the shift from centralized management to scenario-based services. Companies will have a more open environment for innovation and new ecosystems. And city residents will be able to enjoy more convenient urban services.

Based on our goal to build all-scenario intelligence with ubiquitous cloud and intelligence, Huawei has released the industry’s first systematic technological reference architecture to build intelligent governments and enterprises: Intelligent Twins. Intelligent Twins will enable customers and partners to build their own intelligent solutions for any scenario.

We’re already partnering with Shenzhen, Chengdu, Fuzhou, and Nanchang cities to build Intelligent Twins solutions, covering areas such as governance, transportation, power, manufacturing, and environmental protection. Solutions include a self-service facial recognition system in Shenzhen Bao’an Airport, a smart industrial park in Sichuan, a big data platform for the Fuzhou government, and Ganpo Data Lake in Jiangxi province.

An open ecosystem is the key to developing Intelligent Twins. Software and service ecosystems coupled with edge computing ecosystems will spawn a wealth of opportunities for industries. And we will continue working with our customers and partners to build unique Intelligent Twins for different cities, enterprises, and industries and drive the era of all-scenario intelligence forward.
“All-scenario intelligence” will define the future. We asked the experts how they define that future.

Integration
Wu Hequan, Academician, Chinese Academy of Engineering

All-scenario intelligence needs to integrate multiple types of next-gen IT, like 5G, AI, big data, blockchain, IoT, and Industrial Internet. All-scenario intelligence will come as a result of technological integration.

Harmony
Li Bohu, Academician, Chinese Academy of Engineering

Building digital, networked, and cloud-based all-scenario intelligence will enable city systems that are harmonious, safe, efficient, livable, and green. That in turn will require ubiquitous networks and the deep integration of four new technologies: city service systems, ICT, intelligent technology, and system engineering.

Inclusiveness
An Hui, Deputy Chief Engineer, China Center for Information Industry Development (CCID)

The digital divide is a concern for many around the world, but all-scenario intelligence will bridge this divide. I hope everyone, everywhere can benefit from intelligent technology – young and old, urban and rural.
The steam engine, electricity, and computers and IT powered the first three industrial revolutions, respectively. Today, digital technologies like IoT, big data, and AI are driving the Fourth Industrial Revolution. The convergence of 5G, cloud, AI, and computing will make all-scenario intelligence possible.

So, what is all-scenario intelligence and what kind of blueprint does it lay out?

We asked the experts for a keyword that sums up the concept.

Vision

Wen Xiaojun, Director, Electronic Information Research Institute, CCID

All-scenario intelligence is a higher form, even the ultimate vision, of the intelligent development of society. The three driving factors behind it are technology leadership, advancements in industrialization, and market demand built on scenario-based requirements. This "three-wheel" driver will lead to all-scenario intelligence.

Evolution

Wang Xiaoning, General Manager, Digital Transformation Research Center, CCID Consulting

All-scenario intelligence is a process in which social and technological development are symbiotic. It’s a gradual evolutionary process that’s taking place alongside the fourth technological revolution.

Times are changing
And powerful forces are driving us forward

Huawei believes that all-scenario intelligence is the chain reaction of innovation, integration, and industry know-how, with technologies such as 5G, cloud, AI, and computing in city, enterprise, and industry scenarios

It will improve urban governance
improve quality of life
boost enterprise efficiency
and strengthen industry innovation

A technological revolution is coming, all-scenario intelligence is accelerating
Are you ready?

Let’s build all-scenario intelligence together
Building all-scenario intelligence with our partners
Intelligent Twins provides a new reference architecture for enterprises and governments to deploy all-scenario intelligence.

Inclusive AI: Growing with developers
A look at our cutting-edge tools that can empower developers to create intelligent apps.

Knowledge computing for enterprise AI
AI is at the core of Huawei's Intelligent Twins reference architecture – we believe that AI knowledge computing will transform how knowledge is used.

Powering all-scenario AI with hybrid cloud
Computing: The engine of Intelligent Twins

Building smart cities with Intelligent Twins
5G, cloud, and AI are the three key elements of new infrastructure. Find out how they form the engine of smart cities through Intelligent Twins.

Powering industry
Intelligent Twins with upgraded connectivity
Thinking ahead: Intelligent IP networks for IPv6+
Cutting Edge

Exploring the four-layer architecture of Intelligent Twins
Intelligent Twins reduce the barriers to AI development and can help supercharge the intelligent application ecosystem.

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Building a network brain for enterprises with Autonomous Driving Networks
Building 1-ms E2E latency to support City Intelligent Twins

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Expert Forum

ModelArts 3.0: A true AI accelerator
Tian Qi, Chief AI Scientist at HUAWEI CLOUD, talks about our long-term research into AI and explains ModelArts 3.0 – our one-stop AI development platform.

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From physical to digital: Building intelligent infrastructure with digital twins

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How to Operate

The many benefits of the Shenzhen Intelligent Twins
5G, cloud, AI, and computing form the Shenzhen Intelligent Twins – a city-wide solution that’s creating a model for improving urban life.

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Our digital transformation journey explained
What can enterprises learn from our digital transformation experiences?

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Unlocking AI for enterprises with HUAWEI CLOUD Stack

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How Intelligent Twins are transforming cities

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Building all-scenario intelligence with our partners

At HUAWEI CONNECT 2020, Huawei announced its Intelligent Twins solution, the first systematic reference architecture for governments and enterprises to deploy intelligence.
Intelligent Twins enable Huawei’s customers and partners to build their own intelligent solutions to give people, cities, and enterprises smarter experiences in all scenarios. Comprising four layers – intelligent interaction, intelligent connection, intelligent hub, and intelligent applications – the solution forms a system for collaboration across cloud, network, edge, and device resources. As ICT evolves and matures, the synergy and collaboration across five tech domains – 5G, cloud, AI, computing, and industry applications – is accelerating the intelligent upgrade of governments and enterprises, creating new value. This value is most noticeably seen in:

• Reconstructed user experiences, for example, access to public transportation using QR codes, expressway free-flow toll systems, and access to airports and unmanned supermarkets using facial recognition.

• Optimized processes such as AI-assisted CT diagnostics for COVID-19, AI-accelerated drug screening, AI-enabled synthetic fiber inspection from spot checks to full checks, and AI-powered smart contract review.

• Additional industry innovation. We’ve already seen how drones can leverage collaboration between cloud, 5G, AI, and edge to achieve unmanned, automated smart inspection in essential city facilities like power grids, mines, and ports.

This new value shows industries that intelligent upgrades are key for enterprises and industries that want to become more competitive. Enterprises encounter a range of challenges when deploying intelligence, which is often due to a large number of devices and connectivity requirements, the coexistence of legacy and new IT applications, and a shortage of AI talent. Huawei launched the Intelligent Twins to address these challenges by achieving synergy across five tech domains.

The four-layer architecture of Intelligent Twins

By applying AI on top of cloud services to coordinate collaboration across cloud, network, edge, and device, Intelligent Twins enable an intelligent, open system capable of all-dimensional perception, all-domain collaboration, precise judgment, and continuous evolution. The Intelligent Twins architecture consists of four layers:

Intelligent interaction

This layer is like the hands and feet of Intelligent Twins. It connects the physical and digital worlds, allowing software, data, and AI algorithms to flow freely across cloud, edge, and device resources. The intelligent interaction layer uses Huawei’s Intelligent EdgeFabric (IEF), an operating system that
works on edge and cloud resources, to make Intelligent Twins perceptive and actionable. IEF can interconnect with various operating systems, including HarmonyOS, to connect them to HUAWEI CLOUD. KubeEdge, the very core of the IEF, is open source and has contributed to the Cloud Native Computing Foundation (CNCF). With more than 500 core contributors, KubeEdge has been widely adopted in various industries.

**Intelligent connection**

This layer is the trunk of Intelligent Twins, connecting the intelligent hub and intelligent interaction layers. Physical connections, such as 5G, help Intelligent Twins cover all scenarios, connect all things, and achieve collaboration between applications, data, and organizations. Using intelligent connections, HUAWEI CLOUD's ROMA platform promotes collaboration between applications and data, revitalizes legacy applications and data assets, and allows data to flow freely and be shared easily between legacy and new applications. All applications can now run on the same network, and data can be utilized across the whole platform. In addition, the HUAWEI CLOUD WeLink platform can enable collaboration between people and organizations, allowing employees, customers, and partners to enjoy the new Intelligent Twins experience.

**Intelligent hub**

This layer is the brain and decision-making system that runs Intelligent Twins. It runs on hybrid clouds that enable applications, data, and AI. During an intelligent upgrade, many
customers want to access rich, advanced services, but also require local deployment to avoid impacting O&M procedures and to ensure security and regulatory compliance. Neither traditional private cloud nor public cloud solutions can fully meet these requirements.

That’s why Huawei is committed to providing a hybrid cloud solution that truly meets government and enterprise requirements. The HUAWEI CLOUD hybrid cloud solution can provide public cloud capabilities but can also be deployed locally. From mixed resources to hybrid capabilities, the solution is aligned with each organization’s architecture and service processes, implementing a single cloud from the user perspective.

AI enablement is at the core of Intelligent Twins. For AI to be applied in numerous industries and create great value for them, it must be fully integrated with industry know-how. HUAWEI CLOUD’s AI enablement capabilities make AI application development easier.

Intelligent applications

This layer is where we see the best showcases of the value Intelligent Twins bring. Huawei works together with customers and partners to create new user experiences, optimize processes, and enable innovation. It’s crucial that business departments, IT departments, and partners are all deeply involved in this process. Only by focusing on the issues and scenarios that business department faces can we easily build more valuable intelligent applications.

Intelligent Twins are an integrated system that leverages synergies across five tech domains and integrates cloud, network, edge, and device resources. It is perceptive, conscious, actionable, and evolvable.

It is clear that the integration of cloud, network, edge, and device is important. For weather forecasts in Shenzhen, for example, HD cameras deployed throughout the city transmit image data about current weather conditions to the cloud through 5G in real time. The data from each district is then combined and correlated with the data collected by radar, and AI is used to accurately forecast the weather for the next four hours. At the same time, models trained on cloud are sent to the edge to enable the cameras to recognize drizzle, fog, and other subtle weather changes in real time. Intelligent weather applications can be provided through the integration and collaboration of cloud, network, edge, and device. Residents use their mobile phones to keep track of weather changes within a 1 km radius of where they are and make travel plans accordingly.
This example shows that an intelligent system based on the integration of 5G, cloud, AI, and smart edge can create cutting-edge intelligent experiences for all sorts of industries.

**Intelligent Twins adoption by Huawei and in other industries**

Intelligent Twins have already been adopted in numerous industries, and Huawei itself has explored application scenarios for the Intelligent Twins architecture through its own digital transformation journey. To date, Huawei has connected more than 6 million interactive devices including cameras, smart screens, and sensors through IEF, bringing intelligence to the edge. It has made Wi-Fi 6 and 5G connections available on all its campuses for nearly 200,000 Huawei employees and millions of partners and customers through HUAWEI CLOUD WeLink. All Huawei's resources and data have been converged on HUAWEI CLOUD, and it provides IT capabilities for customers as services through the cloud. Huawei has also applied AI to more than 200 scenarios across all of its own major business processes, including sales, R&D, manufacturing, and supply, creating more than 8,000 digital employees.

Huawei operates in more than 170 countries and regions and has 190 central product warehouses. With Intelligent Twins, Huawei has introduced AI to every part of its product supply process. This has shortened Huawei's order fulfillment cycle by 76 percent, cutting costs by over 7 billion yuan (US$1.07 billion) in 2019 alone. For example, in product packing and distribution, which involves more than 80,000 types of packaging and over 30 vehicle models, an AI sorting algorithm increases the vehicle load rate, saving nearly 100 million yuan (US$15.47 million) in costs a year. Huawei has packaged capabilities, such as cloud-based services, and made them available to all industries.

Outside Huawei, more than 600 projects in different industries have also adopted or explored the use of Intelligent Twins. The free-flow expressway toll project in China is one such example. Over 9,400 toll booths and 80,000 expressway lanes were renovated across China to connect them to a single national expressway network, opening up a new era of perception-free toll-booth access. Another example is Yongfeng Steel Corporation, where AI and industrial mechanisms have been integrated to increase the accuracy of intelligent steel ratings to over 95 percent. This is hundreds of times more efficient than manual rating.

**Co-creating an open and shared ecosystem**
Intelligent Twins are created in an open ecosystem. A thriving software and service ecosystem and edge computing ecosystem are crucial to the intelligent upgrade of governments and enterprises. These ecosystems present enormous opportunities for new industries.

Over the next five years, the global software and service market will reach US$1 trillion, and the industry is increasingly trending towards cloud-based software and SaaS. HUAWEI CLOUD has positioned itself as a neutral cloud service provider that opens up its application software and service ecosystem. It enables applications, data, and AI to boost SaaS adoption and intelligent upgrades. By providing the best SaaS development and operations platform, Huawei wants to help its partners achieve business success and shape a sustainable software and service industry.

The global edge computing market will reach US$500 billion over the next five years. HUAWEI CLOUD’s edge ecosystem will be fully open, to give partners’ devices free access to Intelligent Twins through IEF and the HarmonyOS ecosystem. This access will help them enjoy the benefits of upgrading with intelligence.

Huawei is ready and willing to work with partners to create a thriving ecosystem, expand the market, and enable industrial intelligent upgrades. We believe that Huawei’s success can only be defined by the success of our customers and partners.
Inclusive AI: Growing with developers

At HUAWEI CONNECT 2020, HUAWEI CLOUD announced a series of initiatives to support global developers, including easy-to-use development tools, technology enablement services, and business support programs for SaaS and HMS partners. HUAWEI CLOUD also launched ModelArts 3.0, a one-stop development platform for accelerating AI implementation across a range of industries.

Zheng Yelai
President, Cloud BU, Huawei
In recent years, industries have become eager to go digital, always online, and intelligent. Governments and enterprises are moving beyond the digital era to the intelligent era. In 2016, Huawei anticipated the coming of the Cloud 2.0 era characterized by cloud-native Internet and the migration of government and enterprise applications to cloud. This has created an enormous market for developers, enabling them to create value in their own unique ways. Most developers face three challenges:

First, they expect easy-to-use development tools and one-stop development processes for greater agility when developing applications.

Second, they must be able to quickly obtain new technologies and utilize existing industry know-how to build innovative industry applications.

Third, they find it difficult to translate technological innovation into commercial success. Internet application developers require more distribution channels and sources of traffic. Meanwhile, government and enterprise application developers are facing changes in terms of the way benefits are distributed, as SaaS expands the market beyond short-tail users to medium- and long-tail users.

How can developers adapt to these changes and gain greater business value? Huawei believes the answer is development on the cloud.

**HUAWEI CLOUD: Striving to become the best platform for building applications**

HUAWEI CLOUD was established three years ago with three key aspirations: First, to monetize Huawei's R&D investment in ICT through cloud services. Second, to provide customers with cloud services as a representation of the capabilities Huawei has accumulated over the past 30 years. And third, to provide a cloud foundation that can support Huawei's own global business development, including the company's device cloud services and internal IT systems.

After three years, HUAWEI CLOUD has made tremendous progress. Over 1.5 million developers have been part of HUAWEI CLOUD, which has launched over 210 cloud services and more than 210 solutions that serve customers worldwide.

Looking to the future, Huawei will strive to become the best platform provider for building applications that serve as the foundation of the intelligent world. We aim to become a trusted partner for software development companies in China.

HUAWEI CLOUD will provide
developers with a range of simplified tools and templates to make development more efficient. It will also provide three types of technology enablement services – application enablement, data enablement, and AI enablement – supported by a huge amount of industry know-how and asset models, helping developers flexibly respond to changing market demands.

HUAWEI CLOUD is determined to help developers achieve commercial success. It will provide strong application distribution capabilities and leading business support programs. This will give developers access to abundant cloud resources and traffic and create opportunities for them to exchange and collaborate with top enterprise accelerators and incubators. HUAWEI CLOUD will offer developers the best opportunity to grow, succeed, and accomplish great things.

Business incubation accelerates business success for developers

HUAWEI CLOUD Marketplace is an application distribution platform oriented towards government and enterprise users. Its annual turnover has surpassed 1 billion yuan (US$153 million) with more than 100,000 orders. The sales of 30 partners on this platform have exceeded 10 million yuan.

Many promising startups are growing rapidly in the HUAWEI CLOUD Marketplace. CurrentCAD, a new online computer-aided design (CAD) software provider, started offering services in early 2019. After joining HUAWEI CLOUD Marketplace, its sales increased sixfold in one year to exceed 10 million yuan.

HUAWEI CLOUD launched a SaaS application support program to assist more startup development companies. The program will support 1,000 SaaS applications in the initial phase, providing each with 200,000 yuan worth of cloud resources. The aim is to help SaaS application developers perform development, testing, and deployment on HUAWEI CLOUD more quickly and easily.

Huawei’s device application distribution platform, AppGallery, has become the world’s third largest app market, with 490 million active users worldwide and more than 261 billion downloads.

The one-stop mobile app solution jointly developed by HUAWEI CLOUD and AppGallery Connect has provided more technical and resource support for innovative apps that integrate HMS Core. In addition, the HMS ecosystem support program, launched by HUAWEI CLOUD, provides 500 million yuan worth of cloud resources to support 1,500 HMS apps. After its commercial launch, each app receives up to 1.2 million yuan worth of support in advertising resources. With the two application distribution platforms, HUAWEI CLOUD will help developers achieve business success more quickly.

Simplified end-to-end tools for developers

HUAWEI CLOUD provides developers with simplified end-to-end tools as well as business support. The conventional way to create applications is through full-code development, which requires strong coding capabilities. Today, low-code and no-code development are new options. Even non-developers can quickly
build applications through drag and drop and clicks on pre-defined modules.

HUAWEI CLOUD provides a platform with general-purpose tools and numerous scenario-specific toolkits that support different development methods, increasing efficiency tenfold. The simplified end-to-end DevSecOps tool platform, HUAWEI CLOUD DevCloud, provides entirely cloud-based development scenarios, covering the entire lifecycle of software delivery, from planning, development, testing, and release to O&M. HUAWEI CLOUD DevCloud also embeds security capabilities throughout the process, significantly improving R&D and collaboration efficiency while ensuring trustworthy software delivery.

HUAWEI CLOUD provides development toolkits for both full-code and low-code development across a range of scenarios, including cloud-native applications, mobile applications, applets, AI applications, IoT applications, and data applications. For example, in terms of AI applications, ModelArts can help developers use the low-code development method for data labeling, model training, and model release. Another example is the low-code development service AppCube, which enables developers to quickly build an intelligent operation center (IOC) for cities through simple drag and drop operations.

