Striding Towards
the Intelligent World
White Paper

Cloud
Computing

**Everything as a Service:
Building the Cloud
Foundation for an
Intelligent World**

Foreword

"The industry may have numerous uncertainties, but digitalization is never one of them. Digital transformation might have been just an option years ago, but it is now imperative. The next decade will be the last chance for traditional industries to go digital, and 2022 is a turning point for a mindset shift in order to stay competitive. Efficient business models will replace inefficient ones this year." These predictions were from a Huawei Cloud customer actively transforming to digital. Their path for the journey was clear: Build a cloud foundation, adopt Cloud First for new systems, and gradually move legacy systems to the cloud.

Visionary enterprises realize that the cloud frees digital technologies from restrictions of geography and industry. Whether in developed or underdeveloped regions, high-tech or traditional industries, or large or small enterprises, users access the hardware (such as computing and storage) and technology (such as big data, AI, and IoT) they need for digital transformation. The cloud also opens up these users to a wealth of experience and knowledge shared by leading enterprises.

In today's world, this sharing is particularly important. Challenges abound: three years of a pandemic, global pressure to reduce emissions, and increasingly complex business environments. The world is waking up to digital transformation as an urgent reality. First, enterprises need to focus on core business. They also need to be responsive to both regular and unexpected changes. Most importantly, they need to deeply understand their customers and innovate better, faster solutions for them. For various industries, it is critical to digitalize business operations and modernize the technology stack.

While pilot phases have been successfully pioneered and leveraged combined technologies to boost the cloud experience, this development is not balanced. Accenture surveyed 8300 benchmark enterprises around the world from 2018 to 2021 to find out that the first 10% of enterprises to fully embrace digital technologies increased their revenue five times more than the 25% laggard enterprises, and that this gap will continue to widen in the future. While problems faced by each enterprise are complex and discrete, all enterprises are moving in the same direction – towards a digital, intelligent future. The sooner we go digital, the better, and hesitation in deciding will cost us.

As the Chinese saying goes, one must walk the road to know how hard it is. Our own digital journey is how Huawei walks the walk.

As a multi-pronged enterprise, Huawei deeply understands the challenges of transformation. We have been there, we are still on the way, and there is more to come. The road requires an open mind and concerted effort, and we make it smoother by sharing our technologies and experience. Huawei Cloud distills this expertise into open capabilities, including those of our customers and partners, into a flexible architecture of cloud services. In this way, we empower our customers to get maximum value in their digital transformation, at minimum cost.

Fortunately, cloud and technologies such as security, AI, data, media, development platform, and SaaS are actively evolving. To harness the power of more industries toward a common goal, we compiled the *Striding Towards* *the Intelligent World White Paper - Cloud Computing*. This paper shares Huawei Cloud's views and plans on industry and technology trends. I am proud to share it with you, because value co-creation is important in the digital era. I hope that together, we drive industry development and inspire others along the way.

We believe that digitalization is the only way for enterprises to stride towards the intelligent world. Huawei Cloud works with customers, partners, and developers to continue innovating for our vision of building the cloud foundation for an intelligent world, with ubiquitous cloud and pervasive intelligence.

Zhang Ping'an
CEO, Huawei Cloud

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Abstract

① Cloud Native 2.0

Cloud native greatly improves productivity and imposes increasing requirements on digital capabilities. To cope with these, more industries are going digital and enterprises have entered the Cloud Native 2.0.

The future is in the hand of leaders, or innovators, not someone just waiting. Cloud services smash the geographical and industry constraints and lower the threshold for using digital technologies. Any organization can harness cloud services as long as the leader is far-sighted. In the future, all devices and sensors will be connected by the Internet, and all infrastructure and applications will be in the cloud. Now, enterprises should replatform as many as applications or transform them to cloud native applications, and embrace AI to fully unleash digital potential in service decision-making.

② Security & Compliance

The defense of cyber security is a battle that never stops. Attacks are ever changing, so are the defense technologies. Network attacks and data leakage events are increasing exponentially around the world. Cloud security products have become the mainstream.

When industries are going digital with cloud native, they must select cloud vendors with rich security experience as partners and use cloud native security solution to build systematic security and compliance capabilities meeting actual requirements.

③ Data + AI Convergence

Volatility, uncertainty, complexity, and ambiguity (VUCA) accelerate data-driven decision-making for public and private sectors. Public sectors are using a large amount of timely and refined data to evaluate policies; emerging enterprises are performing in-depth market analysis and growing rapidly with big data and AI; for pioneers in traditional industries, they have found ways to break the paradox of "data governance has to be either too stifle or too messy". Big data and AI are more mature and widely available.

According to Gartner's analysis, for companies that have not established a sustainable data

operations mechanism by 2024, the execution of their strategies will be delayed for about two years[1]. On the way towards big data and AI, enterprises should learn from pioneers' cases, work with partners with expertise, and use the latest data and AI to tackle obstacles and achieve "data-driven business".

④ Media Services

Metaverse has attracted wide attention and a large amount of capital. It is gradually covering every aspect of people's life and production economy, reshaping the 2C and 2B fields. To catch the wave, far-sighted enterprises have actively explored fields, such as livestreaming with digital human, virtual live rooms, and online meetings.

Metaverse has high technical demand, therefore, enterprises need to try to integrate the existing services with metaverse by mature technologies to find the breakthrough. Media content consumes a lot of basic resources (networking, storage, and compute). Cloud native is lightweight, easy-to-use, providing enterprises with massive computing power, global coverage, AI, and media technology to march towards metaverse.

⑤ Application Modernization

Cloud native application modernization includes modernization in infrastructure, architecture design, development and O&M, and governance and operations. According to the analysis of global enterprises, application modernization turbocharges the development of enterprises.

Enterprises need to learn successful methodologies and reference architectures in the industry and select the best path and solution based on application characteristics and phases. They can purchase consulting services and professional services to ensure smooth modernization.

⑥ aPaaS

The enterprise application architecture is becoming "composable". The cloud shares cloud native applications among enterprises, who in turn share their industry experience and SaaS capabilities to accelerate innovation.

During industry transformation, enterprises should use mature, affordable services. These services are built up by heavy pioneer R&D that would be hard to re-develop to leading levels in short time. Therefore, if the cost is acceptable, there is no need to reinvent the wheel.

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[1] Top Trends in Data and Analytics, 2022

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Cloud Native 2.0

1.1 Wide Adoption of Digital Technologies

Over the past dozen years, the Internet (especially the mobile Internet) has promoted the digital transformation of consumption behavior and experience. Cloud computing has also emerged and become the foundation of Internet services. Now, the Internet industry is actively introducing cloud native technologies such as containers, microservices, data analysis, and AI to achieve innovative growth.