**Huawei's experience enables services**

To seize opportunities in the Cloud 2.0 era, developers need both simplified development tools and in-depth industry insights.

Based on cloud infrastructure that adopts the QingTian architecture, HUAWEI CLOUD provides consistent service experiences across cloud, edge, and devices. The three types of technology enablement services – application, data, and AI – integrate both technology and services. This involves three layers of capabilities: product lines throughout the lifecycle, core capabilities of industry applications, and the accumulation of industry assets.

HUAWEI CLOUD has abundant project experience. The AI-enablement service ModelArts offers over 300 models based on industry know-how. The application enablement service ROMA integrates more than 2,000 industry-specific applications. And the data enablement service DAYU offers over 200 industry-specific, general-purpose data asset models. Such services are transforming programmers who focus on code into developers with in-depth insights into services.

For example, HUAWEI CLOUD and Northwest Air Traffic Management Bureau have jointly created an air

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**Today, low-code and no-code development are new options. Even non-developers can quickly build applications through drag and drop and clicks on pre-defined modules.**
To date, HUAWEI CLOUD has successfully delivered over 600 AI projects across more than 10 industries, with ModelArts widely used in these projects.

ModelArts 3.0 accelerates AI implementation

With AI deployed in production systems, companies are facing various challenges.

Model building: How can a high-precision model be trained based on a small set of sample data?

Scenario verification: How can AI models be transferred from labs to real-world application within a few weeks?

Engineering delivery: How can algorithms and engineering decouple so that efficient delivery can be achieved with the support of just a few engineers?

Large-scale replication: How can algorithm developers focus on optimizing core models for large-scale replication in other projects?

In May 2018, HUAWEI CLOUD proposed inclusive AI for the first time at the Big Data Expo in Guizhou, highlighting the need to make AI affordable, effective, and reliable. In September of that same year, Huawei released ModelArts at HUAWEI CONNECT in Shanghai, providing developers with a one-stop AI development platform.

To date, HUAWEI CLOUD has successfully delivered over 600 AI projects across more than 10 industries, with ModelArts widely used in these projects. During one railway project, more than 600 types of faults were found on a train, but most had less than 10 data samples – a very small amount. With ModelArts, HUAWEI CLOUD was able to accurately identify 100 percent of major faults and 98 percent of minor faults.

HUAWEI CLOUD has now launched ModelArts 3.0, an AI application development platform for enterprises. ModelArts 3.0 is built on world-class AI algorithms and can intelligently evaluate models and diagnose issues. This enables industries to efficiently apply AI and replicate AI applications on a large scale.

HUAWEI CLOUD has long been engaged in basic AI research, covering computer vision, language and speech, and decision-making optimization, and has proposed six research programs. Many of the research findings have been gradually applied to ModelArts and then offered as plug-and-play functions to accelerate AI deployment. This has made inclusive AI a reality, making AI affordable, effective, and reliable.
In 2018, Huawei asserted that AI deployment in industries must be scenario-specific and proposed three typical scenarios: repetitive, high-volume tasks; tasks that require expertise; and work that requires multi-domain coordination. However, can clear business scenarios alone guarantee the successful implementation of AI in industries? Numerous projects have shown that the answer to this question is no. Industries have sufficient data, but they lack the required computing power for AI.

Al is at the core of Huawei’s Intelligent Twins reference architecture. Huawei believes that AI knowledge computing will transform how knowledge is used and play a key role in helping governments, enterprises, and industries deliver pervasive intelligence for all scenarios.
In addition, the implementation of AI usually involves iterations. The obstacles to this process aren’t due to technology, but existing organizational and talent structures. That’s why in 2019, HUAWEI CLOUD defined the following four keys to successful AI implementation in industries: clear business scenarios, readily available computing power, continuously evolving AI services, and organization and talent.

**AI & industry know-how**

More enterprises are adopting AI. After analyzing its experience during more than 600 projects, HUAWEI CLOUD has found that over 30 percent of these cases used AI in their core production systems, which brought an average increase of more than 18 percent in profitability and efficiency gains.

However, during this process HUAWEI CLOUD also identified deeper problems regarding AI adoption in a number of areas.

**Collaboration between industry experts and AI specialists:** These two types of experts have difficulty understanding each other and working towards common goals.

**Integration between industry know-know and AI models:** Industries have usually spent decades or longer gaining their own expertise, and developed a large number of proven mechanism models based on physical, chemical, biological, and other types of information. The problem is whether these models can be integrated with data-driven AI models. If they can, then how can this be done effectively?

**Integration between industry applications and AI systems:** What is the exact relationship between AI systems and the application and control systems that industries have developed over the years? How can these industry applications evolve smoothly to become intelligent?

The basic issue behind the three problems above is: How can we leverage AI to make the most of industry know-know? If this mechanism is defined, the problems with expert collaboration and system integration will be easily solved.

To solve these problems, HUAWEI CLOUD has come up with a whole new approach – knowledge computing. This uses a series of AI technologies to extract and express various types of knowledge. After this, computing is performed based on large amounts of data to generate more accurate models and empower machines and humans. Knowledge computing is essentially about efficient, knowledge-driven and data-driven integration.

Large amounts of knowledge have been generated during the development of each industry, such as mechanism models about production systems, technical literature, valuable expert experience, summaries of methods developed over the years, and test reports.

Industries don’t lack knowledge. Instead, they lack the methods to efficiently utilize this knowledge. To explain the details of a borehole in the oil and gas industry, for example, well logging experts need to rely on repeated analysis of different systems by specialists in multiple domains, a process that usually takes months.
However, if such knowledge is expressed through graphs, and related borehole data is turned into vectors with graph embedding technology, the large number of vectors that are generated can be used to create a powerful model, which can perform accurate and efficient inference. This approach allows the more effective use and transmission of expert knowledge while saving experts considerable amounts of time.

Full-lifecycle knowledge computing solution

At HUAWEI CONNECT 2020, HUAWEI CLOUD officially launched the industry’s first full-lifecycle knowledge computing solution. Based on the ModelArts AI development platform, the solution consists of four modules: knowledge acquisition, knowledge modeling, knowledge management, and knowledge application.

Knowledge acquisition is the starting point for knowledge computing. In this module, multimodal data parsing and processing are performed. This is the first key step in the process to convert data into knowledge. After this, preliminary knowledge can be used to perform knowledge modeling based on business scenarios.

Knowledge modeling is the most important module. There are many approaches for knowledge modeling such as the graph embedding mentioned in the borehole example. In industrial settings, different approaches can be used to meet the requirements of different scenarios, such as adopting parallel computing powered by mechanism models and AI, and embedding
mechanism models into deep neural networks. In this module, the reliability and explainability of the overall algorithm must be considered, in addition to whether massive amounts of data can be used to improve knowledge computing efficiency.

Once knowledge modeling is complete, effective knowledge management capabilities are required, including automatic updates, conflict management, and quality control. In the knowledge application module, HUAWEI CLOUD provides both basic capabilities such as high-concurrency real-time queries, searches, and recommendations, and advanced capabilities, including knowledge inference and prediction.

Enterprises can build their own knowledge computing platforms based on the HUAWEI CLOUD knowledge computing solution, and use these platforms in core processes such as R&D, production, operations, sales, and after-sales services. This solution has already been adopted in the oil, automotive, healthcare, chemical fiber, coking coal, steel, and transportation industries.

In the automotive industry, China FAW Group has used the HUAWEI CLOUD knowledge computing solution to build its own platform. The platform displays data by business scenario that’s convenient and digital, and quickly drives employee upskilling.

China FAW Group’s platform has benefited one of the company’s Hongqi 4S stores in multiple ways. The store’s one-time repair rate increased by 4 percent and customer wait times for repairs dropped by 23 percent. Manufacturer support and involvement rates and also the time required for training maintenance technicians decreased by 30 percent.

In the steel industry, building on the HUAWEI CLOUD knowledge computing solution, Yantai Walsin Stainless Steel integrated the alloy batching industry mechanism with AI to build a new AI model. This helped alloy batching engineers make more informed decisions and determine the optimal proportioning for alloy batching, which balances the quality of steel with economic benefits. This AI-assisted model increased the accuracy of predicting alloy ingredients to over 95 percent, 10 percent more than mechanism models. This has saved the company 20 million yuan every year.

In the healthcare industry, HUAWEI CLOUD has partnered with the team led by Prof Han Dali from the Beijing Institute of Genomics of the Chinese Academy of Sciences. Prof Han’s team leverages knowledge computing to integrate hydroxymethyl DNA data with gene knowledge graphs compiled over the course of numerous research experiments. This approach accurately identifies the markers of key organisms in the blood, increasing the accuracy of early cancer diagnosis by 9 percent.

In the transportation industry, HUAWEI CLOUD has been working with traffic management authorities to develop a systematic control solution based on AI computing. This is achieved by pairing knowledge computing with a wide range of expertise, collecting real-time feedback on traffic information, and integrating expert experience. The solution is currently able to optimize traffic flow at urban intersections and across entire regions. It has been verified at more than 300 intersections in Shenzhen, where it has reduced the congestion index by 8 percent. Moving ahead, knowledge computing will be further applied to improve the multidimensional traffic management of roads, metro systems, and airports.

Knowledge computing will transform the way knowledge is used and unlock its true power, while preparing every industry for new advancements. Huawei is ready to work with its industry customers and partners to build industry-specific AI knowledge computing platforms, deliver pervasive intelligence for all scenarios, and create new value for all industries.
Powering all-scenario AI with hybrid cloud

Intelligent Twins is a reference architecture for the intelligent transformation of governments and enterprises, which acts as an intelligent hub and decision maker. Underpinned by a hybrid cloud base, it offers three types of enablement capabilities: application enablement, data enablement, and AI enablement.
As demand for intelligent, online digital services continues to surge, governments and businesses are integrating AI throughout transformation. They're migrating applications to cloud faster and evolving them based on massive amounts of data, apps, AI, and industry know-how. These applications will create more value if they combine new technologies with business dynamics and customer needs.

The shift to digital is opening up a plethora of business opportunities for application developers. But many challenges lie ahead, stopping governments and businesses from moving key applications to cloud.

- Developers need easier and faster access to the latest technologies on the cloud, as well as the ability to continuously evolve the technologies they use. Developers also need industry know-how to create unique applications for target sectors.

- The cloud must support on-premises deployment and suit current O&M practices to keep data secure and meet compliance requirements.

- Edge cloud must be available to provide computing power wherever needed. This means the cloud must provide ubiquitous coverage.

Neither traditional private cloud nor public cloud solutions can address all of these challenges. That's where HUAWEI CLOUD's hybrid cloud comes into play for governments and enterprises.

**Redefining hybrid cloud: The ideal platform for intelligent transformation**

Huawei’s customers and partners can build an Intelligent Twins to craft their own intelligent solutions. The Intelligent Twin’s intelligent hub acts as the brain and decision maker, underpinned by a hybrid cloud and three types of enablement capabilities: application, data, and AI. These elements are essential for the intelligent hub to support intelligent applications across all scenarios.

HUAWEI CLOUD hybrid cloud can continuously synchronize with public cloud capabilities and support on-premises deployment. It represents a change in how the hybrid cloud works because it goes beyond merely converging resources to converging capabilities. The solution can adjust to the organizational structure and service processes of governments and enterprises, implementing one unified cloud from the user’s perspective.

HUAWEI CLOUD provides public cloud services, HUAWEI CLOUD...
Stack, and HUAWEI CLOUD Edge solutions, all based on QingTian Architecture. The unified cloud management system ManageOne can achieve privilege- and domain-based management in ways that suit the governance structure of governments and enterprises. HUAWEI CLOUD hybrid cloud can support rapid innovation like a public cloud, while providing the same level of manageability and controllability as a private cloud. This hybrid cloud is an ideal platform for developers to develop applications on the cloud, and for governments and enterprises to upgrade intelligent services across all scenarios.

HUAWEI CLOUD Stack makes it easier to move key applications to the cloud by offering a suite of functions: cloud management, cloud services, AI enablement, application enablement, and data enablement. HUAWEI CLOUD Stack also includes industry know-how and asset models that customers can use to flexibly respond to changing market needs. HUAWEI CLOUD Stack can give a strong boost to governments and enterprises during intelligent transformation.

Cloud services empower continuous capability evolution and innovation. HUAWEI CLOUD Stack uses 11 steps in 3 phases to rapidly synchronize with the new services of HUAWEI CLOUD in a way that’s standardized, lightweight, and easy-to-deliver. Currently, HUAWEI CLOUD Stack provides more than 70 cloud services across 10 categories for data centers.

Cloud management ensures alignment with organizational structure: ManageOne, the cloud management platform of HUAWEI CLOUD Stack, provides a multi-level management model that supports a five-layer organizational structure per tenant. With hierarchical and privilege- and domain-based management capabilities, the platform allows IT resources to be managed with precision.

Application enablement makes innovation as easy as putting blocks together: Huawei has developed more than 2,000 application assets by drawing on its own experience in digitalizing internal operations. These application assets are now accessible via the application enablement services of HUAWEI CLOUD ROMA. Application assets and facility assets can be continuously developed, connected, and orchestrated on ROMA. It makes innovation as simple as putting blocks together.

Data enablement facilitates the development of logical data lakes. DAYU is a one-stop data operations platform for the entire data lifecycle. The DAYU logical data lake solution currently includes more than 200 general data asset models. With DAYU, data from different departments of an organization can be managed and analyzed centrally, and shared across all regional branches of the organization. The logical data lake leverages two core capabilities to achieve efficient, cross-region collaborative analysis of data. First is a global directory that shows the location of data by using blockchain’s trusted data exchange technology. Second is the ability to break down jobs and push operators down to the data lake based on the global directory to perform local data analytics. This capability provides computing power to wherever there’s a need for data analytics.

AI enablement helps create new value for industries. AI enablement is at the heart
of Intelligent Twins and relies on ModelArts, which now provides more than 300 industry-specific knowledge models to simplify and automate the development and management of AI applications throughout their lifecycles. ModelArts allows everyone in the process to do what they do best: developers can create AI applications, while experts can focus on AI algorithms and models. ModelArts can achieve this because it has integrated a huge amount of algorithmic expertise and industry know-how into suites and workflows. It provides templates of industry experience that help partners and developers create AI applications quickly.

**HUAWEI CLOUD Stack breathes new life into all industries**

Huawei also launched the tech partner program for HUAWEI CLOUD Stack. With 200 million yuan (US$30.6 million) in funding, this program aims to produce 2,000 solutions to empower intelligent transformation in eight major industries. So far, HUAWEI CLOUD Stack has been successfully deployed in more than 4,000 government and commercial projects. The latest version of HUAWEI CLOUD Stack has seen large-scale commercial use in many projects, including the Shenzhen e-government cloud, State Grid Corporation of China, and Industrial and Commercial Bank of China. Huawei and its customers have also explored innovations on HUAWEI CLOUD Stack in domains such as smart cities, smart inspections, and smart branches.

The Mayor of Shenzhen Chen Rugui highlighted the importance of Intelligent Twins in his keynote speech at HUAWEI CONNECT 2020, “We’re building Shenzhen into an exemplary city...and raising the bar for great cities around the world. By leveraging advanced technologies from Huawei and other tech companies, our city is growing smarter by the day as we build the Shenzhen Intelligent Twin,” he said.

At the event, Sun Fei, Deputy Director of the Shenzhen Big Data Resource Management Center, stressed how HUAWEI CLOUD Stack has made Shenzhen smarter across all scenarios by providing capabilities the city can use to improve governance, benefit residents, and boost local industries. To achieve this, Shenzhen has created four critical components based on HUAWEI CLOUD Stack: municipal e-government cloud, big data center, big data lake, and digital application platform.

- Municipal e-government cloud: a city-
wide cloud that comprises 1 municipal-level cloud, 11 district-level clouds, and numerous bureau-level clouds, providing all government agencies across Shenzhen with on-demand, scalable cloud services.

- **Big data center**: a robust data directory and exchange system make data-sharing and exchange more efficient and effective.

- **Big data lake**: a huge reserve of data assets owned by the Shenzhen government.

- **Digital application platform**: a unified platform that supports service development and applications and provides data convergence, application collaboration, integration, and development services.

HUAWEI CLOUD Stack has played an important role in Shenzhen’s AI platform by providing a city-wide AI computing resource pool and AI services that are essential for smart city and digital government operations.

HUAWEI CLOUD Stack has delivered incredible efficiency gains for the Shenzhen government. Real estate registration can be completed in an hour, and requests for certain services can be approved online within seconds. Now, 1,723 types of services can be handled online in one place. These data-driven improvements have won praise from the city’s residents.

Shenzhen is also working with HUAWEI CLOUD on developing industrial campuses powered by big data, AI, and cloud computing. Ongoing efforts are being made to innovate IoT and AI applications that can potentially be used for property management, security, transportation, and parking. These developments are sure to inspire new business models in the digital economy.

The Shenzhen e-government cloud is a great example of how HUAWEI CLOUD Stack can help governments and enterprises expand their intelligent capabilities. For power grids, HUAWEI CLOUD Stack is empowering the State Grid Corporation of China (SGCC) with a robust solution that supports unified operations and a two-level maintenance structure. This solution is closely aligned with SGCC’s organizational structure, which comprises the SGCC Group and provincial networks. It gives the group a real-time view of how the entire network works, and allows provincial branches to focus on local O&M.

Huawei is also helping Shenzhen Airport prepare for the future with a solution that includes ROMA, which quickly connects the airport’s AI engines with the operations control system and flight information management system. This has resulted in the smart allocation of aircraft stands. Every year, more than 2.6 million travelers can skip the shuttle bus and board their plane directly. With HUAWEI CLOUD, Shenzhen Airport is more efficient than ever before.

As AI continues to make its way into every aspect of life, business, industries, and cities, it will drive up quality of life, business efficiency, and city governance. The Intelligent Twins is essential for this to happen, providing intelligence across all scenarios. Going forward, HUAWEI CLOUD will continue to strengthen its hybrid cloud solutions to better address any challenges governments or enterprises face during transformation and become the preferred partner for customers’ intelligent transformation.
Computing: The engine of Intelligent Twins

Computing power is the engine of Intelligent Twins and the key for governments and enterprises to deploy intelligence. To maximize computing power, Huawei has developed a full-stack AI basic software and hardware platform powered by Ascend-based computing.

By leveraging diversified computing power (general-purpose computing + heterogeneous computing), the platform allows collaborative innovation across the full stack, from hardware and basic software to application enablement.

As a general-purpose technology, AI is drastically changing the way we live and work and accelerating the deployment of intelligence in industries. Intelligent upgrades are crucial to the continued...
competitiveness of every city, industry, and company. Intelligent Twins form an integrated intelligent system comprising cloud, edge, and networks, serving as the optimal route and a reference architecture for governments and enterprises to become intelligent.

With computing power as the engine of Intelligent Twins, Huawei is committed to working with its partners to develop Kunpeng-based computing (general-purpose computing) and Ascend-based computing (AI computing) to seize the strategic opportunities of the new era. Diversified computing power (general-purpose computing + heterogeneous computing) will facilitate collaborative innovation across the full stack, from hardware and basic software to application enablement, catapulting governments and enterprises into an intelligent world.

**Ascend-powered AI**

The Ascend-based computing platform exclusively provides basic software and hardware to China’s Ministry of Science and Technology’s National Open Innovation Platform for Next Generation Artificial Intelligence.

The platform boasts Atlas series hardware, the Computing Architecture for Neural Networks (CANN), MindSpore AI computing framework for all scenarios, and MindX for Ascend application enablement. On the platform, AI developers, researchers, and industry application partners can more effectively develop scenario-specific AI solutions.

The Atlas series of hardware covers all scenarios across the edge and cloud to support AI inference and training, and offers a broad portfolio including modules, cards, AI servers, and clusters. Following its strategy of opening up hardware and enabling partners, Huawei cultivates certified solution partners and integrates Ascend modules, acceleration cards, and servers into its partners’ own products and solutions. So far, Huawei has developed five solution partners.

CANN – a heterogeneous computing architecture – is crucial to unlocking hardware computing power. Its southbound APIs are compatible with various hardware form factors on devices, the cloud, and the edge, and support 14 major operating systems. In addition, its northbound APIs support the industry’s mainstream AI frameworks. With the unified programming interface AscendCL (ACL), partners can use a full range of AI inference and training hardware for simplified development. The performance of Ascend hardware is maximized through coordinated software and hardware optimization, Ascend-friendly diagram compilers, and over 1,000 high-performance operators. These advantages allow CANN to help our partners develop and provide unrivaled performance.

MindSpore is an AI framework designed for device, cloud, and edge scenarios that serves as the key to ecosystem development. MindSpore features automatic parallelization, end-to-end simplicity, and adaptive, all-scenario collaboration. With growing AI models, the number of GPT-3 parameters has exceeded 175 billion, requiring future frameworks to provide higher parallel computing capabilities.

As the industry’s first automatic parallel framework, MindSpore can divide large diagrams into smaller ones, automatically split operators within these smaller diagrams, and then assign
The MindSpore community now has over 1,500 open source contributors, and daily downloads in September 2020 exceeded 600.

The operators to different computing units. All of this is possible without the intervention of developers. After models are trained, MindSpore generates different-sized models by adapting to different hardware form factors, and then automatically adjusts these models.

MindSpore also supports training local incremental data and provides precise AI models that can meet developers’ requirement for customized frameworks. Developers can rapidly import and debug models, and use tools to automatically switch between models that are trained by third-party frameworks.

Since going open source in March 2020, MindSpore has received high acclaim from global developers. The Mindspore community now has over 1,500 open source contributors, and daily downloads in September 2020 exceeded 600. It’s becoming the most popular AI open-source community in China and is seeing a growing number of downloads outside of China. Huawei looks forward to working with AI developers to build a global mainstream AI framework that can adapt to different scenarios.

MindX features two components for deep learning and intelligent edge, one select model library, and software development kits (SDKs) for various industries. The development toolkit and industry knowledge library for one industry can be replicated for other industries, enabling easier and more efficient development – developers can deploy AI functions with few or even no lines of code using MindX SDK.

Open collaboration

As part of its strategy to open up its software and hardware and enable partners, Huawei has made the full-stack AI software and hardware platform open source for the entire industry, aiming at building an Ascend-based AI industry ecosystem. To enable industry applications and empower industries with AI, Huawei has partnered with over 100 leading global independent software vendors (ISVs) and developed more than 120 solutions using Ascend. Through the concerted efforts of over 100,000 developers, AI applications jointly developed by Huawei and its partners have been widely adopted in the transportation, financial, energy, manufacturing, Internet, and telecommunication industries, among others, and have delivered tremendous value.

The Manufacturing Dept is key to Huawei’s core competitiveness, and is responsible for manufacturing Huawei’s ICT infrastructure and smart devices. Huawei ships hundreds of billions of units every year, and produces one phone every 28 seconds and one piece of base station equipment every three minutes. Despite being a leader both in China and worldwide, quality control of its numerous products is still a crucial task. Many production processes used to be inspected manually and re-inspections were often required to ensure accuracy.

To solve this problem, Huawei’s Manufacturing Dept worked with ADLINK to integrate AI into quality control and launched the Atlas solution with cloud-edge synergy. This solution was first piloted on the production line for computing products – the production line saw a 60-percent reduction in inspection workloads, with accuracy jumping to almost 100 percent since the pilot began in June 2020. Following this, Huawei began applying the solution in over 80 additional production lines, including
wireless and devices. The Atlas solution helps Huawei extend beyond traditional manufacturing to intelligent manufacturing.

Based on its manufacturing know-how and AI development experience, Huawei released intelligent manufacturing SDKs and opened them up to its partners to enable efficient intelligent manufacturing and AI application development. Huawei’s Atlas solution lowers the barrier to developing AI industry applications, and allows smart factories to flourish.

A single architecture cannot support the diversified computing requirements of various scenarios like big data and AI. Huawei aims to enable the intelligent upgrade of governments and enterprises through diversified computing power. Based on China’s New Generation Artificial Intelligence Innovation and Development Pilot Zone, Huawei has built computing power clusters like AI computing centers, and established diversified public computing power platforms to bring together enterprise innovations and empower the intelligent upgrade of industries. On the edge, Huawei has developed edge AI computing devices, such as Atlas 200 modules and Atlas 500 AI edge stations, and launched over 100 industry AI solutions with its partners. These solutions include intelligent grid inspections, intelligent service centers, and intelligent gas stations. Computing power clusters will empower industry clusters and boost regional industries thanks to cloud-edge-device synergy between the clusters and the edge.

Developing talent is the cornerstone of the intelligent world

Talent development is the foundation of industry development. As part of its work to cultivate the computing industry, Huawei has placed talent development high on its agenda. Huawei has worked with various universities to establish a knowledge system that adapts basic theories to industry and market needs, so as to develop talent by combining theory, practice, and application.

Huawei has partnered with experts and scholars from various domains and Tsinghua University Press to publish a series of textbooks and education materials regarding Ascend AI processors, MindSpore, ModelArts, Kunpeng processors, openEuler, and openGauss.

Supported by China’s Ministry of Education, Huawei has also signed agreements with more than 70 universities to build an industry-university talent development base and promote Kunpeng and Ascend. So far, Kunpeng and Ascend courses are available at more than 2,600 Chinese universities, colleges, and vocational schools, and are gradually being adopted outside China. Moving forward, skills relating to Kunpeng and Ascend will become essential for AI, computer, and information majors.

An open and shared ecosystem is critical for Intelligent Twins. Looking ahead, Huawei will continue investing in the R&D of basic computing software and hardware, and opening the full-stack Ascend and Kunpeng platforms to the industry to foster a diversified computing ecosystem. This will provide the computing power necessary to build new infrastructure and move towards a high-quality digital economy.
Building smart cities with Intelligent Twins

5G, cloud, and AI are the three key elements of new infrastructure and engines of the digital economy. Much of this infrastructure is deployed in cities. Based on its deployment experience, Huawei aims to provide a reference for building smart cities with all-scenario intelligence. New infrastructure is digital, Internet-based, and intelligent. 5G provides high-speed digital connectivity; cloud solutions perform data computing and storage tasks and make computing available everywhere; and AI conducts data mining, analysis, and decision-making to realize pervasive intelligence. These advantages make 5G, cloud, and AI the three key elements of new infrastructure.

5G, cloud & AI: Engines of the digital economy

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5G is a digital highway reshaping life and society. While 1G to 4G connected people, 5G goes further and
connects everything, representing a major turning point in the history of technology. Thanks to its high bandwidth, low latency, high reliability, and massive connections, 5G can support millions of connections per square kilometer. It will change the way we live, and bring new opportunities for the high-quality development of vertical industries. For example, 5G’s latency-sensitive service-scheduling provides secure and reliable network connections for connected cars, industrial control, and smart grids, as well as making autonomous driving and telemedicine viable.

**Cloud makes ubiquitous computing possible and is a key indicator of digital transformation.** Cloud computing is characterized by large-scale resource integration, high reliability, scalability, and on-demand provisioning, providing inclusive, comprehensive, and shared computing services for vertical industries. It shifts away from the traditional architecture of information infrastructure and adds agility to existing infrastructure, helping enterprises redefine and optimize their key service models and go digital.

**AI is key to deploying intelligence and pervasive intelligence.** Thanks to advances in algorithms, data, and computing power, AI is in play in real-world scenarios. Extending from support systems to major business processes in production systems, AI has become the core of adding intelligence to systems and is changing the way we work. Huawei Global Industry Vision (GIV) predicts that 86 percent of global companies will adopt AI by 2025. Huawei has introduced AI in all of its major business processes in more than 200 scenarios, including R&D, manufacturing, sales, and supply.

5G, cloud, and AI enable sensing, transmission, storage, computing, and decision-making. Together, they will make cities, enterprises, and industries more productive. They will bring together high-quality resources in the new infrastructure supply chain, and integrate IT with traditional industries to support innovation and boost digital productivity.

**Deploying new infrastructure to build City Intelligent Twins**

At HUAWEI CONNECT 2020, Huawei launched the Intelligent Twins reference architecture to better deploy new infrastructure. The Intelligent Twins is an open, intelligent system built on cloud and AI that’s capable of sensing, cross-domain collaboration, precise judgment, and continuous evolution. By integrating 5G, cloud, and AI with applications, Intelligent Twins provide a reference architecture for the intelligent upgrade of governments and enterprises, serving as a major engine powering new infrastructure and economic growth.

Cities are where consumption and production converge. The building of a smart city requires a systematic approach and top-level design that integrates ICT into every part of the city. City Intelligent Twins aims to give cities the ability to sense, think, and evolve. Specifically, they will improve urban governance and people’s lives, make production more efficient, and give new creative capabilities to industries.

There are four layers to Huawei’s City Intelligent Twins: intelligent interactions, intelligent connectivity, intelligent hub, and intelligent applications. Intelligent interaction refers to interactions between edge devices (which could be built by Huawei or one of our many partners). These are like the sense organs and limbs that sense people, objects, and space in...
Through ongoing exploration and practical experience, Huawei aims to provide valuable reference for building smart cities and move towards all-scenario intelligence.

cities and interact with them.

**Intelligent connectivity** includes technologies such as 5G, F5G, Wi-Fi 6, and IoT. They form the nervous system, which quickly converges data to sense and handle the vital signs of a city with intelligence and inspire innovation across the city.

**The intelligent hub** includes cloud infrastructure, AI enablement (ModelArts), application enablement (ROMA), and data enablement (DAYU). This is the brain and decision-making system that uses AI to achieve synergy across the entire network, identify problems, predict trends, and mitigate and respond to risks.

**Intelligent applications** are a combination of ICT and domain-specific know-how. Huawei works with customers and partners to redefine service experiences, optimize processes, and enable innovative solutions.

At HUAWEI CONNECT 2020, Shenzhen and Huawei launched the Shenzhen Intelligent Twins as a benchmark city for the digital economy. The Shenzhen Intelligent Twins uses new ICT like 5G, cloud computing, IoT, big data, AI, and blockchain to establish a comprehensive, intelligent system that’s driven by data and capable of deep learning. The Shenzhen Intelligent Twins will offer proactive, precise, intelligent, and efficient urban services for the city’s residents and companies.

City Intelligent Twins are now bearing fruit in various industries in Shenzhen. With digital government services, 98 percent of approvals and 95 percent of licensing applications can be handled online. In terms of smart transformation, Shenzhen has managed to control all traffic lights with AI over one network, and traffic speeds during peak hours have increased by 10 percent. Shenzhen airport now supports facial recognition and intelligent gate assignment, increasing the ratio of on-time departures of flights to 90 percent and reducing average wait times by 40 percent.

To achieve greater accuracy in weather forecasting, HD cameras are deployed across the city to collect data about cloud cover, rain, and fog, which is sent back to the cloud in real time using 5G. By splicing the data of various districts into meteorological images and combining them with meteorological radar data, AI can accurately predict the weather four hours in advance. Models trained on the cloud are deployed at the edge, enabling cameras to identify subtle weather changes, such as drizzle and fog. The synergy between the cloud, edge, and networks delivers smart meteorological applications, so that mobile phone users can keep track of weather changes within a 1-kilometer radius of where they are, and make travel plans accordingly.

Besides Shenzhen, Huawei has also worked with Chengdu, Fuzhou, Nanchang, Changchun, and other cities to deploy City Intelligent Twins. Through ongoing exploration and practical experience, Huawei aims to provide valuable reference for building smart cities and move towards all-scenario intelligence.

Intelligent Twins form an open ecosystem underpinned by thriving software and service and edge computing ecosystems. In the next five years, the global edge computing market is expected to be worth US$500 billion, and the value of the software and service market will likely reach US$1 trillion. On the journey to smart cities and an intelligent world, Huawei looks forward to working with partners to grow the industry ecosystem, build City Intelligent Twins, and take intelligence everywhere.
Huawei’s Intelligent Twins solution is designed to help enterprises and governments deploy intelligence in their systems and operations. Consider that a human brain has 86 billion neurons while an African elephant has 250 billion. We’re smarter than elephants, because our neurons are highly connected, with each having more than 8,000 synapses, forming strong connections to the body and limbs. To make Intelligent Twins smart, you need more than powerful computing power; you also need powerful connectivity.

Building industry Intelligent Twins requires transforming connectivity with intelligence – it’s not just a capacity increase. Upgraded connectivity has five new key requirements and three defining characteristics that are defining their deployment in industry scenarios.
3 scenarios & 5 new requirements

When building Intelligent Twins, there are three types of connectivity scenarios: The first is connections within the intelligent hub. These occur between AI servers and cloud data centers; between the intelligent hub and intelligent interactive devices; and between intelligent interactive devices like AI cameras, 4K drones, and robotic arms.

Typical demands differ depending on different industry applications. For example, a short-range four-hour weather forecast for a city requires transmitting mass cloud image data captured by HD cameras in different urban areas for real-time AI analysis in the cloud. To analyze the huge datasets, collaboration between multiple distributed data centers is required. Large bandwidth data center connections with zero packet loss are key to ensuring AI computing efficiency and producing rapid forecasts.

Another example is high-speed rail control systems. With high-speed trains departing Shanghai Hongqiao Railway Station every 84 seconds, the highest dispatch density in China, the station’s control signal system has extremely high requirements on connection reliability.

A capacity increase isn’t enough – intelligence is required. Intelligent Twins have five requirements for connectivity: high reliability, zero packet loss, differentiated services, real-time large bandwidth, and intelligent operations and maintenance (O&M).

Connectivity is productivity

Higher bandwidth, lower latency, and thinner network slices can all enhance connectivity and create value. For example, a report on Wall Street financial transactions revealed that each millisecond decrease in latency generates US$1 million of revenue. Conversely, one OTT company reported that a packet loss rate of 0.1 percent lowers AI computing power by 50 percent on its cloud data center.

Over the past 40 years, the value of the connectivity has conformed to Metcalfe’s law, which holds that a network’s value is proportional to the square of the number of connections. For Intelligent Twins, we need to add a few more variables to Metcalfe’s law, like bandwidth, latency, and slices, so that connection quality becomes a value for factor of production.

The 3 features of intelligent connectivity

Intelligent connectivity has three major features:

Ubiquitous gigabit: Bandwidth is the cornerstone of connectivity. Ubiquitous, seamless gigabit connectivity is needed for ultra-HD AI cameras, drones, industrial cameras, and industrial VR and AR applications.

Deterministic experience: An Intelligent Twins solution mainly involves connections to things in a diverse range of production scenarios. In the case of Shenzhen Airport, it saw one aircraft take off or land more than once a minute during peak times in 2019. Thus, guaranteed real-time connectivity on its network is essential. At the same time, electric power companies must guarantee six- and even seven-nines reliability and less than two minutes of power outage per household annually. Without deterministic connectivity, companies won’t be able to ensure
Hyper-automation: As industries become intelligent, the scale and complexity of networks are increasing. 5G networks can support 100 times more connections than 4G networks, but this also means more complex network O&M with at least 10,000 times more parameters to configure. A manual O&M model isn’t viable, so big data and AI are required to reduce decision-making complexity and enable hyper-automation where intelligence handles all complex tasks and where manual O&M is simple.

Intelligent Twins in different scenarios

City Intelligent Twins

Smart cities are built around five priorities: government services, social governance, public services, green living, and industrial parks.

City governance monitors infrastructure like roads, waterways, bridges, and underground utility tunnels using surveillance cameras that opens up data from different government departments. As such, City Intelligent Twins comprises two connectivity features: the intelligent connection of all things and the interconnection of all intelligent things. For example, an industrial park in Suzhou connected all of its surveillance drones and HD cameras with real-time, high-bandwidth connectivity on 5G and F5G networks, with the data from more than 5,000 surveillance cameras and over 13,000 IoT sensors, laying a solid foundation for the intelligent city.

A municipal government in Guangdong introduced IPv6+ and one-hop direct access connecting the data centers of different departments and supporting fast video surveillance access across different districts and departments. The solution solved the problem of slow, multi-hop connection to data centers, which was inefficient and made coordination difficult.

Ubiquitous intelligent connectivity will help build City Intelligent Twins, bringing intelligence to every corner of urban centers and delivering a smart city experience that benefits governance, residents, and industries alike.

Transportation Intelligent Twins

The intelligent upgrade of airports, for example, must consider three things: passengers, freight, and aircraft. For passengers, the main aim is to improve their travel experience. Given the high density of passengers and frequent travel, airports can deliver a better travel experience by using Wi-Fi 6 to build a full-coverage network that connects all passenger touchpoints, from check-in and waiting to boarding. For aircraft, the low latency and high reliability of 5G connectivity can make flights safer and more efficient, for example, a 5G ground lighting solution greatly increases aircraft taxiing efficiency by enabling real-time, low-latency connectivity to the thousands of lights used to direct aircraft. Airport patrol vehicles can use 5G to upload 4K surveillance images and videos, enabling real-time monitoring and accurate video review. This will increase the efficiency of handling incidents and help establish comprehensive security systems at airports.