With the popularization of cloud services, cloud native is far beyond the Internet and is extended to all industries in all regions around the world. According to Gartner[2], by 2025, the proportion of digital services running on cloud native platforms will increase from 40% in 2021 to 95%. Over the past couple of years, the world has come to realize just how important and urgent it is to go digital. The increasingly complex global business environment requires enterprises to prioritize resilience as part of their business strategy. In addition, economic recovery and low-carbon development are both pushing enterprises and organizations of all shapes to act faster in digital transformation. Technologies related to digital transformation (such as compute and storage resources, software development tools, big data, AI, AR/VR, IoT, and blockchain) are evolving and providing services based on the cloud. Cloud can reduce the carbon footprint of users, break the existing industry pattern, and provide opportunities for startups and small- and medium-sized enterprises (SMEs) to compete in the digital economy.

Founded in 2019, Singapore's UCARS is a car trading startup enterprise and serves

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[2] Top Strategic Technology Trends for 2022, Gartner

individual buyers and sellers, as well as car dealers. During the pandemic, UCARS migrates all its services to the cloud, cuts the TCO by 30%, and reduces the development cycle of consumer innovation services from 7 days to 1 day. UCARS provides the best time-limited sale for customers based on AI-enabled valuation. Today, UCARS is the fastest-growing online car trading platform in Singapore.

The Beibu Gulf Port in Guangxi, China, is the 14th largest port in the world and the gateway for goods from ASEAN countries to and from China. Digital transformation gives them resilience to cope with global logistics difficulties. Through regular operations and innovative service development based on unified data, the container circulation cycle is shortened by 13%. In addition, they are continuously making iterative innovations for more scenarios.

The NGO Rainforest Connection (RFCx) applies cloud- and AI-based ecological acoustic monitoring systems to nature conservation, from tropical rainforests in South America and Southeast Asia to high mountains in Greece and southern waters in Ireland, the guardian system can detect poaching, logging, and acoustic monitoring of local biodiversity.

These pioneer organizations from different regions and industries show the huge value brought by cloud native. The advanced technologies and capabilities on the cloud are deeply integrated with the industry,

which helps enterprises to gain a deeper customer insight and innovate services more agilely, fully unleash productivity and turn the market entry barrier to the opportunity for digital technology. Although we see that a few enterprises have successfully crossed the transformation pilot phase and the Solow Growth Model tells us that the application of new technologies is the key to growth, many organizations are still indecisive. According to Accenture's latest surveys, from 2018 to 2021, among the world's 8,300 benchmark companies, the top 10% leaders that fully embraced digital technologies had increased their revenue 5 times faster than the 25% laggards (figure 1).

Revenue (USD1 billion)
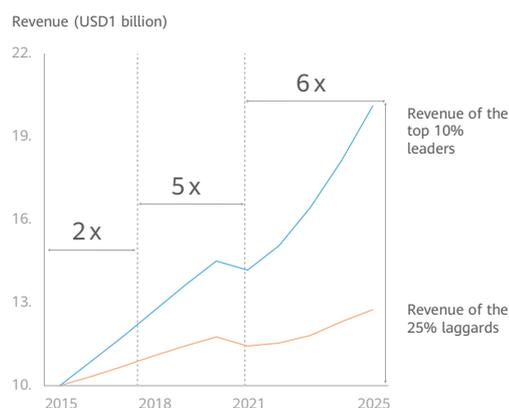
Figure 1 10% leaders vs. 25% laggards

The future is in the hand of leaders, or innovators, not someone just waiting. Cloud services smash the geographical and industry constraints and lower the threshold for using digital technologies. Any organization can harness cloud services as long as the leader is far-sighted. In the future, all devices and sensors will

be connected by the Internet, and all infrastructure and applications will be in the cloud. Now, enterprises should replatform as many as applications or transform them to cloud native applications, and embrace AI to fully unleash digital potential in service decision-making.

1.2 Cloud Native 2.0 Bridges the Digital Technology Divide

McKinsey's data[3] shows the cloud enhanced by cloud native will bring Fortune Global 500 enterprises EBITDA (earnings before interest, taxes, depreciation and amortization) of more than USD1 trillion in 2030.

However, to achieve digital transformation, non-high-tech organizations are short of talent and capital and have insufficient data volume and computing power which are factors of production and productivity in the digital era. The data volume is insufficient because of data silos caused by complex organizational structures and old IT systems, insensitivity and neglect to data, and lack of collection and analysis methods. The computing power is insufficient because of backward data center, high O&M cost, and outdated traditional IT security. However, Internet enterprises are born in the IT era and on the public cloud. They have self-built data centers.

The cloud native technology is developing in recent years, aiming to better serve global organizations to promote digital and intelligent transformation with efficient, reliable, and secure services. It widens and deepens the use of the cloud. The Cloud Native 2.0 era (figure 2) comes. Application-centric is the key. Enterprises use digital technologies to transform applications, ease the innovation of emerging technologies, and improve the utilization of infrastructure resources and security protection capabilities.
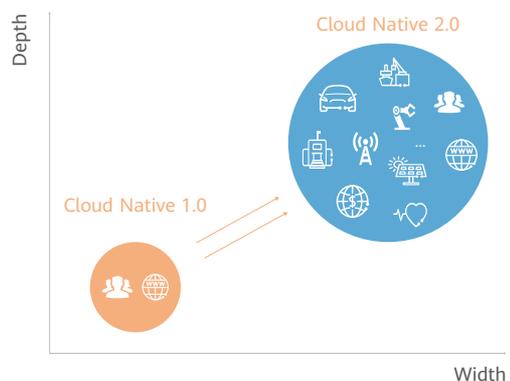
Figure 2
From Cloud Native 1.0 to Cloud Native 2.0

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[3] McKinsey Digital, Cloud's trillion-dollar prize is up for grabs