Digital transformation is making airport network systems more complex, with some airports now boasting seven or more networks. While traditional networks will be unable to ensure reliable O&M and increased service efficiency, Huawei’s ADN solution can provide hyper-
automated O&M while ensuring stable service operations.

Wi-Fi 6, 5G, and ADN are the three keys to building Transportation Intelligent Twins.

**Finance Intelligent Twins**

Intelligent financial services are now an integral part of people’s day-to-day lives.

By creating user profiles, banks can optimize financial services for customers through precision marketing and intelligent risk control. But to build user profiles, banks need to accurately identify user parameters across thousands of dimensions, for which AI computing power is vital. However, the quality of connectivity can bottleneck for AI compute, because a packet loss rate of 0.1 percent in data center networks can cause a 50-percent drop in AI computing power.

Huawei’s Intelligent IP network solution ensures zero packet loss on data center networks, unleashing the full potential of AI computing power.

Banks are automating their branches with large amounts of intelligent devices. As traditional private lines are unable to meet these massively increased bandwidth demands, high-bandwidth, low-latency 5G networks are required. Moreover, new services that require increased bandwidth drive up network architecture complexity, making AI-powered O&M necessary. Huawei’s ADN solution delivers “1-3-5” smart O&M performance: fault detection in 1 minute, location in 3 minutes, and troubleshooting in 5 minutes.

Intelligent IP networks, 5G and ADN are the pillars of Finance Intelligent Twins.

**Intelligent connectivity for all scenarios**

Huawei harnesses 5G, Intelligent IP, and F5G to provide all-scenario intelligent connectivity solutions with ubiquitous gigabit, deterministic experience, and hyper-automation to support the intelligent upgrade of enterprises.

**5G intelligent connectivity**

Huawei has delivered 5G networks that feature ultimate experience, simplified networking, and smart O&M for operators worldwide. And to meet industry needs for intelligent upgrades, Huawei continues to improve its 5G network capabilities in uplink bandwidth, latency, and positioning accuracy.

Huawei’s Super Uplink (SUL) enables Gbps-level 5G network uplink speeds, supporting the requirements of HD video uploads in intelligent manufacturing. One major aviation manufacturer uses 5G, HD video, and AI for tasks like joints inspection, staff perimeter control, and tracking portable toolkit inventory. This has helped reduce inspection time on aircraft in the hangar from 30 days to 3 days. In scenarios such as ports, pre-scheduling and mini-slot enable 20-ms latency, facilitating remote crane operations. Finally, UTDOA and higher bandwidth that support submeter-level positioning accuracy are able to meet positioning needs in smart manufacturing and asset management, raising the production and management efficiency of industrial parks to a new level.

**Intelligent IP networks**

With our three-layer AI architecture, intelligent
IP networks can identify service needs, analyze network status in real time, and allocate network resources to deliver a deterministic experience. In addition, we’ve made network O&M more efficient with AI-powered smart network O&M, which enables rapid service deployment and automatic troubleshooting.

Huawei has also launched upgraded 2.0 versions of various solutions.

**CloudCampus 2.0** makes campus networks gigabit, fully wireless, and intelligent, supporting gigabit access for any device or application.

**CloudWAN 2.0** brings full-service intelligence to WAN networks. Introducing the IPv6+ protocol end-to-end realizes multi-cloud on one network and cloud-network interconnection, while network slicing isolates different services to meet the needs of differentiated services.

**CloudFabric 2.0** takes the data center network into the intelligent era, adopting a unique AI scheduling algorithm to achieve zero packet loss in data center networks, increasing both AI compute and storage efficiency by over 30 percent.

Intelligent IP networks are a key part of Huawei’s intelligent connectivity solutions, showcasing the integration of computing power and connectivity.

**Intelligent all-optical F5G networks**

Huawei is committed to bringing an ultimate service experience to every person, home, and organization. To achieve this goal, we’ve put forward our all-optical network strategy for the F5G era.

The intelligent all-optical F5G network solution has three features. The first is passive optical LAN (POL), which enables an all-optical campus. In the past, optical technology was mainly used in backbone and MAN networks. In campus networks, optical technology offers high bandwidth access, meeting the needs of new services such as 4K cameras, and VR/AR.

The second feature is an all-optical bearer solution powered by Liquid OTN technology. Some enterprise services now need 1 Gbps bandwidth, while others may only require 100 Mbps. Liquid OTN is an innovative solution that divides a single-fiber line into 10 Mbps, 100 Mbps, and 1 Gbps channels, meeting diverse transmission speed requirements and dramatically increasing efficiency.

The third feature is an all-optical data center interconnection solution built on automatic fiber discovery and commissioning technologies. The solution frees transport networks from planning and maintenance. Even IT staff with no expertise can deploy the one-click plug-and-play solution in enterprise scenarios in just 8 minutes.

Intelligent all-optical F5G networks have helped over 140 industrial customers, including financial institutions, ISPs, and OTT providers, deploy data center interconnect networks.

**Connectivity never stops advancing**

Over the past 40 years, Huawei has worked with all stakeholders to build a fully connected world and connect the unconnected. And in the next 40 years, we will help realize intelligent connectivity by building Intelligent Twins for industry.

Next-generation connectivity technology, including 5G, IPv6+, F5G, and Wi-Fi 6, is bridging the virtual and physical worlds with ubiquitous gigabit, deterministic experience, and hyper-automation capabilities, bringing the smart society within reach.

Huawei will continue to invest in basic research and systematically improve its engineering capabilities in platforms, modules, algorithms, and techniques. And as we move towards 6G, New IP, F6G, and Wi-Fi 7, we will continue to challenge technological limits to offer the world’s best connectivity with the best network performance and service experience.
Thinking ahead: Intelligent IP networks for IPv6+

Wu Hequan, an academic at the Chinese Academy of Engineering, explained to Communicate the role of IPv6+ and SRv6, artificial intelligence, and network analytics in the creation of intelligent IP networks and what this means for the digital transformation of industries and the construction of China’s New Infrastructure.

By Daniel Tang, CTO, Data Communication Product Line, Huawei

Big data, AI, and next-generation protocols are imbuing IP networks with data analysis and closed-loop optimization capabilities, powering the leap from traditional IP networks to intelligent IP networks that understand customer intent. They’re also at the heart of China’s New Infrastructure plan, a national roadmap for boosting the nation’s digital capabilities in the three areas: information infrastructure, integrated infrastructure, and innovation infrastructure.

Knowing intent

Communicate: With all industries undergoing digital transformation and integrated innovation, what new requirements are placed
on IP networks?

**Wu:** As networks become more complex and larger in scale, demand for traffic/bandwidth is increasing. Diverse types of network services are emerging, including consumer, office, and production applications. Different applications have different bandwidth requirements. For example, the bandwidth requirements of sensor applications might only be in the order of Kbps, but some ultra-wideband applications could need up to 20 Gbps of bandwidth.

With so many service types, we can't use the same approach to support different services, nor can we have multiple variations of the physical layer. Therefore, we need to provide a connection service for each service on the same physical network that's specifically tailored to their service quality requirements using different logical combinations.

However, on a traditional network with manual management, it's clearly impossible to meet this requirement. Can the network understand a customer's intent and automatically organize network resources to configure all network elements in a way that meets customer requirements?

Therefore, the network needs to be able to think. With an understanding of the customer's service intent, it can transform that intent into network topology and other resource configurations and verify whether the resource configuration channel meets the customer's requirements using simulations.

It can monitor network conditions in real time and quickly make adjustments to changes. This form of management model is highly complex and difficult to implement in a traditional network, as it's impossible to fully understand the needs of different services and network resources without technologies like AI and big data analytics.

Even if you know application layer requirements and have a scheme for arranging network resources, you still need a technical method at the execution layer to implement them on the physical network. This kind of method didn't exist before. Now, technologies based on IPv6+ can quickly convey application layer requirements to the specific network layer and link layer and enable resource adjustment.

**Communicate:** What technologies can create intelligent networks that can think?

**Wu:** First, we need to adopt AI and big data analytics to enable real-time understanding of customer intent and network resource status. Understanding that can automate network slicing, IP routing, and other network resources to provide seamless connection services. Simulation verification can predict whether a connection service meets requirements, and real-time service quality monitoring is needed to ensure that it does.

Second, innovative IPv6+ technologies such as SRv6 can enable network resource configuration schemes in the physical network. IPv6 not only supports a much larger number of IP addresses, but also has strong protocol extension capabilities. We can implement a range of protocols based on IPv6. For example, the IPv6-based segment routing (SR) protocol SRv6 allows the entire path to be adjusted at the source node, eliminating the need for a high number of MPLS signaling exchanges.
AI gives the network the ability to think, while the flexible routing capabilities of IPv6+ SRv6 give it the ability to quickly execute commands.

AI gives the network the ability to think, while the flexible routing capabilities of IPv6+ SRv6 give it the ability to quickly execute commands. The combination of AI and IPv6 enables the intelligent IP network to understand customer service intent, translate it into network resource configurations, and quickly implement intent in the physical network.

Communicate: With today’s increasingly complex and large networks and diverse service types, how can AI and big data analytics improve automated network management?

Wu: We haven’t completely done away with reliance on manual operations and experience in network O&M management. Responses to service requirements and troubleshooting are still comparatively slow, but the goal of network intelligence is autonomous driving. To use a comparison, in the transportation sector autonomous driving has a hierarchy from L1 to L5. In networks, we also hope to achieve an autonomous driving hierarchy. Some equipment vendors and operators are already working together on experiments on intelligent networks and promoting hierarchical autonomous driving networks.

AI and big data analytics help the network understand customer service intent and quickly respond, perceive network status in real time, identify network problems or potential risks, and rapidly locate problems and recommend solutions by matching fault models. This allows us to improve automated network management, reduce network failures, and improve O&M efficiency.

Enterprise digital transformation

Communicate: With industry verticals going digital, how do you envisage the application of network intelligence in sectors like finance, transportation, education, and manufacturing?

Wu: Some private networks don’t have a huge amount of network elements or particularly large service volumes, so it’s comparatively easy to implement an intelligent IP network. However, enterprise customers have much higher demands for network intelligence than individual users, and they’re also willing to invest budget to achieve this. That means that these industries are good entry points for intelligent IP networks.

Financial services and manufacturing companies, for example, require intelligent networks. They want reliable and quality-guaranteed external network connection services that use software-defined WAN technology. They also have a clear demand to build high-quality corporate intranets using new connection technologies. An enterprise with many plants and workshops would need low-latency and even deterministic-latency networks to interconnect them. Without adopting intelligent technology, networks cannot achieve low latency or deterministic latency.

The traditional ICT industry is very familiar with consumers’ needs, but they don’t yet fully understand the needs of industries, especially the requirements of production networks. Therefore, the two sides need to
cooperate more closely to promote the large-scale deployment of intelligent IP networks in the IPv6+ era. That can also help the digital transformation of enterprises and cultivate more versatile talent in the process.

Standardization is also very important. Interoperability can only be better implemented with standards. Standards organizations like IETF are already standardizing IPv6+ technologies, with contributions from many Chinese enterprises and experts.

Network security is another important factor. In production scenarios, both financial and industry enterprises want to ensure network trustworthiness and security when promoting network intelligence.

New Infrastructure

Communicate: What role will enterprise and operator IP networks play in China’s New Infrastructure construction?

Wu: We can say that they’re the cornerstone of New Infrastructure, that they’re critical.

The information infrastructure aspect of the New Infrastructure comprises three parts: one, communication networks, including 5G, IoT, Industrial Internet, and satellite Internet. Two, new technologies such as cloud computing, big data, AI, and blockchain. And three, computing power, which includes data centers and intelligent super-computing centers.

The IP network is the bottom layer of information infrastructure and forms the foundation of 5G, IoT, and the Industrial Internet. It’s also the foundation of integrated infrastructure, such as smart grids and the Internet of Energy, and innovation infrastructure. ✨
Exploring the four-layer architecture of Intelligent Twins

*Huawei's Intelligent Twins is a self-growing and evolving intelligent system that requires application development partners from diverse industries to build. It will reduce the barriers to AI development for industry partners and help supercharge the intelligent application ecosystem.*

*Yuan Jing*
Director & Chief Scientist, Speech & Semantic Innovation Lab, Huawei
The Intelligent Twins architecture has four layers. From bottom up, they are intelligent interaction, intelligent connectivity, intelligent hub, and intelligent applications. These four layers rely on digital technologies to form an integrated whole and they work in conjunction.

**Intelligent interaction:** Where the physical and digital worlds converge

Consisting of intelligent edge devices, the intelligent interaction layer is a vehicle for optimizing and transforming the physical world.

The intelligent edge can be located anywhere between the data source and the cloud data center. It provides IT services through computing, storage, and the network. Any entity with intelligent capabilities that enables collaboration using cloud AI and other technologies can be called the edge. It takes the form of nodes, gateways, and even edge clouds.

The device-edge-cloud collaborative AI runtime framework can run massive edge AI applications to build a network of connected intelligent twins. Here, the core engine at the perception end is an edge Intelligent Twins with capabilities of holographic sensing, edge AI computing, and service decision-making. For the highest level of intelligence possible, consistent specifications for applications, deployment, runtime, data formats, and management interfaces are adopted across devices, the edge, and cloud to create a unified application ecosystem. This will boost application development efficiency and facilitate the sharing of digital assets in the community, so that efficient intelligence based on rapid application development, deployment, promotion, and data aggregation become possible. It will serve as a guide for the evolution

![Figure 1: Where intelligent interaction lies](image-url)
and upgrade of intelligent applications. On this basis, management and operations can be flexibly launched to provide the capabilities of continuously generating revenues. It also gives the ecosystem the drive and vitality to grow sustainably.

**Intelligent connectivity: The nervous system of Intelligent Twins**

In the digital world, connected people, things, and devices will interact with each other. The intelligent connectivity layer enables massive amounts of data from the digital world to continuously flow into the intelligent hub. The intelligence generated by the intelligent hub can then be injected into every application scenario, forming all-scenario intelligence.

To achieve this, the intelligent connectivity layer first provides ubiquitous ultra-autonomous gigabit networks with deterministic experience using physical connections like 5G and optical fiber to achieve seamless coverage and the connection of everything. It also enables digital assets to be created (development and integration) and also recycled (continuous sharing and revenue generation) on the cloud, allowing these assets to flow between different applications. This allows applications and data to collaborate on the same network.

**Intelligent hub: The core of Intelligent Twins**

The intelligent hub is the core of the entire Intelligent Twins architecture. It is designed to integrate infrastructure, data, AI, and application capabilities into a powerful hub. Harnessing cloud, it injects AI into enterprises’ main business and decision-making processes to generate huge value.

To achieve this, the intelligent hub processes data obtained by the intelligent interaction and intelligent connectivity layers and integrates it into intelligent applications. The intelligent hub includes data enablement, AI enablement, and application enablement modules.

**Data enablement module**

The data enablement module enables data that is physically distributed in different departments to be centrally managed and analyzed, so that data is shared within the entire organization. To meet enterprise needs for digital operation, Huawei provides one-stop intelligent data management capabilities to help organizations quickly build end-to-end intelligent data systems that integrate features from data access to data analysis. This, in turn, helps enterprises eliminate data silos, unify data standards, and accelerate revenue generation with data.

The data enablement platform consists of four parts:

**Data technology platform:** This platform integrates a range of components including the data lake governance center, data warehouse, databases, and big data. It enables logical data lakes, global data lifecycle management, and the centralized collaborative analysis of cross-source and cross-domain data. The platform also supports a two-level security collaboration mechanism: (1) intra-lake data security and inter-lake trusted computing, and (2) a global security brain.

**Enablement kit (methodology):** This is an online enablement workbench that consists of a workbench and an industry enablement
knowledge base. It helps users generate their asset models and improve asset efficiency.

**Asset center (data asset market):**
This integrates asset management and data models. Asset management refers to the basic management of asset models. Data models define standard data construction templates for industries/scenarios and accumulate industry asset models to enable trusted asset management and intelligent analysis of asset models.

**Data application (or data consumption):** Applications such as data visualization, sharing and exchange, and tag-based profiling are provided to build a data application ecosystem.

To sum up, the data enablement platform provides customers with a one-stop data lifecycle management solution. It forms a global, service-oriented, asset-based, intelligent, and secure data system, unleashing data value.

**AI enablement module**

The capabilities of the AI enablement module determine the level of intelligence of Intelligent Twins. Currently, the main AI capabilities are perception, cognition, and decision-making. To integrate all three, the AI enablement module includes an AI development platform, knowledge computing solution, and an AI application development kit derived from the AI development platforms and knowledge computing solution.

The AI development platform is a one-stop development platform for AI developers, and includes data processing, algorithm development, model training, and model deployment. To enable more AI developers to use it, the platform adopts multiple technologies including data pre-labeling, AutoML, and automatic parallelism. It offers a fast, user-friendly development process for AI developers with different levels of experience, making AI development easier.

Knowledge computing is a one-stop, end-to-end solution. Its core modules include knowledge acquisition, knowledge modeling, knowledge management, and knowledge applications. It’s designed to enable machines to acquire, present, manage, and apply knowledge using computer and AI technologies and thus utilize the vast amounts of domain knowledge contained in structured and unstructured data. With knowledge
Based on the most advanced AI technology, knowledge computing is a new way to integrate industry knowledge and AI.

Various forms of industry knowledge are scattered in different parts of every industry. To truly utilize industry knowledge, multiple technologies, such as multi-modal sensing and industry knowledge graphs, are required to perceive and represent multi-source heterogeneous multi-modal knowledge.

However, current AI technology is still in the phase of using the second-generation data-driven approach. To truly integrate AI with industry knowledge, a knowledge-driven approach needs to be developed and adopted, and technologies such as pre-trained models, neural-symbolic computing, and knowledge embedding should be used. This will create next-generation AI that is driven by both data and knowledge.

For example, in scenarios such as manufacturing and scientific research, examples of industry knowledge include domain knowledge, expert experience, and mechanism models. Mechanism models are derived from first principles and physical knowledge, and usually take the form of differential equations, forming a highly concise perception of things.

Knowledge computing focuses on integrating AI models and mechanism models. In general, there are three types of integration depending on the mechanism model involved: serial, parallel, and embedded. They respectively apply to three different scenarios: incomplete mechanism models, mechanism models with poor prediction performance, and mechanism models with prior knowledge extracted.

There still exists a great deal of knowledge that cannot be represented with mechanism models, for example, domain knowledge and expert experience. It's also important for knowledge computing to solve the problem of utilizing such knowledge.
Industry knowledge graph technology should be used to build industry-specific knowledge graphs, and the graph representation technology should then be used to model knowledge and observation data to yield more useful results of identification.

The AI development kit is an AI productivity tool. It utilizes the capabilities of the underlying AI development platform and connects underlying AI capabilities through workflows built up with multiple functional components to help customers easily build AI services specific to their domains. Workflow developers compile knowledge accumulated by algorithm and industry experts in corresponding kits and industry workflows. Technologies such as automatic labeling, small sample learning, and semi-supervised learning can make labeling easier for users. Users can then orchestrate new workflows for specific scenarios using existing functional components.

Application enablement module

The application enablement module enables fully cloud-based online development and one-click deployment on and off the cloud through low-code and zero-code development capabilities. With continuously accumulated industry assets, it makes software assets reusable, so that application development becomes as easy as building blocks. It also enables data interoperability between old and new applications in a way that's standardized, centralized, service-oriented, and non-intrusive.

Intelligent applications: Bringing intelligence to industry knowledge

Intelligent applications provide a personalized and active service experience every individual in a smart society can have. They are an important means of promoting effective industry decision-making and improving labor efficiency. Intelligent applications will provide services and solutions tailored directly to different problems, enhancing audiences’ smart experiences.

HUAWEI CLOUD will enable and aggregate industry know-how, reduce the barriers to AI development for industry partners, and help supercharge the intelligent application ecosystem of the digital world.
Building a network brain for enterprises with Autonomous Driving Networks

Huawei unveiled its Autonomous Driving Network (ADN) solution for the enterprise market at HUAWEI CONNECT 2020. By integrating AI capabilities at the network element (NE), network, and cloud layers, the ADN will power hyper-automated digital services and operations.
Enterprise digital transformation used to be about reducing cost and boosting efficiency, but now it’s about survival, particularly given the global pandemic.

Companies have realized the importance of ICT capabilities – from remote offices to research, production, and sales synergy. A firm’s digital capabilities determine its ability to quickly respond and innovate in the face of a crisis.

IDC reports that companies that implement digital-first strategies will not only be less affected by the outbreak, but will also lead recovery in the post-pandemic era. By 2024, 51 percent of the worldwide IT budget will be spent on digital innovation/ transformation – and in China the figure will be over 70 percent.

In the enterprise sector, digital transformation is moving away from traditional IT architecture-based information management towards cloud architecture-based intelligent operations. AI will enter every industry and become an integral part of the production systems and business processes of every enterprise.

**Connectivity powers business productivity**

Connectivity and computing are the two key components of enterprise digital transformation, with connection density and computing power amplifying each other. The combination of the two will both drive enterprise digital transformation and greatly boost the digital economy.

The increasing diversity of service scenarios, connected objects, and services means the demands on the capabilities of connections have risen. Connections need to intelligently identify service scenarios, efficiently orchestrate network resources, and swiftly and accurately provide reliable and secure connection services.

In essence, connectivity has become vital to driving businesses’ digital transformation. But it will not be possible to meet the connectivity demands of digital transformation through continuous bandwidth increases alone, which is how networks have traditionally evolved.

There are three driving forces behind ADN:

**Driving force 1:** From supporting offices to supporting production, networks are vital for business survival.

Over the past 20 years, connection networks for enterprises have been built chiefly to serve office scenarios. Digital office, tasks, transactions, and operations became the main focus of transformation as digital transformation advanced.

With the advent of the intelligent era, entire industries, processes, services, and audiences have undergone intelligent transformation, and the scenarios requiring network connectivity have extended from the office to production, cloud migration, and more.

In the case of one silicon wafer manufacturing plant, a 13-minute network interruption would cause a loss of more than 6 billion yuan (approx. US$917.2 million), due to the nature of wafer production – they have to be scrapped if production is halted partway through. A high-quality network at the plant would increase production efficiency by 6 percent, equivalent to gains of 3 billion yuan, compared with a
conventional network.

**Driving force 2:** Breakthroughs in networks continue to be made such as the evolution towards network-wide collaboration.

When enterprises go digital, many applications move online. Services are migrated to the cloud and multi-cloud architecture is adopted. Applications often need to traverse multiple networks, including networks in corporate branch offices and HQ, wide area networks, and data center networks. To meet the demand for different service levels, network-wide collaborative management is required.

Financial data centers have gone through three stages of digital innovation. In the Bank 2.0 era, financial data centers powered ATM services. There were few online services, and applications were mainly centrally deployed. Single data centers were adopted with monthly service launch cycles. Next, the Bank 3.0 era saw many new innovations in Internet financial services. Various payment and transfer services went online and applications shifted from a centralized to a distributed architecture. There was also a shift to multiple data centers and the service provisioning cycle was weekly.

In the Bank 4.0 era, there has been a growth in online services. During the pandemic, offline services have significantly contracted, while online services have grown rapidly. Financial institutions have been quick to launch innovative applications to help and protect people’s livelihoods. Some examples include an online service for providing rapid fund allocation, which was launched in a week, a service for donating points rolled out in a day, and a cash management service deployed in 8 hours.

Data centers have evolved towards multi-cloud and service rollout has been shortened to days or even hours. Quickly deploying services in a multi-cloud environment with heterogeneous vendors, networks, and computing is a huge challenge for the financial industry.

**Driving force 3:** The transition from static deployment to dynamic changes to ensure high-quality experience requirements.

The number of enterprise services is growing and these increasingly important services need to be rapidly adjusted, but frequent alterations are challenging the limits of manual network O&M. Networks must be able to flexibly implement dynamic strategies that enable intelligent perception and automated changes.

The Guangdong Government Affairs Network, for example, consists of a wide variety of private network services from over 20 departments, all with varied connection requirements. Sensitive services, such as emergency command and the finance department’s financial data, pose low latency and strict bandwidth requirements, calling for isolated hard pipe bearer channels. Real-time application services, such as video conferencing and online training, need the network to be able to respond in real time and services to be rolled out quickly. Surging cloud traffic and inter-cloud data center exchange traffic means the network requires large bandwidth connections.

In the education sector, nearly 300 million people took online lessons at home during the COVID-19 outbreak in China. After it was
brought under control, classes were resumed in 530,000 schools, which needed to be fully prepared with pandemic-prevention measures.

Many introduced innovative teaching models, such as multi-room classrooms, where a single teacher can teach students in up to eight classrooms, and “rain classrooms”, where teachers and up to 150 students can interact on their mobile devices, issuing coursework, uploading homework, asking and answering questions in real time, and interacting with bullet comments. And in addition to interactive and live teaching video services, campus networks also host course selection systems, educational administration systems, library searches, as well as services for students to browse the web, watch videos, and play games.

Ensuring a high-quality experience for core services, such as teaching and scientific research, on a campus network which carries a large number of different services has become a key challenge.

Building a network brain for enterprises

With the Autonomous Driving Network (ADN) solution, Huawei has introduced AI into the full stack for the connectivity sector. Huawei aims to build autonomous, self-healing, and self-optimizing autonomous networks through continuous innovation and data-driven network architecture to bring intelligence to networks.

The ADN solution will endow enterprises with “network brains” by integrating AI capabilities on three layers: network elements (NE), network, and cloud. Doing so will drive enterprise networks towards the autonomous driving era and empower hyper-automated digital services and operations across industries.

**NE + AI:** AI is introduced on NEs to create intelligent digital NEs. Each NE and the entire network are endowed with more precise perception, data processing, and inference execution. Forwarding strategies can be adjusted based on service intent, offering real-time guarantees of optimum service experience.

**Network + AI:** AI is used to reinvent the network management system. By building a digital twin of a network through an intelligent management and control system, the network can be controlled dynamically and managed in a closed-loop manner. Key enablers include automatic deployment, pre-event simulation, post-event verification, prevention and prediction, and proactive optimization.

Huawei’s integrated intelligent management and control systems iMaster NCE and iMaster MAE for management, control, and analysis can perceive network dynamics in real time, and construct a digital twin of a network to gain insights into the connection service experiences of each user, for every service, at every moment. They also automatically recommend network connections, repair network faults, and optimize network performance based on application intent.

**Cloud + AI:** Network AI training and model services are provided on the cloud. The software systems and AI models on devices and networks are continuously upgraded to boost autonomous driving capabilities. As a result, the more the network is used, the more intelligent it becomes. Huawei iMaster
NAIE provides data lake, model generation, model training, and ecosystem opening services on a cloud platform.

**Enabling digital innovation**

Revolutionary intelligent technology and a booming smart industry are evolving the interconnected era into the intelligent era, the development needs of which can be met by the ADN solution.

At the height of the COVID-19 outbreak in China, Wuhan’s Huoshenshan Hospital was built in just 10 days. Moreover, 1,000 Wi-Fi 6 devices were deployed in just three days, thanks to the cloud management network plug-and-play capabilities of the campus network. And supported by the automated hardware detection and configuration capabilities on the wireless network, deploying three 4G/5G converged base stations only took 30 hours. It was the ADN’s automated operational capabilities that powered the blindingly fast network construction and O&M and made this speedy miracle possible.

During the pandemic, insurance giant PICC also did its bit to support society, simplifying claims documents and procedures, and fully upgrading its 24-hour online services, including its rapid car accident claims service. Car owners can complete the entire claims process, from the accident report to payment settlement, at the scene of an accident, as long as they are using the app or on WeChat. But when it was in operation, PICC's customer services discovered that about 50 percent of user complaints about the service were linked to the data center network.

To solve this, PICC adopted the ADN solution. Huawei’s ADN identifies faults and abnormalities in one minute through machine learning. And leveraging knowledge graphs, it can locate faults in three minutes and repair them in five minutes. In this way, ADN helped PICC ensure an around-the-clock service experience for its customers.

Huawei’s own network spans more than 170 countries and regions, supporting 190,000 wireless offices and 80,000 audio and video conferences every day. During the COVID-19 outbreak, video and live broadcast traffic jumped by 350 percent.

When Wi-Fi networks transition from the office network to manufacturing scenarios and more devices and applications are connected, issues like wireless signal interference and roaming failures can impact service experience. Drawing on Huawei’s extensive experience and innovation in office and manufacturing scenarios, Huawei’s ADN solution leverages AI and big data technology to support features like radio frequency tuning and intelligent roaming.

The ADN solution has not only improved Huawei's network performance by more than 58 percent, but also driven up flexible manufacturing efficiency. On our mobile phone production line, for example, we can now produce one Huawei P40 model every 28.5 seconds.

The next decade will be a golden age for intelligence. Huawei will fully deploy AI into connectivity, leveraging data to transform the traditional O&M model and build more ADNs. This will see the network evolve from simple automation towards hyper-automation based on human-machine collaboration. Machines will go from assisting us to enhancing and empowering us. We also expect to achieve level-3 conditional autonomous networks in three years, level-4 highly autonomous networks in five years, and level-5 fully autonomous networks in seven to ten years.

Huawei is committed to taking on the complexity ourselves while making things simple for our customers. The evolution of the network towards fully autonomous driving will be a long-term process. Huawei will join forces with all stakeholders, from governments, enterprises, and partners to research and standards groups. Together we will scale new heights and usher in the age of autonomous driving networks.
Building 1-ms E2E latency to support City Intelligent Twins

Smart cities are a major vehicle of the digital economy, offering a new model for modernizing urban governance systems and capabilities underpinned by new digital infrastructure like 5G and F5G (fifth-generation fixed networks).

All-optical F5G networks & City Intelligent Twins

Intelligent Twins integrate data perception, data analysis, and data processing layers in a closed-loop system. Leveraging an intelligent
Building Intelligent Twins requires more than just capacity and speed increases in connectivity – it needs connectivity to become intelligent.

brain, intelligent edge platform, and ubiquitous on-device perception, they analyze and upload big data generated from people-to-people, things-to-things, and people-to-things connections. Through computational analysis, this complex big data and industry intelligence is fed back and applied to the physical city.

The intelligent connectivity layer is the body that supports the City Intelligent Twins solution. It connects the intelligent hub and intelligent interaction layers and enables seamless coverage, the connection of everything, and synergy between applications, data and organizations.

Building Intelligent Twins requires more than just capacity and speed increases in connectivity – it needs connectivity to become intelligent based on ubiquitous gigabit, deterministic experience, and hyper-automation.

**Ubiquitous gigabit:** Bandwidth is the cornerstone of connectivity. Ubiquitous, seamless gigabit connectivity will become a basic requirement for expanding the adoption of ultra-HD AI cameras, drones, industrial cameras, and industrial VR/AR applications.

**Deterministic experience:** Intelligent Twins mainly involves connections to things in industry scenarios, which are bringing increasingly diverse requirements. For example: in the Shanghai Stock Exchange, more than 3,000 transactions involving over US$1 million are conducted in under 1 ms. In one large cloud computing data center, a 0.1 percent packet loss was shown to cause a 50 percent decrease in computing power. And future smart grids will need to guarantee up to six-nines reliability and maximum average annual power outages of under two minutes per household. These three examples show that only connections with deterministic experience can guarantee service quality.

**Hyper-automation:** Industry digital transformation has multiplied the number of services and the scale and complexity of networks, increasing the difficulty of O&M management. Introducing intelligent AI technology will make it possible to transition from traditional manual O&M to semi-automated O&M and then to hyper-automated, intelligent management and control. This will, in turn, continuously improve the efficiency of intelligent connectivity.

Computing power enabled by “cloud + AI” is the building block of the intelligent hub. Transport capacity built on the all-optical
Building 1-ms E2E latency to support City Intelligent Twins

F5G network is the foundation of intelligent connectivity. Large bandwidth, high reliability, zero packet loss, differentiated services, and intelligent O&M will guarantee the quality of intelligent connectivity and form the basis of connectivity for Intelligent Twins, helping us to bring ultimate service experiences to every person, home, and organization.

Building a foundation for the digital economy with 1-ms E2E latency

A network’s value used to be determined by its transport capacity. But a “new” Metcalfe’s law has redefined measurement standards. Now a network’s value is dependent not only on network scale, but also on network quality – bandwidth and latency have become key factors determining network quality. Fiber’s powerful advantages such as terabit bandwidth, petabit capacity, and light-speed transmission will ensure stable and high-quality transport capacity.

Under China’s New Infrastructure Plan, the scale of data center construction continues to expand. Providing differentiated service experiences and seizing the strategic opportunity of going fully cloud-based through extensive cloud-network integration has become a key development goal for operators worldwide.

Operators should aim to build cloud-network synergy, promote the cloud with the network, and establish low network latency to maximize the advantages of communication infrastructure and build all-optical networks for the city with 1-ms E2E latency in three scenarios: edge-to-cloud, cloud-to-cloud, and edge-to-edge.

Edge to the cloud: 1 ms latency from the network edge to the cloud. In home scenarios, the optical transport network (OTN) and optical line terminal (OLT) handshake enables 1-ms latency from the OLT to the cloud, guaranteeing the quality of cloud services, such as home virtual reality (VR) and cloud gaming. In enterprise scenarios, 1-ms latency from OTN customer premises equipment (CPE) to the cloud supports ultra-low latency transmission for latency-sensitive services, such as financial securities transactions.

Cloud to cloud: Network interconnection between different clouds with 1-ms latency. One-millisecond latency between data centers in different locations in the same city enables high-speed collaborative computing between data centers.

Edge to edge: 1-ms latency between any two points on the network edge. In 5G bearer scenarios, moving the OTN to the baseband unit (BBU) supports 1-ms latency between base stations, minimizing transmission
latency. Together with the low latency of the 5G air interface and 5G core network, this can guarantee low latency for 5G B2B services and applications.

All-optical networks with 1-ms latency in cities will drive the rapid growth of the digital economy, in the same way that 1-hour intercity journey times realized by intercity high-speed trains have provided a massive economic boost to cities.

**All-Optical City 2.0 defines KQIs for city network transport capacity**

Since 2013, China has been extending the fiber network and decommissioning copper, and building full-fiber cities, with the term "full-fiber city" being included in the government’s 2016 work report. Building full-fiber cities is aimed at improving home services – providing fiber-to-the-home, 100M access bandwidth, and meeting people’s basic broadband connection demands, as part of the Broadband China strategy.

However, smart city services and applications have moved beyond the home to every person, industry, and enterprise. Intelligent Twins is a notable example. These new applications and services have higher connection, bandwidth, and experience requirements.

To meet the needs of this Cloud + Network + X intelligent connection of everything, Huawei has launched the All-Optical City 2.0 development concept – a new infrastructure based on F5G that will offer improved bandwidth, connectivity, efficiency, and experience:

**Bandwidth:** 10x increase in
bandwidth, with 100 Gbps for campuses, gigabit access, and 10 Gbps for buildings.

**Connectivity:** 100x increase in connectivity supporting the optical connection of everything, with fiber coverage to every desktop, room, and machine.

**Efficiency:** 100x efficiency increase with the automatic driving network, supporting private line deployment in minutes and home broadband deployment and decommissioning in seconds.

**Experience:** Deterministic experience with stable low latency, stable availability, and zero packet loss.

As AI technology matures, the demand for computing power in every industry is rising rapidly. As a whole, the industry has shifted its focus to unlocking computing power through transport capacity and ramping up the digitalization of all industries. For service experience, All-Optical City 2.0 defines KQIs for latency, capacity, availability, service activation time, and autonomous driving.

**Latency:** 1-ms E2E latency, cloud-network synergy, and promoting the cloud with the network can meet the low-latency requirements of innovative applications in various smart city connection scenarios.

**Capacity:** 3-gigabit full-fiber access and terabit bandwidth full-fiber gateways will provide E2E ultra-large bandwidth capacity guarantees for smart cities.

**Availability:** Moving from best-effort to deterministic experience offers guaranteed five-nines high availability, ensuring secure operations for smart cities.

**Service activation time:** Cloud-fiber integration, collaborative control, and unified orchestration enable on-demand access to cloud network resources, providing minute-level service activation for smart cities.

**Autonomous driving:** An intelligent management and control platform with AI technology and applications provides automated, self-service service experience and differentiated service capabilities. Active O&M and fault prediction make it possible to transition from manual O&M to tool-assisted execution and then fully intelligent operations with self-service decision-making, enabling full autonomous driving in smart cities.