To be inclusive, Cloud Native 2.0 will propose brand-new technical concepts in compute, application, data, intelligence, and security to form a systematic technical architecture, as shown in figure 3.
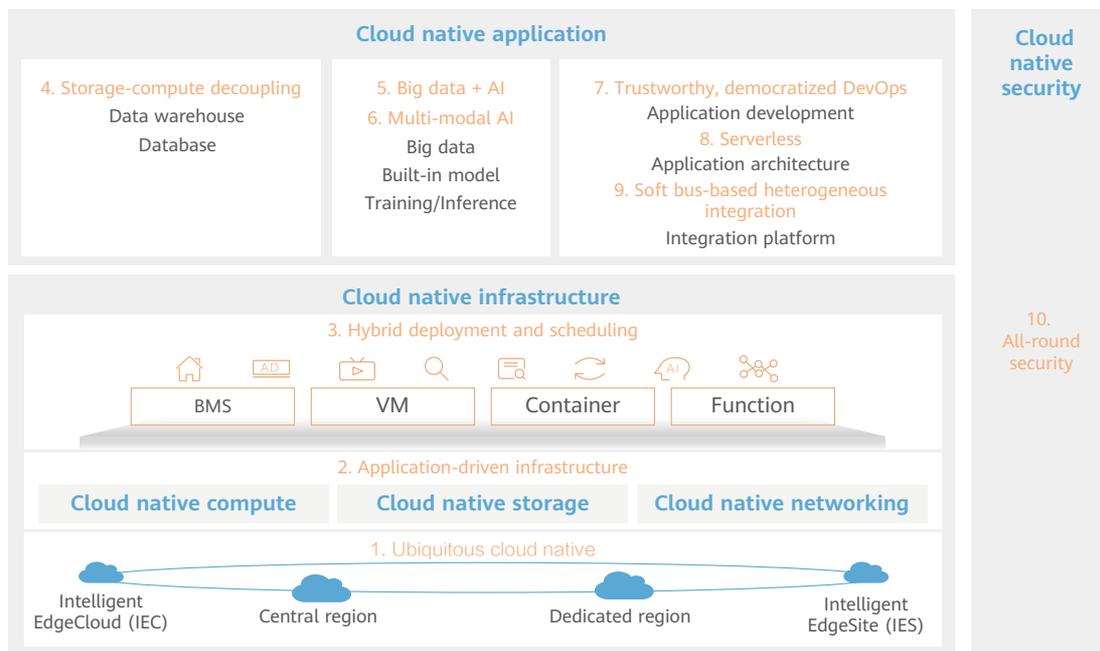
Figure 3 Ten key technology trends of Cloud Native 2.0

- **Ubiquitous cloud native:** Cloud native applications can be deployed anywhere required by services, such as self-built data centers, edge clouds, or edge nodes, to solve the conflict between SLA assurance and resource centralization. In other words, applications can be deployed in a single region, multiple regions, or multiple clouds. Resources and tasks of latency-sensitive hot applications are allocated to nearby regions or edge nodes. Resources and tasks of latency-insensitive cold and warm applications are deployed in central regions with more cost and energy consumption advantages. For example, services that require a latency of less than 5 ms can be deployed at edge nodes; services that require a latency of less than 20 ms can be deployed at nearby regions; services that require a latency of no more than 100 ms can be deployed on the central cloud.

- **Application-driven infrastructure:** In the Cloud Native 2.0 era, enterprises shift their focus from "resource-centric" to "application-centric" for agile application delivery, fast elasticity, smooth migration, and lossless disaster recovery (DR). They expect a better application platform with more efficient running, monitoring, and governance by integrating with infrastructure. Therefore,

infrastructure needs application-centric upgrade. Technologies such as software-hardware synergy, non-intrusive application governance, and application-feature-based intelligent scheduling emerge to comprehensively upgrade the existing infrastructure and application architecture, improving collaboration between applications and resources, resource utilization, and management efficiency throughout the lifecycle of service applications.

- **Hybrid service deployment and unified scheduling:** The application-driven cloud native infrastructure unifies the deployment, monitoring, and scheduling standards of all services for enterprises to build a unified resource pool. For example, Volcano, an intelligent scheduling open source project and technology, integrates application features and resource requirements of all services based on different resource scheduling models to maximize resource utilization.

- **Decoupling of storage and compute:** The decoupled storage-compute architecture which has a distributed storage shared by diversified engines replaces the database/data warehouse cluster that couples storage and compute, for flexible management of diversified compute engines and data storage, higher cost-effectiveness, and easier data management.

- **Big Data + AI:** AI for Data achieves automated, intelligent, and navigation-based data governance that is independent of professionals or even SQL skills, reduces construction and maintenance costs, and implements one-click data import to the lake, automatic metadata discovery, data privacy processing, data supplementation, and data relationship graph construction. Data for AI streamlines the data and AI analysis engine to manage data based on unified metadata, fast transfer one copy of data among engines. In addition, the combination of DataOps and MLOps saves the time of data preparation during model training.

- **Multi-modal AI:** The mechanism model built on industry knowledge graph is combined with the data-driven industry model to provide sufficient industry model data. MLOps allows industry AI models to iterate in the production environment and in an agile way. Through real-time feedback and data accumulation, foundation models can obtain more accurate generalization capabilities.

- **Trustworthy and ready-to-use DevOps:** A series of measures is embedded into agile development and O&M to build DevSecOps pipelines. Iteration can be agile and fast. Quality control becomes strict. Industry applications are assetized through low-/no- code development, a much more efficient manner.

- **Serverless:** Infrastructure resources are totally and flexibly managed by cloud service providers. Application developers only need to focus on application development logic. Application development is simplified in event-driven mode. Non-infrastructure resources are charged by application request.

- **Heterogeneous integration based on the soft bus:** The RESTful soft bus that adapts to complex networking environments and is more lightweight than the traditional ESB is introduced to achieve co-existence and seamless integration between non-cloud native inventory applications and new cloud native applications and data, and between online cloud native applications and offline traditional IT applications and data, to form a pure cloud native architecture.

- **Comprehensive, all-round security:** Discrete cloud security capabilities are interlocked with all cloud services and tenant applications to maximize security and trustworthiness capability and architecture-level reuse. Cloud native applications have built-in security. Trusted intelligent computing is introduced to ensure cross-industry data privacy in data circulation and value mining by using multiple technologies together such as blockchain, software and hardware trusted execution environment sandbox, and federated training and learning.

The value brought by the Cloud Native 2.0 can be summarized using the formula shown in figure 4. The first and most valuable element is to improve productivity. With agile development and O&M mode and the latest digital technologies, applications are more innovative and can meet more customer requirements. In addition, the accumulated experience can optimize the next application. For example, the streamlined data can predict product sales volume, help the R&D department for product improvement, and reduce inventory. The second element is to defend against risks. System security is a never-stop, laborious battle which cannot be borne by a single enterprise. However, the latest security technologies are in the cloud. Advanced data analysis methods in the cloud can also predict conventional and unconventional changes, enabling enterprises to quickly respond to the changes. This is especially important for enterprises' survival. The last element is to reduce cost. Although it is important, if enterprises regard it as the only goal of replatforming, they cannot unlock all the value of cloud native. During cloud migration, enterprises should focus on the first two elements and understand the essence of cloud native, so they can select the right path and make the best plan.

$$V_{alue} = f \left(G_{rowth,} \quad R_{isk,} \quad C_{ost} \right)$$

Cloud native value	**Improve productivity** Innovative services Innovative products Data overflow	**Defend against risks** Harden security and compliance Quick sense changes Fast respond to emergencies	**Reduce cost** Resource cost Cost of new technologies Improve efficiency

Figure 4 Cloud Native value

1.3 Unlocking the Value of Digital Technologies with Cloud Native 2.0

In 2021, Huawei Cloud proposed the "Dive into Digital with Everything as a Service" strategy. Conventionally, cloud services mean only IaaS, PaaS, and SaaS, which are more presented from the perspective of technology providers. However, digital transformation is sweeping all industries, especially traditional ones such as agriculture and manufacturing. For them, not only technologies and resources, but also experience, services, concepts, and everything that can be shared are required.