**All-Optical City 2.0 enables deterministic service experience**

Huawei’s All-Optical City 2.0 strategy aims to build communication infrastructure that matches the needs of cities based on the requirements of innovative smart city application scenarios. As part of the strategy, 1-ms E2E latency will support a cloud-based full-fiber network for user and cloud connections, enabling innovative applications in different industries upstream, lighting up dark fiber downstream, and facilitating the full management of underlying resources. This will decouple physical fiber resources and the service logic network, and in combination with photoelectric integration to reduce equipment energy consumption, will free up more equipment room resources. All-Optical City 2.0 will enable deterministic service experience in home, government, and enterprise scenarios.
The first step will be extending the fiber network to the terminal to connect every person, home, and business, to provide the most reliable physical connections and build a pipe foundation for connectivity.

Second, extending OTN coverage in the metro network closer to access points, such as optical line terminals (OLT), baseband units (BBU), and company branches, will provide high-speed 100G links, supporting edge-to-edge and edge-to-cloud high-speed connections.

Third, all-optical cross-connect (OXC) at the core of the metro network will form a mesh interconnection network, supporting one-hop to the cloud between any two points thanks to 200G/400G ultra-high-speed transmission.

Finally, an E2E intelligent management and control system will support manageability, visibility and control of the city’s entire fiber network, providing operational guarantees for the entire All-Optical City 2.0 network.

Building the target architecture of an all-optical network for a city will require full-fiber access, all-optical gateways, all-optical switching, and all-optical autonomous driving.

**All-optical access:** Diversified fiber access scenarios support fiber access for homes, factories, buildings, large enterprises, and 5G sites. In the home, eAI can intelligently identify the type of home services. Wide-scale use of 10G PON and Wi-Fi 6 will drive gigabit acceleration of legacy broadband networks. Fiber-to-the-router (FTTR) will guarantee high-quality Wi-Fi coverage for the whole house, helping achieve our three gigabit goals (gigabit 5G, gigabit broadband, and gigabit Wi-Fi). Fiber access to the factory (FTTF) will further improve the reliability of connections in industrial manufacturing scenarios. Fiber to the building (FTTB) will upgrade a large number of SME private lines. And extending OTNs to large enterprises, buildings, and 5G sites will provide optical connections that will support the digital transformation of large enterprises and increase the adoption of 5G B2B applications.

**All-optical gateways:** Multiple gateway technologies including OTN, OLT, and BBU are deployed at access sites in cities’ all-optical networks. They will act as the “metro stations” of the smart city, bearers for network capabilities, junctions for multiple services, and the starting point for deploying services to the cloud. Deploying deterministic full-fiber gateways addresses the uncertainty of the access segment, not only enabling anytime access in the city within a distance of 2 km to 5 km, but also maximizing the economic value of 1-ms E2E latency.

**All-optical switching:** All-optical switching provides a “highway interchange” for the smart city. Fast and efficient multi-layer, multi-directional traffic grooming will replace multi-hop forwarding in legacy network transmission, further reducing the number of photoelectric conversion nodes, enabling one-hop to the cloud from optical gateways. Also, OSU-OTN technology will simplify encapsulation, reduce single-site latency, and provide high-reliability and low-latency guarantees for various services with end-to-end all-optical slicing.

**All-optical autonomous driving:** AI-powered intelligent management and control and integrated analysis will equip all-optical city networks with smart brains. These will perceive...
City Intelligent Twins networks in real time using multi-dimensional dynamic monitoring and provide data analysis and the visual presentation of network resources. This will enable the rapid fixing of link failures and deliver modern operations and governance capabilities for smart cities. At the same time, directional optimization of network paths through the visibility, manageability, and controllability of the latency of each service will enable committed latency for services and accelerate business monetization.

Thanks to deterministic experience, All-Optical City 2.0 can guarantee zero jitter and zero packet loss between any nodes, satisfying 1-ms low-latency applications. At the same time, it can provide an ultimate experience for minute-level service activation, terabit gateway bandwidth egress, and maximum five-nines availability, enhancing the all-round competitiveness of smart cities and allowing city Intelligent Twins to thrive.

**Three steps to accelerate All-Optical City 2.0**

To accelerate the implementation of All-Optical City 2.0, Huawei recommends that the following three steps are carried out concurrently:

**Proactively plan gateways:** move from passive to proactive planning, and rationally distribute the location of all-optical gateways in the city using scientific urban network planning methods and tools, according to the existing layout of all-optical access resources and edge data center plans. This will achieve the synergistic layout of urban infrastructure such as 5G, gigabit access, and data centers.

**Reconstruct the metro network core:** optimize the network structure using all-optical switching to promote full mesh, flattening, and integration of the network to improve network robustness.

**Cloud-network interconnection planning:** optimize cloud resource pool deployment to overcome limitations in data center space planning with high-quality all-optical networks and reduce the difficulty and overall cost of cloud pool construction.

Digital opportunities are accelerating at a new level and all industries are undergoing intelligent upgrades. All-Optical City 2.0 as the foundation of connectivity will support digital governance, digital economy, and digital lifestyle applications for the city, and create a trillion-dollar blue ocean for the optical networking industry. Huawei will work with both upstream and downstream partners to harness the integrated intelligent architecture of cloud-network-edge-device for cities, enable industries, support application innovation, and turbocharge the ecosystem and build a smart society.
ModelArts 3.0: A true AI accelerator

During HUAWEI CONNECT 2020, Tian Qi, Chief AI Scientist at HUAWEI CLOUD, presented the results of HUAWEI CLOUD’s long-term research into AI and unveiled ModelArts 3.0 – a one-stop AI development platform designed for AI application in industries.
HUAWEI CLOUD’s Enterprise Intelligence (EI) has achieved strong results in numerous industry competitions and evaluations. HUAWEI CLOUD has invested heavily in the basic research of AI in three domains: computer vision, speech and semantics, and decision optimization. Focusing on four areas – model efficiency, data efficiency, computing power efficiency, and knowledge efficiency – Huawei has proposed six basic research plans:

- High-performance Model for large models
- Lightweight Model for small models
- Data Magic Cube for multi-modal learning
- Data Iceberg for small sample learning
- Generic Vision for general knowledge extraction
- V-R Integration for a new learning paradigm

To help AI empower all industries, the ModelArts enabling platform supports the plug-and-play deployment of HUAWEI CLOUD’s research results in areas such as automatic machine learning, small sample learning, federated learning, and pre-training models.

**The three basic research areas of AI**

In the area of perception, HUAWEI CLOUD continues to be an industry-leader in ImageNet large-scale image classification, WebVision large-scale network image classification, MS-COCO two-dimensional object detection, nuScenes three-dimensional object detection, and visual pre-training model verification, including downstream classification, detection, and segmentation.

Perception models driven by ModelArts have been widely used in sectors such as medical image analysis, oil and gas exploration, and fault detection in manufacturing.

In cognition, HUAWEI CLOUD integrates industry data based on its expertise in semantic analysis and knowledge graphs. By managing diverse, complex, and siloed datasets, it has leapt from perception intelligence to cognitive intelligence. Cognitive models driven by ModelArts have been used for a range of tasks, including drug-target prediction, financial fraud analysis, and intelligent after-sales services.

In the field of decision-making, Huawei has built a complete foundation for decision-making based on various algorithms, including operations research optimization, reinforcement learning, and intelligent control algorithms. This has made possible a true intelligent closed loop of perception-cognition.decision making.

The decision-making engine driven...
by ModelArts has already been deployed in multiple sectors, including aircraft stand allocation, industrial manufacturing, intelligent transportation, and gaming and entertainment.

HUAWEI CLOUD’s ModelArts 3.0 is a one-stop AI development platform for the AI industry. HUAWEI CLOUD has been exploring ways to use AI to efficiently solve industry challenges, such as training high-precision models with very little data, lowering the barriers for AI adoption in the enterprise sector, and solving business concerns about the safe use of data. ModelArts 3.0 integrates backbone models, federated learning, intelligent diagnosis, evaluation and optimization, and high-efficiency computing power.

The four new features of ModelArts 3.0

HUAWEI CLOUD’s backbone tool-chain EI-Backbone integrates model efficiency, data efficiency, computing power efficiency, and knowledge efficiency, and optimizes AI deployment capabilities by enterprises in different industries. EI-Backbone’s capabilities have already been successfully verified in over 10 sectors, it’s won more than 10 industry challenge competitions, and had more than 100 top-level conference papers presented on it.

EI-Backbone offers a new paradigm for AI development. For example, medical image segmentation for the lung used to require hundreds or thousands of labeled data for training, but with EI-Backbone, training can be completed using just dozens of labeled data – and even as few as ten – reducing labeling costs by 90 percent.

In the past model selection and hyperparameter tuning for lung medical image segmentation required extensive expert experience and trial and error. Now, with EI-Backbone’s full-space network architecture search and automatic hyperparameter optimization technology, it can be completed quickly without manual intervention.

Moreover, precision is greatly improved. And instead of the weeks it would take from scratch, model training, testing, acceptance, and deployment can be completed in a few hours, or even minutes, by loading a pre-training model integrated into EI-Backbone. This can lower training costs by more than 90 percent.

ModelArts 3.0's latest big feature: federated learning

Data is the cornerstone of AI applications and intelligent perception by AI depends on diverse data. However, when AI is deployed in industry scenarios, data silos in industry applications created by data being scattered across different data controllers reduce the effectiveness of training AI algorithms.

To solve this issue, HUAWEI CLOUD’s ModelArts 3.0 provides federated learning, which supports joint modeling while letting the data stay where it is. Users use local data for training and exchange updated and encrypted model parameters, rather than exchanging the data itself, therefore enabling collaborative training.

In collaboration with Professor Jiang Hualiang from the Shanghai Institute of Materia Medica, Chinese Academy of Sciences, HUAWEI CLOUD EI leveraged Huawei’s self-
developed FedAMP algorithm and AutoGenome algorithm in AI tasks for drug research and development. They were able to accurately predict the water solubility, cardiotoxicity, and kinase activity of a drug at a level far exceeding traditional federated learning and deep learning algorithms.

Furthermore, HUAWEI CLOUD's cloud collaboration service supports federated training using data from different locations and customers. Encrypted data can be uploaded to servers where the global model is updated and then distributed to edge devices. This makes it easy to support same-format horizontal federation and cross-format vertical federated learning.

Users can participate in federated training through the cloud or the computing capabilities of HUAWEI CLOUD edge devices (such as intelligent microsites), which enables intra-industry joint modeling.

Models must be fully evaluated before they are deployed and launched. Models with excellent results are directly put into the production environment, while those with unsatisfactory results need to be further optimized and iterated.

ModelArts provides a comprehensive visual evaluation and intelligent diagnosis function. This lets developers intuitively understand the performance of all aspects of the model and carry out targeted tuning or deployment for production.

To evaluate the classification model for epithelial disease cells, for example, ModelArts maximizes precision by providing a data sensitivity analysis module to evaluate the performance of the model in different data feature sub-intervals, as well as providing conventional indicators such as accuracy, precision, recall, F1 value, confusion matrix, and ROC curve.

ModelArts provides operator-level time and space consumption statistical analysis and various overall performance indicators. It also gives suggestions for model performance such as model quantification and distillation. For interpretability, it provides a heat map to show areas the model uses to make inferences. ModelArts also offers various methods for evaluating model trustworthiness, providing multiple evaluation indicators for model security and capability. It can also give diagnostic suggestions for improvements based on the model's current performance.

With the continued growth of distributed training for deep learning, model training has increased demand for computing equipment. However, resources for training tasks are often not fully utilized for a number of reasons, including:
Flexible training is one of ModelArts' core capabilities. It can adapt to required model training speeds for optimum resource allocation.

ModelArts provides two modes. Turbo mode fully utilizes idle resources to accelerate existing training tasks by 10 times or more without affecting the convergence precision of the model. Economic mode maximizes resource utilization, providing developers with the ultimate price/performance ratio, boosting it by over 30 percent in most scenarios.

To better support AI R&D with large computing power requirements, the ModelArts platform has optimized cluster size, task numbers, and distributed training, and the ModelArts R&D platform can manage tens of thousands of nodes for large-scale training tasks. By optimizing the service framework, the ModelArts platform can run and support large-scale distributed tasks with 10,000 processors while supporting 100,000 operations.

A key capability of distributed training on a large-scale cluster is its excellent distributed acceleration ratio, and this is also a key factor encouraging users to opt for large-scale clusters to accelerate AI services. HUAWEI CLOUD's ModelArts offers industry-leading distributed acceleration capability. Its 512-chip cluster can run the ImageNet 1K image classification MLPerf benchmark in 93.6 seconds, smashing the NVIDIA V100's 120-second record. Thanks to backbone models, federated learning, model diagnosis and optimization, and efficient computing power, HUAWEI CLOUD's ModelArts will accelerate the application of AI in business scenarios.

Looking ahead, Huawei will continue to concentrate on the four areas of model efficiency, data efficiency, computing power efficiency, and knowledge efficiency, and invest heavily in AI research. Focusing on its basic research plans in the AI domains of computer vision, speech and semantics, and decision-making optimization, HUAWEI CLOUD will keep striving to provide powerful AI technology to help each developer reach their full potential and create unique value. We will continue to make AI more inclusive and grow together with developers around the world.

Expert Forum
Digital twins have become increasingly popular as Industry 4.0 and IoT continue to develop. When combined with Huawei’s Industrial Intelligent Twins and big data analytics, digital twins provide a full chain of intelligent services, covering design, production, logistics, sales, and services. They can also help enterprises analyze and extract value from data to build leadership in the industry.

When a digital twin is created for an industrial robot, it accurately displays the angle, speed, and acceleration of robotic arms in real time. Based on data about the robot’s previous and current state, the digital twin can predict if and when a fault will occur, making O&M more efficient and reducing unexpected downtime and labor costs.
What are digital twins?

The idea of a digital twin was first proposed by Professor Michael Grieves from the University of Michigan. He described it as "a virtual presentation of a physical product" in the product lifecycle management (PLM) concept. As IT becomes more advanced, the meaning of digital twin is also evolving. According to NASA, a digital twin is about using data, such as physical models, real-time status, and running history, to reproduce, map, and synchronize the shapes, attributes, behaviors, and rules from the physical world in a virtual world through simulation. The simulation is based on established experience and knowledge, so as to reflect the whole lifecycle process of the physical world.

With a digital twin, we can digitalize entire processes from product design and production planning to manufacturing execution, making product innovation and manufacturing more efficient. Imagine building a complete digital twin for an entire city. By monitoring a whole urban environment in real time with the digital twin model, we could better utilize city resources and enable intelligent traffic scheduling.

Key technologies behind digital twins

There are several key technologies behind digital twins:

**Digital models to connect the physical and virtual worlds**

How do you link the physical world with the virtual world? By modeling the physical world. That means you need to digitalize the physical world with models and map the physical world to a virtual world.

**Simulation and real-time synchronization**

When a product is put into actual production and running, its status changes along with changes to materials, processes, personnel, or environment parameters. These changes happen in the digital space in real time through synchronization with digital twins.

**Data analytics for intelligent prediction**

Machine learning and AI analyze the large amounts of data generated by sensors installed in the physical world in real time. This allows the digital twin to detect exceptions and perform predictive maintenance based on established experience and knowledge, so that enterprises can make more accurate predictions and informed decisions.

Unified modeling languages like DTML can support unified digital twin modeling and open ecosystem building, contributing to an interconnected digital world.
The combination of digital twins with IoT devices and business systems can be scalable, enabling enterprises to track the past and predict the future.

**From physical to digital: Building intelligent infrastructure with digital twins**

The combination of digital twins with IoT devices and business systems can be scalable, enabling enterprises to track the past and predict the future, perform real-time predictions, and leverage intelligent data analytics and AI services.

**HUAWEI CLOUD IoT helps build digital twins**

Digital twins can be great, but they can be challenging to implement. First, the physical objects that need to be modeled are usually complex systems. For example, one production line in a steel plant can have more than 6,000 measurement points, and the relationships and interactions between those points are complex.

Second, digital twins require powerful real-time computing capabilities. Physical objects are constantly generating data, and real-time mapping between digital twins and physical objects is very computing-intensive. Measurement points on a production line report data every few milliseconds and thousands of service indicators need to be calculated in real time, so that raises the bar for the model's real-time computing resources.

HUAWEI CLOUD IoTA centers on the digital twin model and is deeply integrated with asset models through the standard modeling language DTML. During data analytics, developers can easily reference IoT model data to get their job done more efficiently. Numerous algorithm models, which are pre-integrated in HUAWEI CLOUD Industrial Intelligent Twins and draw on the best practices of Huawei and the industry, are available to help users greatly improve data analytics efficiency.

Devices in the real world are not discrete. They are connected through complex relationships, such as space, organization, person, and context. IoT companies need to connect the physical world to the digital world, better understand their devices, and quickly and efficiently analyze data. These have become basic services that IoT services desperately need.

HUAWEI CLOUD IoTA provides a set of open and scalable advanced modeling languages (DTML), which contains basic words for things like object attributes and relationships between private events. With this, users can create their own vocabulary for their own industries to accurately define the digital forms of their complex physical objects.

For buildings, as an example, we can build complex relationships between things and other things, between things and space, and between things and people. Then we interpret the data generated from these connections in the context of the digital model. Finally, we can use an IoT+ asset model to build a digital twin that is synchronized with the physical world in real time. This way, a unified and consistent data foundation can be provided for data analytics through model abstraction.

HUAWEI CLOUD IoTA provides powerful tools and capabilities to build digital and intelligent infrastructure.

**Efficient and visualized modeling**

HUAWEI CLOUD IoTA uses "What You See Is What You Get (WYSIWYG)" graphical modeling to simplify the development of complex digital twins. A tree structure is used to describe the internal relationships of complex physical objects, including spatial relationships, combination
relationships, and upstream and downstream relationships. Virtual measurement points support multiple calculation operators, including basic arithmetic, scientific notation, triangle functions, sliding windows, and stream computing. Asset model templates can also be defined and quickly copied.

**High-performance model engine**

HUAWEI CLOUD IoTA’s high-performance model engine supports high concurrent and real-time computing capabilities that can easily complete 100,000 concurrent computing tasks to ensure that digital twins can map optimal statuses in real time.

**A unified model with multiple analysis capabilities**

HUAWEI CLOUD IoTA supports spatio-temporal convergence and analysis, enabling users to analyze data based on a digital twin across multiple time and spatial dimensions. It has also embedded an interface for interconnection with AI. Developers can deploy AI with just a click, imbuing digital twins with intelligent inference and new capabilities.

**Case study: Asset tracking in smart warehouses**

With digital twins at its core, HUAWEI CLOUD IoTA, can build a digital model for warehouses and act as a one-stop platform for data collection, cleaning, storage, and analysis capabilities.