Huawei Cloud is providing everything as a service to serve customers with Huawei's core technologies, practices, and understanding in the ICT field accumulated over the past 30 years and experience, with an aim to fuel your digital transformation. Specifically:

- **Infrastructure as a Service** helps you connect to the cloud from one single point and run services globally through Huawei Cloud's global infrastructure and networks with unified architecture and consistent experience.

- **Technology as a Service** extends leading technologies as cloud services to wherever you need them to make innovation easier.

- **Expertise as a Service** opens Huawei's years of experience in digital transformation in the form of industry aPaaS services to realize shared excellence.

Every year, Huawei Cloud services iterate in the preceding three aspects. In 2022, service updates include (Figure 5):

- **Infrastructure as a Service:** Huawei Cloud continues to expand the global data center and network layout, and releases KooVerse, the global network that

allows a latency within 50 ms. Huawei Cloud will be deployed in 29 regions and 75 AZs around the world, serving more than 170 countries and regions. To meet the diverse organizational structure and deployment requirements of governments and enterprises, Huawei Cloud QingTian architecture extends the efficient, agile, and open cloud native infrastructure to service sites through the distributed cloud. In this way, applications can run freely across clouds and regions with intelligent traffic distribution, ensuring consistent experience and injecting cloud native into more scenarios. Huawei Cloud launches CCE Turbo (the next-gen container engine), brand-new block/file/object storage services, simplified network, and enhanced IoT and hybrid cloud capabilities to make the cloud infrastructure more cost-effective.

- **Technology as a Service:** Huawei Cloud launches four pipelines: DevCloud (software development), DataArts (data governance), ModelArts (AI development), and MetaStudio (digital production). These pipelines ease service development and innovation through cloud native.

- **Expertise as a Service:** Huawei Cloud launches MacroVerse aPaaS to enable API conversion, SaaS development, and marketplace release (KooGallery) as virtuous circle of business. Huawei Cloud joins hands with Huawei consumer service ecosystem to build Koo services, such as KooMessege, which integrates multiple

customer access channels such intelligent messaging, Business Touch, message push, and 5G messages; and KooMap, which aggregates spatiotemporal data and map APIs. Huawei Cloud develops aPaaS services by working with Huawei industry teams. For example, the Mining aPaaS provides AI models for users to DIY mining applications. The City Governance aPaaS provides a SaaS framework for e-Government services. The Industrial Software aPaaS builds XDM/LinkX and streamlines the three core service flows for enterprises.
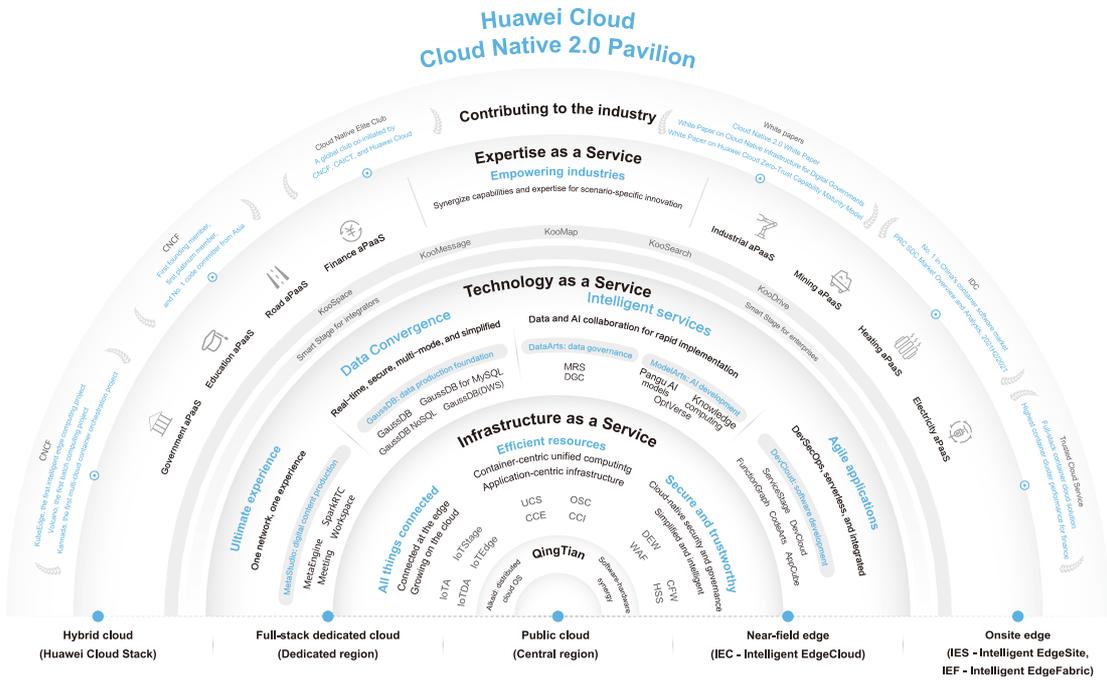
Figure 5 Cloud Native 2.0 Pavilion

Huawei Cloud always stands ready to help you succeed in digital transformation and business growth with innovative digital technologies.

02

Security
Compliance

2.1 Security Defense Advancing Forward, Cloud Security Products Have Become Mainstream Technology

Cloud security is fundamental aspect of any cloud operations, especially for the multiple parties that are involved with its services. Multiple analysis has revealed that security issues are one of the major obstacles for governments when using clouds, especially public clouds. Cyber defense security is a continuous battle that never ceases. As the nature of attacks continue to change, so must the protection technologies. Therefore, our concept of cloud security should keep pace with the changing tides.

According to McKinsey's analysis[4], network attacks and data leakage events are increasing exponentially around the world. The attack methods have changed from purely breaking down systems, to economic crimes such as blackmailing. In the future, hackers may use new technologies such as AI and big data analysis to commit business crimes, which sabotage the business environment and enterprise reputation. On the defense side, security products delivered on the cloud are increasing rapidly, from 10% in 2016 to 60% in 2020. Cloud security products have become fully integrated. It is predicted that by 2030, global companies will suffer losses of approximately US$650 billion, attributed to system breakdowns and network security vulnerabilities. With a more elastic cloud native architecture, application downtime can be reduced by about 57% and the loss caused by security violations can be reduced by about 26%. The cloud can also improve the integrity of platform security protection and reduce

[4] McKinsey&Company, Cybersecurity Trends Looking Over the Horizon

security risks through automated embedded security processes and controls (such as DevSecOps).