When an asset enters or leaves a warehouse, an RFID reader automatically scans its RFID tag information and reports it to the cloud IoT platform. The cloud performs further data analytics based on the digital twin model to determine whether the asset is inbound or outbound. The entire process goes as follows:

1. Check whether the assets have entered and left correctly based on inbound and outbound orders, and provide the onsite service dashboard that gives onsite operators real-time visibility on the check results.

2. Collect information of assets inbound and outbound, and update the statuses of assets immediately after they are taken into or out of the warehouse. These capabilities support transparent management of inbound and outbound assets.

Making sense of the massive amounts of data generated by both the physical world and the Internet is a crucial step towards building a digital world that supports real-time interaction. With HUAWEI CLOUD IoT, users can tap into their IoT data and digital twins to push the envelope of what’s possible and stay ahead of the digital curve.
For Intelligent Upgrades, Go for Intelligent Connectivity

Ubiquitous Gigabit
Deterministic Experience
Hyper Automation
The many benefits of the Shenzhen Intelligent Twins

Working with the Shenzhen government, we've leveraged our superior technology in 5G, cloud, AI, and computing to build the Shenzhen Intelligent Twins and create a model for a global digital economy and city.

By Lin Qing, Marketing Operations Department, Huawei Cloud & AI BG
The many benefits of the Shenzhen Intelligent Twins

The Shenzhen Intelligent Twins solution is a city-wide integrated intelligent system that enables the city to perceive, think, evolve, and be more human. It provides citizens and enterprises with active, accurate, intelligent, and efficient services. The solution has introduced intelligence to many sectors in Shenzhen, allowing its people to enjoy the fruits of the city's smart transformation.

The Shenzhen Intelligent Twins solution builds on the “Six Ones Digital Shenzhen” initiative, which includes:

- A comprehensive perception network
- An electronic public service system
- A one-click decision-making assistance system
- An integrated public safety and urban operations management system
- An innovative and entrepreneurial service platform
- An integrated citizen service platform.

The Shenzhen Intelligent Twins solution represents the top-level design and planning blueprint for Digital Shenzhen. It harnesses intelligence to power all scenarios in the city, to provide high-quality and convenient experiences for residents and enterprises alike, making Shenzhen a fantastic place to live and do business.

It also enables machines to take on high-risk, highly-repetitive, high-precision tasks, massively improving overall productivity and safety. The system’s all-encompassing perspective allows us to exceed the limits of space, time, and representation. It equips us with new capabilities and permits us to see higher and further, with greater accuracy.

Battling the pandemic with technology

During the coronavirus outbreak, Shenzhen harnessed AI for early detection, early reporting, early diagnosis, early isolation, and early treatment.

Experts from Peng Cheng Laboratory and Shenzhen’s Center for Disease Control and Prevention built a virtual doctor for COVID-19 using a deep matching model for medical knowledge. The virtual doctor not only assisted medical staff with inquiries, but also provided clinical recommendations for medical care or diagnosis and treatment guidelines compliance.

Shenzhen University General Hospital and Bao’an People’s Hospital used AI in a range of tasks, including to identify and label pneumonia lesions in images, visually display the size and proportion of patients’ lesions, generate the anatomical positioning of the lesions, distinguish the left and right lungs, and automatically output a 3D reconstruction. AI was also used to compare patients’ initial diagnosis and re-examination. The visual presentation of results allowed doctors to quickly conduct qualitative analysis and give diagnoses in seconds, considerably improving diagnosis efficiency.

Digital airport: A first-class experience

To transition from paper boarding passes to a facial recognition system, Shenzhen Airport collaborated with Huawei and the Shenzhen Civil Aviation Administration to plan and roll out nearly 100 smart projects. The new
The system has reduced the number of delays and improved flight punctuality.

The intelligent large-scale operations and control system based on airport collaborative operations (A-CDM) and an intelligent operations center (IOC) built by Shenzhen Airport has helped it implement global situational awareness, prediction and early warnings, coordinated operations, and intelligent decision-making, greatly shortening flight transit time.

Shenzhen Airport also launched a high-intelligence guaranteed flight phases acquisition system that uses IoT and intelligent video analysis to collect data on on-the-ground assured critical flight phases, with an accuracy rate of 95 percent. By monitoring the whole flight guarantee process, anomalous conditions in guaranteed phases that may affect clearance delivery can be rapidly discovered and solutions coordinated, which has improved on-time performance.

Shenzhen Airport is also the first airport in China to introduce AI algorithms into its intelligent terminal stand allocation system to enable the automatic and intelligent allocation of terminal stands. Now the airport can complete the allocation process for more than 1,000 daily flights in a minute; before it used to take four hours. The system can also be refreshed every 10 minutes. The new solution has improved contact stand rate and passenger boarding bridge turnaround time at the airport.

Shenzhen has 3.35 million motor vehicles, equivalent to 510 cars per kilometer, the highest vehicle density in the country. This used to be the cause of significant conflict between pedestrians, cars, and roads. To solve the issue, Shenzhen Traffic Police (STP) adopted AI and 5G technology in various aspects of traffic law enforcement, congestion reduction measures, and control and command.

Working with Huawei Cloud, STP constructed a unified, citywide intelligent traffic lights control network. The traffic light timing solution powered by AI, big data, and other technologies has slashed average wait time at key intersections by 17.7 percent and boosted traffic capacity by 10 percent. The system also allows emergency vehicles such as ambulances to encounter only green lights on the way to their destination.

AI is also used to assist law enforcement. A decision-making platform can respond in seconds to data from automatic vehicle identification checkpoints, while a secondary AI-based recognition system is used to identify unique features of vehicles, increasing the recognition efficiency of traffic infringement images by 10 times, ensuring closed-loop processing of these images.

**Weather predictions are spot on with intelligent detection**

The Shenzhen Meteorological Bureau (SMB) and Huawei inked a framework agreement to build a comprehensive Weather + Cloud + AI + 5G cooperation model, leveraging cloud computing, AI, 5G, and IoT. The model has helped SMB launch an intelligent grid-based precise forecasting service for the mega city.
and realize the cross-generational upgrade of weather services.

The solution uses advanced technologies, such as 5G and edge computing to improve the frequency and accuracy of meteorological observation collection. Images collected by cameras are pieced together to generate a complete picture of clouds in the sky, which can be used for grid-based accurate weather prediction.

Machine vision is used for the automatic observation of clouds and rain. The solution can observe just 0.2 mm of light rain, which offers faster, more accurate, and more frequent observation compared to manual methods.

Finally, the solution leverages AI for the precise short-range prediction of rainfall. AI algorithms build a spatio-temporal convolutional recursive network to capture the dynamics of cloud clusters and then predict future trends in radar echoes based on mass historical data. It provides powerful assistance for manual forecasting and can significantly improve forecasting for short-range rainfall compared with conventional optical flow.

Intelligent inspection safeguards reliable power consumption

In partnership with Huawei, Shenzhen Power Supply Bureau set up a joint innovation lab to build an intelligent power inspection solution. The solution uses machine vision with Internet-connected monitoring cameras on power transmission towers and drones to identify five typical potentially hazardous scenarios and seven major defects in transmission lines. The solution has increased inspection efficiency by dozens of times, and can also quickly discover hidden hazards that are not easy to detect using conventional manual ground inspections. The solution can detect faults and hazards in real time and perform predictive maintenance, dramatically improving the reliability of the power grid and guaranteeing the power demands of Shenzhen residents.

Intelligence speeds up government administration

The management services command center built by Shenzhen Government and Huawei is the operational and command hub of the smart city. Opening up massive amounts of data and systems, it forms a three-level subdistrict-district-city command system. The full visualization of information and coordinated operations across a single network makes data-driven city management services more precise, scientific, and intelligent. This has helped Shenzhen continue to top the tables in terms of online government services in China.

In Longgang District, Shenzhen, Huawei and its partners helped the government integrate the service systems of 89 departments. In total, the government aggregated a dataset of more than 3.7 billion rows. The city’s IOC has five capabilities: data center, operations center, monitoring center, distribution center, and command center. So far, 2,534 items of structured service data have been fed into Longgang District’s big data platform. The total volume of data exceeds 3.7 billion rows and measures 2.7 TB. This will serve as a solid and powerful foundation for government data. AI-powered intelligent customer services,
pre-checks, and form-filling have cut down user wait time by 50 percent by increasing the handling rate by 29 percent and the pre-registration rate by 22 percent.

Smart policing ensures the city's safety

Through fund planning, platform construction, data management, and application integration, the Technology and Information Committee and Intelligence Committee of Shenzhen Municipal Public Security Bureau (SMPSB) has integrated more than 100 of their systems into six core platforms, cleaned and added 150 billion rows of data to the database, and standardized the acquisition standards.

This has helped SMPSB achieve its goals to acquire data through police work and apply that data and share data across the entire police force. A network of cameras with AI-powered facial/license plate recognition, intelligent video retrieval, trajectory analysis, and gesture recognition form a system that incorporates multiple investigation technologies in one, helping support the fight against crime and a grassroots governance model tailored to Shenzhen.

In Bao’an District, China Telecom and the district’s public security sub-bureau conducted a smart police station application scenario test at Tangtou Police Station. The solution comprised 5G, intelligent law enforcement devices, real-time HD video backhaul, and AI intelligent recognition. It enabled multi-dimensional police patrols consisting of automatic police drone patrols, police motorcycle patrols, an officer-based intelligent law enforcement system (with AR glasses and law enforcement recording devices), and visualized emergency command. The technologies have helped continuously improve the effectiveness of policing and are being used to build a multi-dimensional law enforcement system for 5G scenarios and a 5G multi-dimensional police station.

Smart risk control supports worry-free spending

To become a financial center, ensuring a safe financial environment is key. To guard against financial risks, China Merchants Bank, which was established in Shekou, Shenzhen in 1987, has for many years used a smart risk control system built on big data risk control and AI for its credit cards to keep the rate of non-performing debt low.

China Merchants Bank recently upgraded its credit card smart risk control system with a transaction + behavior risk management solution that leverages AI for intra-event risk management intervention. It boasts ms-level calculation of more than 100 million data points every day, and has cumulatively prevented billions of yuan in risk losses.

Intelligence makes the water safer

Huawei, Shenzhen Ecology and Environment Bureau, Guangming Administration Bureau, and Guangming District Water Affairs Bureau collaborated to build an intelligent integrated water management and control platform. The solution adopts big data, cloud computing, and other ICT to support decision-making for environmental water affairs. The platform’s functions include comprehensive data perception, information interconnection,
situation prediction and early warning, disaster prevention and control, scientific and efficient decision-making, and visible and available results.

The system also links with the district-level Guangming Management Service Command Center and the Guangming Emergency Management Center, enabling comprehensive perception of the whole network, full system graph visualization, and one-click decision making – a new concept in environmental water management.

The system can comprehensively perceive and aggregate network-wide indicator data on the environment and water supply. Users can check various dimensions and the overall situation of the environment and water supply across the whole district with the one-graph service. They can view an entire event and remotely monitor the on-site situation using the intelligent environment and water monitoring and early warning services, and then implement unified command and resource deployment through an emergency response system. Results data provided by the system data service can support decision-making.

The combination of smart scenarios boost city intelligence

The Shenzhen Intelligent Twins solution takes the city into the intelligent world, driving the coordinated development of digital government, digital citizens, and digital economy, and ensuring the sustainable development of the city through intelligence.

Harnessing data and intelligence, the Shenzhen Intelligent Twins solution will help digital government and governance and public services to become more proactive, accurate and intelligent. It will help establish service-focused, integrated management and governance solutions.

The Shenzhen Intelligent Twin is people-oriented and provides digital services for residents that are safe, reliable, equitable, and beneficial. It includes a digital citizen certification, management, and application system, a data account and user information authorization mechanism. It will establish and improve a data sharing and comparison mechanism for citizen services. And it will promote digital citizens with cross-city services and cross-district data applications and continuously optimize citizens’ experience of public services.

Strengthening the integrated application of ICT will promote the use of ICT in local industry. With data circulating in accordance with the law and inclusive and shared AI computing resources, the Shenzhen Intelligent Twin will provide enterprises and industries with a data platform and intelligent platform for application innovation. This will invigorate the application ecosystem, turbocharge the development of digital industries, and drive the intelligent upgrade of traditional industries.

The Shenzhen Intelligent Twin will also help the edge, perception, and interactive ecosystems flourish. By promoting digital industrialization and industrial digitalization, the Shenzhen Intelligent Twin is a touchstone and vehicle for implementing new infrastructure that will drive the high-quality development of the digital economy.
Our digital transformation journey explained

As emerging technologies like cloud computing, big data, and AI develop rapidly, enterprises from various industries around the world are being pushed towards digital transformation. Huawei is no exception. Powered by a revolution in data columns, Huawei has achieved efficient business operations and well-coordinated management of its global business.

By Xu Rongjun, Director of AI Enabling Department, Huawei

In 2019, Huawei’s global sales revenue reached 858.8 billion yuan (US$131 billion). Huawei employs 194,000 staff worldwide, serving more than 3 billion people in more than 170 countries and regions. And these numbers are reflected in our operational complexity.

Huawei believes that those who make parachutes should be the first to try them. That’s the best way to serve customers and Huawei does this by being the first to
use its own products in its own operations, covering sales, R&D, supply, manufacturing, engineering delivery, service, and administrative services. By doing this, Huawei can refine its products and field test its own intelligent digital products.

AI lets elephants dance

Huawei has always been, at heart, a traditional company that provides products and services as opposed to a digitally native Internet company. As a result of detailed division of labor, Huawei has a large number of interdependent operation links, creating an internalized supply chain. This kind of structure means Huawei, like other traditional companies, struggled with digital transformation.

A seller on Taobao, China’s largest online shopping website, for example, only deals with three main objects: the buyer, the seller, and the commodity. At Huawei, however, a sales order can be translated into an internal order that has 139 objects and more than 5,000 data columns, covering user satisfaction, cost, time, quality, and flexibility. To make its internal supply chain more efficient, Huawei had to undertake its own transformation journey.

Huawei’s digital transformation started in 2016. Before that and like other traditional enterprises, Huawei had completed the informatization phase that moved processes online. With informatization, employees could input the results of each process activity into systems like ERP, OA, and BI, but execution, management, and decision-making were still done offline.

Moving one step further than informatization is digital transformation, which moves execution, management, decision-making, and commands online. This helps improve user-centric service experiences, reduces user requirement response times, and improves the efficiency and quality of entire work flows.

It also completely changed how Huawei’s internal IT systems work. Huawei has been working to digitize objects in the real world as well as business processes and rules. Records generated in traditional systems and massive amounts of signal data from various touchpoints can be translated into valuable knowledge through algorithms and AI to better inform operations and decision-making.

As a large traditional company, Huawei has complex business operations and many work flows. One of the most important transformations we’re undergoing every year is to streamline various end-to-end processes. Huawei has more than 50,000 process activities and more than 10,000 business control points. A conventional approach to digital transformation would be both ineffective and costly. Because of this, Huawei began more widely using AI technologies internally in 2018, and established the AI Enabling Dept under its Quality, Business Process & IT Mgmt Dept. This new department uses AI technologies to increase internal efficiency, especially in repetitive, high-volume, and complex tasks.

Scenarios, algorithms, computing power, and data: Four key factors of digital transformation

Huawei has faced many challenges over the course of its digital transformation.
Challenge 1: It had to select which business scenarios to start with and create digital employees to generate greater business value.

Huawei’s business scenarios are complex, so we had to be careful that automating high-volume and repetitive tasks didn’t end up making operations more complex down the line. To make sure this didn’t happen, Huawei began creating digital employees in 2020. This is about defining business roles, building or improving operations and cognitive models along business processes, and using AI to boost business efficiency.

Challenge 2: Huawei had to digitize massive objects, which required more efficient technologies and methods.

Huawei’s Intelligent Operations Center solution does this by making operations and decision-making more data-based, timely, accurate, and effective. It digitizes tens of thousands of Huawei’s business objects, rules, and processes. In 2015, Huawei started building a data lake platform based on big data, which integrated the company’s logs and IoT sensor data. In 2018, we enhanced images, voice, and text data to become AI-aware. However, there was still one problem: Legacy objects usually lack enough touchpoints to support their digitalization and the barriers to abstracting and digitalizing the rules from perception to cognition were very high.

Challenge 3: New metadata technologies were required for data sharing and consumption across the entire chain as they can ensure the consistency, reliability, and timeliness of cross-node core data.

Due to the large number of nodes, a single information processing chain for digital operations typically requires more than 30,000 pieces of data, with more complex scenarios requiring up to 300,000 pieces of data. Traditionally, metadata is manually recorded and managed, making it difficult to ensure the consistency, reliability, and timeliness of data required for intelligent operations. Huawei has more than 50,000 operation analysis processes, which requires AI to drive the new development of metadata. In addition, due to the large number of data columns, the company’s data lake also needed to have a unique design to better share data internally.

Challenge 4: Massive models caused efficiency bottlenecks.

To become intelligent, traditional enterprises need to embed massive business algorithm models within and between nodes. They need to explore how to automatically generate algorithm models, machine resolution, and AutoML to enable automatic training and fast API generation, instead of having data scientists to design and deliver APIs.

Challenge 5: Replication of digital employees

Huawei’s current achievements from its digital and intelligent transformation rely on complex support platforms, data platforms, and tool platforms. Integrating software and hardware based on computing capabilities and productizing and replicating them in different departments is still a great challenge.

To cope with these challenges, Huawei is exploring an approach that integrates scenarios, algorithms, computing power, and data. Based on its data lake, data workshop,
and data governance, Huawei's cloud platform has been designed to provide a series of intelligent services such as intelligent operations, intelligent assistant, and intelligent robotic process automation (RPA), building an intelligent brain for the company. Digital employees built for business scenarios have greatly reduced AI construction costs and cut construction cycles from 14 to 16 months down to between 2 weeks and 2 months.

The key to this process is using intelligent metadata to connect complex work division data and build a reliable, consistent, and timely data foundation. Based on DWI's data warehouse, Huawei has used big data edge computing, edge integration, and data graphing to build a unified data model that connects nodes using AI, and builds perception and intelligence over data and data links to enable intelligent business operations.

**General capabilities empower industries**

Huawei has developed hundreds of use cases to continuously enable smarter business scenarios.

One such use case is the intelligent processing of contracts worth tens of millions of dollars, bringing intelligence to every contract activity, including contract-drafting, reading, and review.

- **Intelligent contract-drafting:**
  Recommends contract elements and templates for different scenarios and generates a draft contract in minutes.

- **Intelligent contract-reading:**
  Automatically analyzes contract clauses for over 90 categories (including tax, legal, and commercial clauses) in over 140 countries and over 20 languages.