Security Defense Advancing Forward

Figure 6 Security threat growth & cloud security products

Countries and regions have enacted legislation to protect cyber security and data security. According to a report from the European Law Firm (DLA), 26 countries have enacted data protection regulations and 11 countries have revised data protection regulations over the past three years. After implementing the Cyber Security Law of the People's Republic of China on June 1, 2017, China has released specific regulations such as Data Security Law, Cryptography Law, Personal Information Protection Law, Regulation on Protecting the Security of Critical Information Infrastructure, and Multi-Level Protection Scheme 2.0. The promulgation of multiple laws and regulations poses challenges to enterprises' compliance controls.

These new changes make us realize that security challenges come not only from embracing

different technologies, but also from the concept change that's associated with the transformation of technology. Rumors and misunderstandings will certainly hinder the popularization of cloud native technologies, therefore, for all organizations to participate in this transformation, these must be quashed. In 2009, the University of Berkeley released an epoch-making paper Above the Clouds: A Berkeley View of Cloud Computing. There is one important paragraph in the paper that notes: "We believe that there are no fundamental obstacles to making a cloud-computing environment as secure as the vast majority of in-house IT environments, and that many of the obstacles can be overcome immediately with well understood technologies." More than a decade has passed since the release of this paper, and advanced security solutions provided through public clouds should be advantageous for enterprises, given that cloud

architectures are standardized and cloud vendors have invested large sums in cloud security.

ABB is an electric power enterprise that makes up one of the Fortune Global 500 companies. ABB's factories in China use Huawei Cloud situational awareness (SA) service to prevent cyber-attacks. Before potential attacks occur, ABB uses SA to detect security threats, such as DDoS attacks, brute force attacks, web attacks, Trojan horses, zombies, abnormal behaviors, and vulnerability attacks. It then performs aggregated analysis on collected statistics such as threat alarms and attack sources, displays the overall security situation, and predicts attack behavior. Whereas, during attacks, ABB uses SA to detect the attack status and flexibly respond to them. Finally, for the post-attack period ABB uses SA to restore the entire attack process, trace attack sources, and produce summaries.

Security goes hand in hand with cloud technologies. In the cloud native era, a simplified and standardized architecture can be used to integrate secure and trusted designs, and software tools into the development of the cloud service, ensuring the security and reliability of such services. In this way, security threats can be responded to much faster and more systematically, compared with traditional IT that uses a cluster of software combinations to respond to security threats. This is especially important for vulnerability detection and fixing, which require global analysis, firmly demonstrating the cloud's advantageous nature. In terms of the security systems structure, this cannot be built in one go. Moreover it requires continuous operations to cope with the ever-

increasing and evolving attack methods. At the same time, experience is pivotal in the construction of cloud native security systems. Companies at different stages of maturity implement differing security policies, and the effect also varies greatly. For example, companies with comprehensive security experience, include not only technologies, software, and hardware, but also processes, organizations, and personnel are integral to their overall security policies.

Firstly, when building a cloud-based security system, enterprises are advised to select cloud vendors with rich security experience as partners to ensure that they grasp the scale of the project, and dispense professional knowledge. Secondly, enterprises need to build a dynamic security system, in which enterprises proactively plan, design, and implement security solutions that match their risk levels, and continuously conduct compliance self-assessments and third-party assessments, based on relevant laws and regulations. Thirdly, enterprises need to establish a regular security operation mechanism, covering the security operation process, services and products, and security expert services, and develop special protection solutions for major events (such as festivals, exhibitions, and attack-defense drills). Fourthly, enterprises need to align their security budgets with their business value. That is, to tailor their security investment budgets based on both their commercial and data values. Furthermore, more priorities should be dedicated to the efficiency of general systems and security of core systems. A scientific approach to security investment is highly recommended, as this will ensure the long-term stable development of various industries.

2.2 Latest Insights into Cloud Security Compliance Systems

Global compliance and country/region-specific certification policies. In the early stages of digital transformation, enterprises tend to seek a spectrum of comprehensive accreditation categories, then produce a slew of documents and proofs, and deliver them for certification. For easily certifiable projects, this method is well prescribed. However, with the deepening of digital transformation, countries, enterprises, and individuals attach increasing importance to data security and personal privacy protection. Traditional certification methods now have difficulties in coping with certification items that are large in number and diverse in kind. Some certifications use a proof-based evaluation, but this cannot

ensure that enterprises always meet specific compliance requirements during daily operations.

New cloud technologies bring new solutions for traditional compliance certification. Large cloud service providers usually deploy their services across regions, and these cloud services, as part of their infrastructure, are often subject to routine checks by regulators. Some cloud service providers with advanced management take the initiative to create a baseline for compliance requirements in different regions and unify them. For compliance requirements that include regional characteristics, labels are used to manage these, and compliance accreditation is achieved through automated inspection and forensic tools.
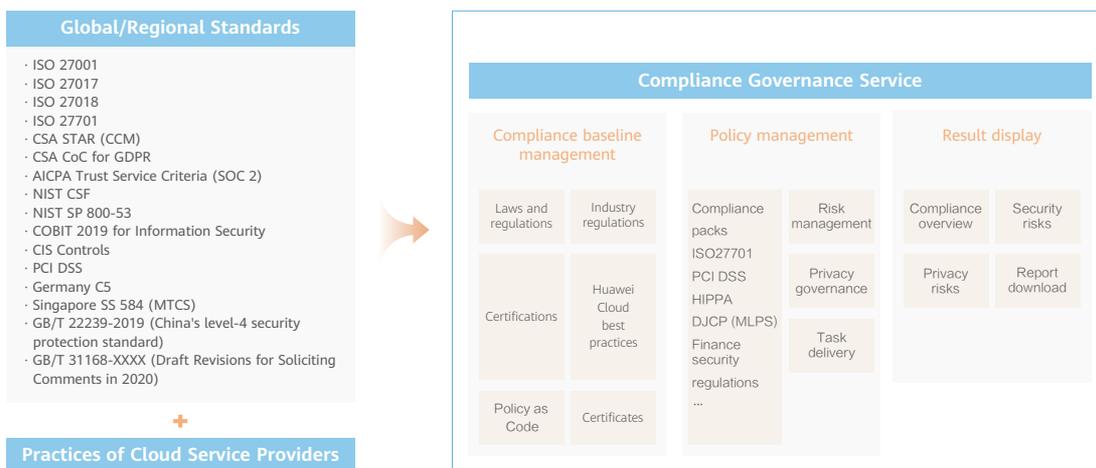
Figure 7 Global compliance capabilities

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Compliance requirements in different countries and regions may vary, including different certification processes, varying time periods and monetary costs. Enterprises need to develop compliance certification policies based on their respective regions. The details are as follows:

- Classification: Audit requirements in compliance standards should be divided into categories, such as system management, solution, and implementation. Thereafter, enterprises must communicate with regulators about whether the system management and solution evaluation can be conducted in a unified manner, and if there is no major change, the evaluation result is valid within a certain period of time (two to three years). For implementation-specific requirements, use automated tools to regularly inspect, collect evidence, and report the inspection results (including any evidence) to regulators.

- Tiered certification: For complex application systems, enterprises can separate items that need basic certifications, and items that need special certifications. Some basic certifications can be used for special certifications.

- Reuse: Cloud service providers generally obtain a wide range of certifications (for example, Huawei Cloud has obtained more than 120 compliance certificates, meeting compliance requirements in each region it provides services), some among them

are of very high standards. Therefore, once an enterprise places its services on the cloud, the physical layer and infrastructure have already passed the local compliance certification requirements. Enterprises can obtain related certificates from cloud service providers to accelerate their accreditation.

"30% R&D + 70% operations" Security attack methods and security vulnerabilities are continuously on the rise. Ensuring the security of service systems is a continuous process, rather than just deploying a few products or services. Therefore, continuous security operations are required. Security operations are not just about a department, team, or set of technologies. It is the continuous process of finding and implementing best practices. Security operation personnel need to use emerging security technologies to quickly detect and mitigate threats, including vulnerability detection, policy compliance detection, account permission management, security event analysis, security event response and handling, and employee security training. The goal of security operations is to intercept all security threats, periodically summarize the overall security situation of the service system, and predict security risks in advance.

"Shift-left security" in software development. Shifting security to the left has become a consensus in the software industry. Discovering and fixing vulnerabilities at the early stage of software development is far less time-consuming and labor-intensive than rectifying it at the later stage.

In the cloud era, more automation and pre-set security functions can be directly integrated into application development. The core value of DevSecOps is achieved by presetting security check items in each phase of software development, this ensures security requirements are a part of developers' daily work, and the negative impact of post-event security checks on development efficiency is reduced. A good DevSecOps pipeline tool should cover the entire lifecycle of threat modeling, secure design, secure coding, secure testing, secure compilation, and secure release, and preset the security development baseline in each check point. When developers submit design documents, code, and test cases, the system automatically scans deliverables and generates risk alarms. This ensures that security risks are effectively controlled in the development environment, and any such potential risks are prevented from being transferred to the live network.

Systematic security defense. The causal link of a network attack may be triggered by unfixed vulnerabilities, or malicious files that may have been dormant in the system for several months, and attacks that can be completed within several seconds. Therefore, the security operation system of an enterprise must be able to detect abnormal behaviors in 10 GB of log data per day, and block the behaviors immediately. However, it is difficult to achieve this by relying purely on current security policies. After enterprise applications go online, a security defense system consisting of personnel, processes, platforms, tools, and experience should be built to mitigate security threats on the live network.
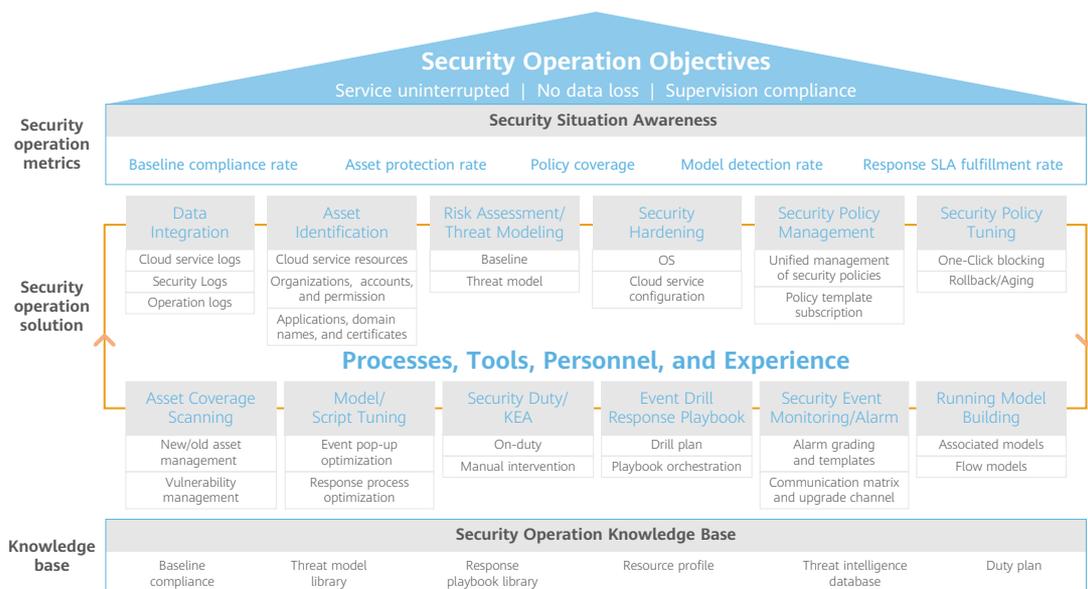
Figure 8 Security defense system

The cloud transforms security from a fragmented single-point operation to a large-scale operation based on a unified architecture. The architecture uses unified identity management, unified network security connection, and unified host security to implement a unified management of global security events. This brings enterprises a better, more comprehensive operation system, compared with traditional IT. Generally, the number of attacks faced by cloud service providers are in the thousands, or even tens of thousands, in comparison to a single enterprise. However, their security operation systems consist of many top experts and advanced tools. Therefore, the cloud native security operation solution has more advantages than the traditional security operation solution in terms of risk identification, discovery, and response SLA.

As cloud technologies continue to metamorphize and turn the traditional IT world on its head, the bearer of security responsibilities also changes, from the customer to a hierarchical risk sharing mechanism between the platform and tenants. Cloud services on the tenant side and platform side share the same technical architecture and service framework. Therefore, tenants can purchase services to build a security operations platform with the same capabilities as the provider. This makes it easier for tenants to build their security operation platforms and improves deployment efficiency. Cloud service providers can offer services such as secure hosting and secure agent maintenance to help cloud enterprises

quickly bridge their professional knowledge gaps.

Investment in security construction is preferred. Security is the prerequisite and guarantee for normal business operations. The precondition that security construction and business construction must be synchronized (synchronous planning, construction, and use) has become both a legal and regulatory requirement. Security should be one of the highest priorities when investing in digital systems.

Therefore, when making a security construction budget, enterprises should consider both service value and risk impact. For services with less value, simply allocate less budget. Whereas, important services where attacks on them may cause far-reaching social impacts, such as data leakage (causing significantly large losses), allocate a greater share of the budget. The security budget can be allocated based on the following proportions: 40% for purchasing common security software and hardware products, 40% for building security operation organizations and processes, and 20% for purchasing security commercial insurance and conducting routine security drills.