- **Intelligent contract review:**
  Intelligently issues over 50,000 alerts for commercial risks to quickly respond to risks.

**Huawei is also working to bring intelligence to customer services.**

Huawei provides intelligent customer service capabilities for consumers, partners, and internal hotlines, greatly improving customer experiences. The company can serve a maximum of 4,000 customers per minute and answer more than 6 million customer inquiries every month. Satisfaction ratings for Huawei's robot agents are at 92.8 percent.

**Engineering projects are a test field for intelligence.** Huawei is further improving its onsite and offsite collaboration and resource-sharing capabilities. It provides intelligent assistance to the survey and delivery of more than 1 million sites, remotely and intelligently manages EHS and the work of more than 6 million workers, and intelligently reviews and accepts more than 50 million installation items.

Based on its years of experience, Huawei is aware of the challenges traditional companies face during digital and intelligent transformations. Its advice to others is to focus on:

1. Starting to use AI for high-volume and repetitive tasks.

2. Prioritizing data during AI adoption. For traditional enterprises, this means data governance is required. AI must be embedded into data flows, and a stable and timely service platform and data neural network must be built.

3. Increasingly using data analytics and AI to drive AI adoption. Traditional enterprises have a very detailed division of labor. They need to explore the value of digital transformation from the perspective of a revolution in data columns and nurture fertile soil for data and intelligence.

4. Talent and culture. Business and talent transformations are also critical for digital and intelligent transformation.

Looking ahead, Huawei will continue its digital transformation, build up general capabilities, and contribute to the digital transformation of other industries while improving its own efficiency and effectiveness.
Unlocking AI for enterprises with HUAWEI CLOUD Stack

HUAWEI CLOUD Stack is the best path for enterprise users to cross the ecosystem chasm and go intelligent. It acts as a bridge connecting enterprises today with the intelligent future.

By Xu Shangfeng, Technology KOL

In 321 BC, the Samnites defeated a powerful Roman army at the Caudine Forks, a narrow canyon surrounded by mountains. To humiliate the defeated, the Samnites forced the Roman prisoners of war to pass under a yoke, considered the greatest form of humiliation at the time. Later, “Caudine Forks” came to be synonymous with a "canyon of shame" and used as a metaphor for a disastrous event. The term grew to mean when a company, organization, or individual encounters great difficulties or challenges. Over time, the Caudine Forks theory
continued to evolve and Karl Marx elevated it to a philosophical problem and scientific methodology. Today, the theory still offers significant practical guidance.

Companies also face “canyons”, or chasms, at important stages. Those that cannot cross them will be trapped and lose market opportunities. Businesses stand at the brink of the intelligent age, facing a gathering surge of new technologies and new applications. To cross this chasm, they need to eliminate gaps and turn their passive position into an active one. But to complete such a formidable task, choosing the right cloud service partner is critical.

At the two-day China Info100 2020 summit in August 2020, Huawei Senior Vice President and Vice President of Huawei Cloud & AI BG, Zhang Shunmao, spoke on “six ecosystem chasms” facing enterprises and how HUAWEI CLOUD Stack can help add intelligence to the enterprise armory.

**Six chasms**

In his book *Crossing the Chasm*, bestselling author Geoffrey Moore sets out how businesses and products will lose market opportunities and fail if they cannot cross the lifecycle chasm. But by crossing the chasm, an enterprise (product) opens an upward channel that allows it to occupy a dominant market position.

Today, both high-tech and traditional firms need to confront various chasms that lie ahead of them. New technologies, such as cloud, AI, 5G, and IoT, and applications are rapidly iterating and traditional IT architecture can no longer keep up. Moreover, many businesses worry that new information architecture will become outdated as soon as they deploy it.

We need to understand the current situation of intelligent enterprise transformation – in other words, what “chasms” enterprises face. According to Zhang, "As companies move towards intelligence, they will encounter chasms in six areas: applications, data, capabilities, talent, technology, and the industry ecosystem."

**The application chasm:** Companies accumulate many legacy IT assets that cannot be discarded when building new information architecture, because it’s impractical to tear down and reconstruct everything. Therefore, how old and new systems can be integrated and coexist is a difficult question for intelligent enterprise transformation.

**The data chasm:** Enterprise users suffer from severe issues with data siloization, which makes it difficult to share, analyze, and use data, or tap into its potential.

**The capability chasm:** As enterprise
The large-scale application of new technologies such as cloud, AI, and 5G, requires skilled workers, but most firms lack talent, limiting their ability to maximize the value of these new technologies.

The talent chasm: The large-scale application of new technologies such as cloud, AI, and 5G, requires skilled workers, but most firms lack talent, limiting their ability to maximize the value of these new technologies.

The technology chasm: Data is a core asset for enterprises and the importance of data security is higher than ever. Many enterprises don’t know which technology to use to ensure data security.

The ecosystem chasm: For industry leaders, it isn’t enough to rely on their own strengths alone. They must also deal with constructing and enabling industry ecosystems. When facing an industry ecosystem chasm, using digital technology to support industry ecosystem development is vital.

Taken together, crossing these six chasms represents a complex and systematic project that imposes extremely high demands on a cloud service partner. The cloud service provider needs comprehensive capabilities itself – it must be an all-rounder, not just an expert in a single area.

Based on over 30 years of technical expertise and industry experience, HUAWEI CLOUD has built full-stack, all-scenario capabilities that can help users cross the six chasms. Zhang believes that, “HUAWEI CLOUD Stack is the best path for enterprise users to cross the ecosystem chasm and go intelligent. It acts as a bridge connecting enterprises today with the intelligent future.”

Cloud + AI: A two-pronged approach

China Life is a large state-owned financial and insurance company, with revenues of more than 900 billion yuan in 2019. To ride the digital wave, it partnered with HUAWEI CLOUD to build the China Life One Cloud with HUAWEI CLOUD Stack, integrating the management, resources, and computing power of the entire group and greatly boosting efficiency. The China Life Hybrid Cloud financial cloud platform provides the group with unified cloud services and ecosystem, cutting IT expenditure by over 30 percent. And thanks to Huawei’s public cloud EI, China Life’s claims service has been able to boost efficiency and cut costs in areas like processing medical bills. It processes tens of millions of medical bills every year and it usually takes three minutes to enter a bill into the system. With Huawei’s AI technology, it now takes less than 10 seconds.

Cloud and AI are essential for enterprise intelligent transformation.
Huawei Global Industry Vision (GIV) predicts that by 2025, all companies will be using cloud technology. It also forecasts that the penetration of AI will accelerate, with 97% of businesses using it in production and operations management by that year.

As Zhang sees it, "In the digital age, the application of cloud and AI will directly determine enterprises’ capacity to innovate and their competitiveness." Cloud and AI are two formidable tools for intelligent enterprise upgrades. Cloud is the cornerstone of innovation and a means to improving efficiency for companies, while AI is their core productivity and innovation engine. Cloud and AI each complement the other.

**Connectivity:** HUAWEI CLOUD Stack has dual-core IT architecture, which adapts to legacy IT architecture and builds on what it inherits. The HUAWEI CLOUD ROMA platform on the HUAWEI CLOUD Stack has multiple connectivity capabilities. It connects:

- New and old applications and data, breaking down data silos
- On-cloud and off-cloud systems, removing barriers between enterprise systems
- IT and OT, connecting the digital and physical worlds
- Enterprises and partners, breaking down barriers between ecosystems.

**O&M:** When carrying out intelligent transformation, businesses encounter three major problems: High O&M complexity, high O&M risks, and high labor costs. With HUAWEI CLOUD Stack, companies receive the support of Huawei frontline teams and can outsource O&M work to HUAWEI CLOUD.

**Data security compliance:** Core data is stored locally while innovation services are on cloud. This ensures that core data is not lost or stolen while enabling service innovation. HUAWEI CLOUD Stack supports local storage of user core data, ensuring the security and compliance of enterprise core data.

**Shared open ecosystem:** HUAWEI CLOUD Stack and HUAWEI CLOUD’s application ecosystem are deeply integrated. Enterprises can acquire many industry applications with a click of the mouse to support service innovation and create industry-oriented dedicated application markets. For example, using the extensive range of ecosystem applications in HUAWEI CLOUD’s Marketplace, China Life built a cloud application market for the insurance industry to empower businesses in the ecosystem chain.

HUAWEI CLOUD proposes making AI more inclusive by allowing companies to master AI capabilities quickly, easily, and at low cost. Advanced AI tools clear roadblocks

Companies today still face obstacles when adopting AI technology. Huawei has discovered that the main issues are insufficient AI talent, high entry requirements, inability to use the technologies, and difficult deployment. The lack of AI talent is especially critical. Therefore, simplifying AI is very important.

HUAWEI CLOUD provides powerful AI tools that can be used to build leading AI
ModelArts supports automatic learning to lower the barriers to entry for developers, so that they can easily complete development work even without AI development experience.

In March 2020, HUAWEI CLOUD launched ModelArts Pro. This enterprise-class application development kit for AI comes integrated with industry algorithms, empowering industry AI application developers and boosting AI development efficiency and deployment results. It also integrates the experience and know-how of industry experts and is very easy to operate.

In certain industries, highly experienced experts are indispensable but scarce resources cannot be replicated. HUAWEI CLOUD can universalize the experience of industry experts using AI. ModelArts Pro builds up key capabilities, such as algorithms, data, and models, which can help companies achieve service innovation.

For oil surveys, operational experience is crucial and key considerations such as the location and drill depth of oil wells depend on specialist expertise. PetroChina has used HUAWEI CLOUD ModelArts Pro to quickly build a professional oil well logging model that combines the industry knowledge, experience, and survey data of highly experienced experts, so that their knowledge and experience can be copied and passed on. Using the model, general workers can accurately and quickly complete work that could previously only be done by these experts.

Developers often complained about the low efficiency of AI development. This is why Huawei has integrated a wealth of operator libraries and model algorithms in its AI computing framework. MindSpore can help AI engineers efficiently develop high-performance AI applications. It natively adapts to scenarios and offers easier development, reducing the time and entry requirements for model development.

A McKinsey report estimates that AI may contribute an additional US$13 trillion to GDP by 2030. And PwC predicts that by 2030, the global AI market will exceed US$16 trillion. But without strong computing power, the development of AI lacks a driving force.

Huawei has solved the problem of insufficient computing power for enterprises and AI researchers. Huawei's AI cluster, Atlas 900, provides powerful computing power and efficient operator development capabilities. It's currently the world's fastest AI training cluster. With Atlas 900, AI experts can innovate AI technology and conduct scientific research more flexibly and quickly. Leveraging the Da Vinci architecture and all-scenario AI computing framework, Huawei's Atlas 900 AI cluster offers device-edge-cloud collaboration. It is accelerating intelligent transformation in all industries and is used in a wide range of sectors including transportation, energy, and finance.

When facing uncertainties in the future, companies will only be able to turn crises into opportunities if they embrace change and arm themselves with digital technology. HUAWEI CLOUD Stack is the best partner for enterprise intelligent upgrades. It provides an optimal path for transformation, which can help customers cross the ecosystem chasm and stand at the forefront of the new digital era.
How Intelligent Twins are transforming cities

Technology is driving the latest revolution. Huawei’s Intelligent Twins reference framework, includes three branches of intelligence: connectivity, hub, and applications. This framework can help partners build new competitive advantages in the digital economy.

By Liu Huafang, Technology KOL

At HUAWEI CONNECT 2020, Huawei unveiled the Intelligent Twins, a reference architecture for governments and enterprises to deploy intelligence. On September 24, Shenzhen City and Huawei announced the joint development of the Shenzhen Intelligent Twins solution. Building a city-level integrated intelligent collaboration system with deep learning capabilities will allow the city to perceive, think, evolve, and be more livable. It will position Shenzhen as a benchmark city for the digital economy. And five days later on September 29, 2020, Chengdu High-tech Industrial Development Zone and Huawei inked an agreement to develop the Chengdu Intelligent Twins – an integrated city Intelligent Twins solution comprising one center and three platforms.

Chengdu Intelligent Twins: One center and three platforms

The White Paper on the Development of China’s Digital Economy (2020) published by the China Academy of Information and Communications Technology (CAICT) reveals that China’s digital economy was worth 35.8 trillion yuan in 2019, accounting for 36.2 percent of the country’s GDP.

The reference architecture for Intelligent Twins has a completely open ecosystem – one that doesn’t involve tearing down and reinventing existing smart city projects, as opposed to an “intelligent upgrade”. It leverages Huawei’s synergistic advantages in 5G, cloud, AI, and computing to build a digital foundation and smart hub for smart cities and urban governance.

The Chengdu Intelligent Twins has a clear strategy behind it: deploying an AI-powered big data center in Chengdu and then build the integrated city Intelligent Twins comprising one center and three platforms.

The one center refers to the National Integrated Big Data Center. A key function of the center
is scientific research and innovation leveraging Chengdu's economic, political, and technological status in West China.

The three platforms are the city brain, world-leading exascale AI computing platform, and a global research and innovation platform for intelligent data storage and machine vision.

City brain platform: supports the needs of smart cities, industry scenarios, and campuses, prioritizing the following industries: transportation, public security, healthcare, government, emergency response, education, environmental protection, and the Internet.

World-leading exascale AI computing power platform: includes an inclusive AI sub-platform and a dedicated research and innovation sub-platform. The inclusive AI sub-platform will serve a diverse range of industries and enhance the capabilities of AI companies and industries. The dedicated sub-platform for research and innovation will support the strategic demands of the Chengdu AI Pilot Zone. Powered by Huawei's AI computing cluster Atlas 900, the exascale AI computing power platform will power production, learning, research, and application capabilities in research institutes. It will enable them to conduct cutting-edge research and innovation using AI, and support strategic scientific research in key national and regional industries.

Global research and innovation platform for intelligent data storage and machine vision: leverages Huawei's industry experience in global data storage and the machine vision industry, coupled with its local big data management and intelligent research and innovation experience and capabilities. The platform will help accelerate the development of Chengdu's digital industry.

To date, Sichuan Rural Credit Union, the West China Second University Hospital of Sichuan University (WCSUH-SCU), and Chengdu Shuangliu International Airport have all partnered with Huawei to help them drive service transformation and build smart capabilities and experience.

In November 2019, WCSUH-SCU collaborated with China Mobile and Huawei to build the world's first 5G private network for the healthcare sector, using mobile edge computing (MEC) equipment and network slicing. The solution represents a three-in-one integration of cloud, network, and industry.

In the context of China's dual circulation economic strategy, building smart cities will be an important driving force for industry transformation, innovation and
development, and refined urban management.

The Chengdu Intelligent Twins solution will provide a world-leading one-stop AI engine for Chengdu government organizations and businesses. It will power intelligent governance and business, enhance quality of life for residents, stimulate the digital economy in the Chengdu-Chongqing Economic Circle, and support the city's global competitiveness.

**All-scenario intelligence: Synergy across 5 tech domains**

In 2020, Huawei's cloud and AI business set out new goals: to bring ubiquitous cloud and pervasive AI and build all-scenario intelligence for cities, industries, and enterprises. It will extend this approach from B2C to B2B, open up capabilities to all of society, enhance productivity and innovation capabilities, and enable the era of the smart economy. Intelligent Twins make the goal of all-scenario intelligence possible.

Huawei is collaborating with different partners to develop the three key scenarios – all-scenario smart city, all-scenario smart enterprise, and all-scenario smart industry – and build key capabilities for the smart economy, which will benefit every individual, home, and organization.

**All-scenario smart city:** This represents a new stage in smart city development. Intelligence in every corner of the city will power accurate analysis, system predictions, coordinated command, scientific governance, and scenario-based services for entire cities. Enterprises with a more open environment for innovation will continue to spawn new industries and new ecosystems. Residents will be able to enjoy convenient urban services, which will increase their quality of life. It will facilitate a city with an innovative smart ecosystem for all based on joint creation, sharing, and mutual benefit.

**All-scenario smart enterprise:** New technologies, such as cloud, AI, computing, and 5G, will help companies deploy intelligence in all enterprise operation scenarios. This will enhance service experience, optimize business processes, and enable business innovation. It will help companies build competitive advantages and the ability to innovate in the intelligent era.

**All-scenario smart industry:** This will revolutionize technology and drive industrial transformation, and create high-value scenarios, service models, and business models in industries. It will accelerate digital transformation and intelligence in industries and boost productivity.

To achieve all-scenario intelligence, Huawei will build an ecosystem of technologies, including 5G, cloud, AI, computing, blockchain, and big data, that will create a fertile environment for development and become a foundation for the digital world.

Following on from the Shenzhen Intelligent Twins and Chengdu Intelligent Twins, City Intelligent Twins are set to be deployed in more cities across the country. Huawei’s roadmap, technical capabilities, and a world-leading AI computing platform will facilitate the gradual implementation of all-scenario intelligence, leading to truly intelligent cities in the future.
Synergy across five tech domains – connectivity, AI, cloud, computing, and applications – will enable digital transformation to evolve to the next phase of development. The five technologies are the basic capabilities that will support all-scenario intelligence.

With this synergy, Intelligent Twins can play a huge role in all industries in major scenarios. They will transform efficiency and experience in society, optimize production processes, and enable industry innovation. Our cities will have more convenient and seamless transportation networks. Companies will have more efficient production processes, such as using AI vision for quality inspection, and industries will be smarter and safer, including smart inspections for mines and power grids.

**Accelerating deployment**

In addition to proposing the Intelligent Twins reference architecture and publishing a complete architecture diagram, Huawei has also released a white paper on the Intelligent Twins with various organizations to promote the overall development of AI engines in China.

The AI engine architecture can be used in multiple scenarios including cities, enterprises, and industries. It uses an open ecosystem that will allow many companies to participate in smart city construction and improve the competitiveness of China's digital economy.

Intelligent Twins have a four-layer architecture: intelligent interaction, intelligent connectivity, intelligent hub – the brain and decision-making system – and intelligent applications.

Powered by a commitment to infrastructure build out, Chinese cities are ushering in an intelligent revolution. As they take their next steps to becoming smart cities, they are smashing data silos and technical barriers and reducing duplicated construction.

Intelligent Twins will offer stable structures and flexible implementation. They will also meet the needs of cities of various scales, from small cities to mega cities. Intelligent Twins will accelerate the development of the smart economy and ecosystem.

Each city's Intelligent Twins can have their own characteristics that reflect local scenarios. Huawei will work with various city partners to create a fertile environment for the development of the digital economy.
ModelArts 3.0 Redefines Intelligence for All Industries
HUawei Cloud EI
Integrated with Industry Business to Update Enterprise Intelligence