2.3 Huawei Cloud Security Brain Provides All-round Security Services and Global Compliance Capabilities

To address the development of security compliance requirements, Huawei Cloud constructed a brand-new security operation service in 2022, based on Huawei's three decades of security practices and operation experience - the Cloud Security Brain. This service provides a full set of security operation capabilities, such as log collection, security governance, intelligent analysis, situational awareness, and orchestration response. It presets security handling playbooks, integrates third-party security operation capabilities, and shares security operation experience in the industry. Thanks to the uniformity and standardization of the cloud native architecture, customer services can be migrated smoothly from public clouds to industry clouds and hybrid clouds. This directly helps customers build security capabilities equivalent to the Huawei Cloud, including routine operation, protection drills, major assurance, website monitoring, and security evaluation.

The main innovations of the Cloud Security Brain are as follows:

- Log collection and analysis. More than 200 types of security data both inside and outside of the cloud, as well as data from

security products of dozens of traditional security companies are aggregated for risk analysis. Combined with expert experience and AI capabilities, unknown threats can be detected in a timely manner. Security events are classified and graded so that they can be responded to in a meticulous fashion.

- Situational awareness. Compared with traditional data centers, data architectures on clouds are clearer and more consistent, and asset management on clouds is conducted in real-time, and more effective. The Huawei Cloud Security Brain can quickly complete security asset mapping and generate security information such as assets, accounts, risks, and vulnerabilities, allowing customers to visualize the security situation of their services on one screen.

- Visual reports. The Cloud Security Brain provides a variety of visual reports on which customers can clearly view their asset changes, including the baseline compliance of new assets, and security protection coverage. It also provides a full view of security risks and generates work orders for missing risk information, aimed at covering all assets and protection capabilities.

- Intelligent analysis. Based on the immense computing resources and strong AI capabilities of the cloud platform, the Cloud Security Brain gathers many types of security

data in the security operation system, such as cloud services, cloud configurations, logs, and external intelligence, and quickly completes security analysis based on these data fields. It then uses AI to classify and grade security incidents, and sets pop-up policies for them. This greatly improves the attack response efficiency.

- Response orchestration. The Cloud Security Brain uses AI technologies and Huawei cloud's security operation and incident handling experience to create more than 100

types of security models and more than 100 sets of security incident response playbooks. 90% of security events can be automatically responded to and handled. The SLA of first level events can be achieved within ten minutes. The Cloud Security Brain also allows customers to tailor security response orchestrations. Through visual operations, customers can build their own emergency response playbooks or import third-party playbooks. This enables the unified handling of global security incidents, improving handling efficiencies and security incident response times.
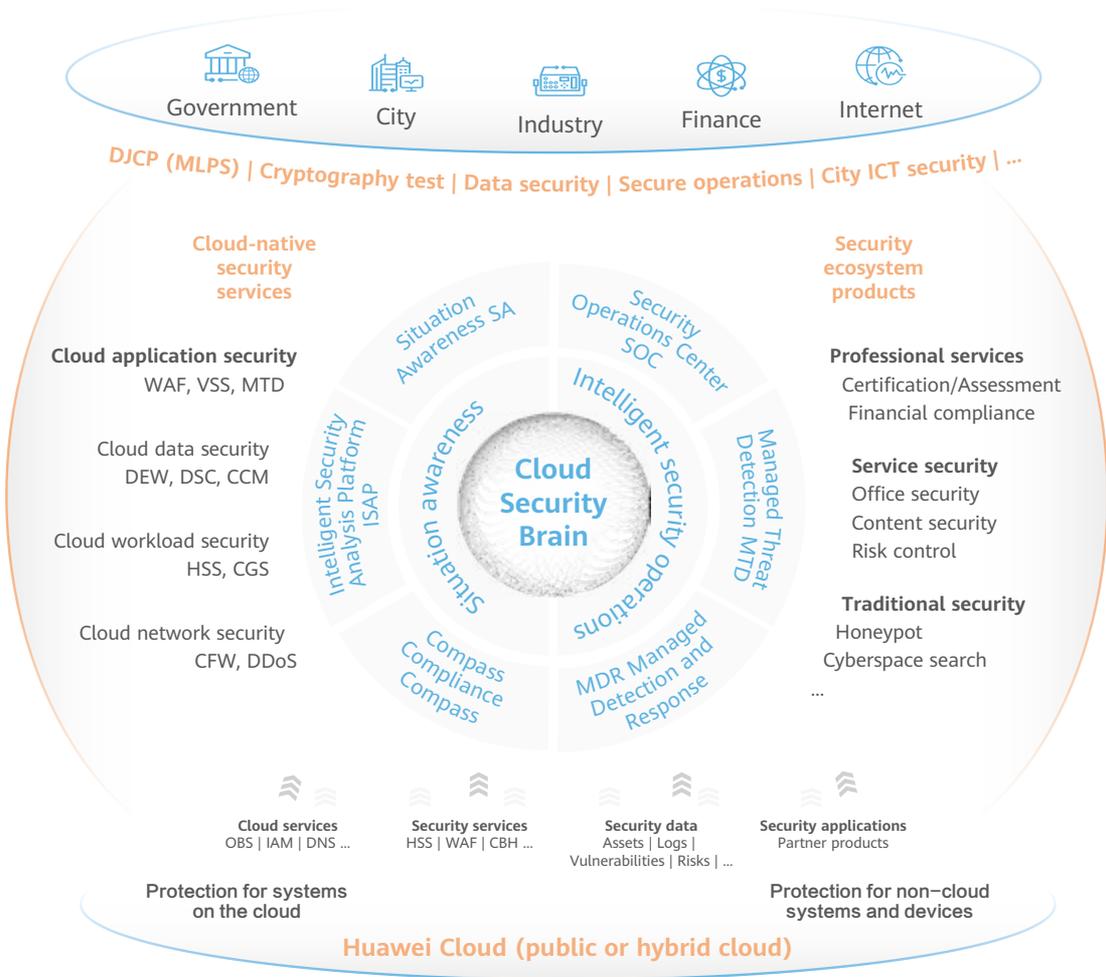
Figure 9 Cloud Security Brain

Based on Huawei's security operation experience, the Huawei Cloud Security Brain provides security operation capabilities as services that adapt to rapidly changing operation requirements in real-time, ensuring continuous service security.

03

**Data + AI
Convergence**

3.1 Data-Driven Decision-Making is On Track

Just over five years have passed since The Economist published the argument that "the world's most valuable resource is no longer oil, but data" in 2017. Factors such as epidemic, supply chain tension, inflation, and technology change are intertwined. Governments and enterprises around the world face systematic uncertainties and depend on data for dynamic resource allocation, which offers them competitive advantages to rapidly changing commercial landscapes. Data-driven decision-making is sitting firmly in the driver's seat, however, we must be acutely aware of the changes and new characteristics in the use of data by both governments and enterprises.

Firstly, government decision-making puts more emphasis on "using data to understand citizens and provide a basis for policy making". In recent years, the global pandemic has led to traditional economic predictions falling short of their respective targets (such as oil price rise, energy shortage, and inflation). Governments in the US and Western Europe have begun to use a large amount of timely and sophisticated data, such as the number of airport passengers per day and credit card consumption per hour, to evaluate the impact of policies[5]. The Chinese government is vigorously promoting a "one-network unified management", "one-network office", and "data exchange" to streamline data, and enable data to flow like commodities.

Secondly, emerging enterprises in many industries can find valuable information through the in-depth mining of industry data to produce competitive products and services, even if they are without upstream and downstream industry data. Narwal is a

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[5] The Economist, OCT 23RD 2021, Instant economics: The real-time revolution

smart manufacturing enterprise founded in 2016. It uses the results from data analysis to bring intelligent features to its robots, predict customer requirements, and optimize decision-making in production links. This has enabled the company to grow by a dozen times over the past two years. Another example includes the relatively new e-commerce company Mengxiang Group, which was founded in 2017, and has only taken four years to achieve a monthly transaction amount of US$150 million. Mengxiang Group used cloud big data and AI technologies to develop a "magic data box" that provides market insights, store advisers, price comparison services, incentive methods, and material libraries. Millions of housewives can use this magic box to start their own businesses without having to invest, store goods, or master digital technologies. Utilizing data and AI, e-commerce vendors can sell their goods without investing in advertising, customer service, and marketing teams. Furthermore, e-commerce platforms can bridge the gap between vendors and customers, without making significant efforts in customer operations.

Thirdly, for pioneers in traditional industries, they have found ways to break the paradox of "data governance has to be either too rigid or too chaotic". These enterprises need to manage a large number of systems as their services expand. Each system generates a large amount of structured, unstructured, log, and real-time data. These different types of data cannot be shared for further analysis or other usage. They become data silos. What's worse, the technical environment of data

is becoming increasingly complex and new silos are formed between warehouses, lakes, and AI systems along with the development of data analysis and AI analysis. Such silos reduce data migration efficiency and data reliability due to inconsistent data sources. As a result, the precision and accuracy of business results are low. These problems have led their technical departments to a common dilemma: either to start anew, causing a crisis of trust, as huge investment brings no benefits in the short term; or just sit and wait, letting their capabilities lag behind the development of data applications and AI technologies. Nevertheless, we are delighted to see good data governance practices, such as that of the Beibu Gulf International Port Group and Hunan Valin Xiangtan Iron and Steel. Their data governance is based on the data + AI foundation, and driven by both operations and applications. In this way, they not only ensure a smooth transition from traditional applications to cloud-native applications, but also improve operation efficiency and innovation, powering a new wave of business transformations.

Although the preceding changes have not become commonplace, it is foreseeable that as time goes by, more governments and enterprises will adopt a more agile and accurate intelligent decision-making style. These decisions should be made in minutes, rather than days or months. They should be based on complete and accurate data, instead of partial, dirty data, and should be made by operational personnel and data analysis personnel, instead of going through complex processes and multi-department cooperation.

3.2 Technical Driving Forces Behind Using Data

Innovation is driving these aforementioned pioneers to find rules and values hidden in data, and apply them directly to business. However, one aspect that will not change is the need for innovative thinking, especially considering about how to adapt to the data + AI era. Needless to say, one change that is on the way is innovation. Data and AI analysis technologies are developing vigorously and presenting convergent trends. The breadth and depth of analysis are continuously fine-tuned, and the threshold for using analysis is continuously lowered.

First and foremost, the data-centric cloud native architecture enables enterprises to balance data volumes, costs, and efficiencies. To fully share data, reduce costs, and break data silos, a storage and compute decoupling architecture is developed. Storage and compute

resources can be elastically and independently scaled and used on demand. However, in this case, due to remote storage, I/O bottlenecks occur, and performance deteriorates. Therefore, a high-performance cache layer is required to store hot data with high I/Os. This leads to a hierarchical data-centric architecture style. From the perspective of necessity, the computing-centric architecture cannot adapt to the current data ecosystem development: Data-centric workloads such as big data and AI develop rapidly. The storage and compute decoupling architecture of data lakes has low storage access performance, affecting real-time analysis. From the perspective of feasibility, the rapid development of media, networks, and protocols drives architecture transformation: Storage-Class Memory (SCM) fills the media gap for memory scale-ups. The competition for cache consistency standards becomes hot. High-speed memory direct connection protocols and technologies make remote direct memory access no longer an obstacle.
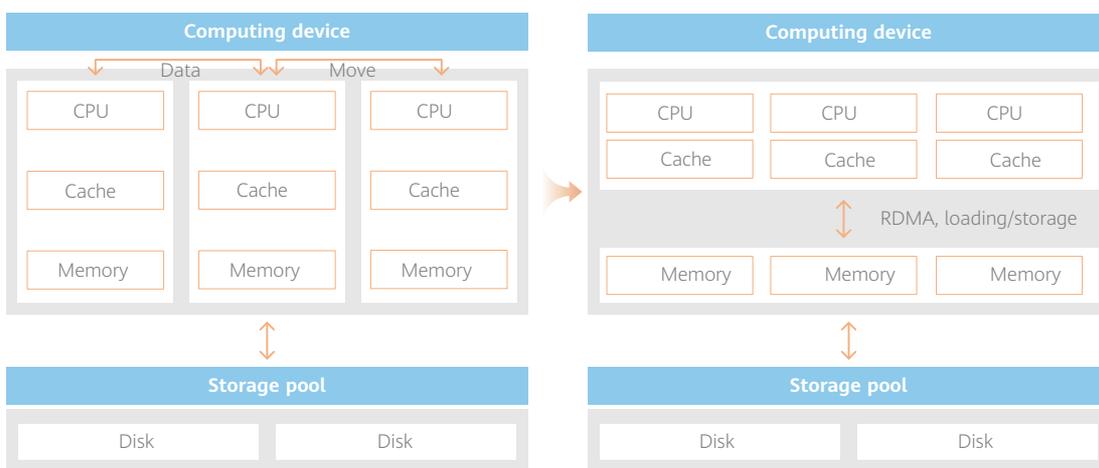
Figure 10 From "decoupled storage and compute" to "data-centric architecture"

Secondly, lake warehouse technology, which is aimed at data sharing, makes decision-making suggestions based on data insights trustworthy. After many years of data analysis and AI analysis development, multiple task-dedicated data systems have emerged. As a result, data analysts and AI developers have to depend on the conversion scripts written by data engineers to obtain the desired data, which prevents them from collecting their data analysis and modeling quickly. Data engineers need to understand the requirements of data analysts and AI developers before embarking on the development journey, so

as to prevent bottlenecks when tasks become insurmountable. What's even more serious, is that the transfer of data between different systems will cause data inconsistencies, resulting in inconsistent and unreliable analysis , which affects decision-making and hinders data usage. To solve this problem, lake warehouse integration technology has been developed. The core idea of the technology is to store and share all data and models in a unified manner, and then manage the data based on unified metadata. This enables the free transfer of data among multiple engines, while all the analyses are based on a single source.
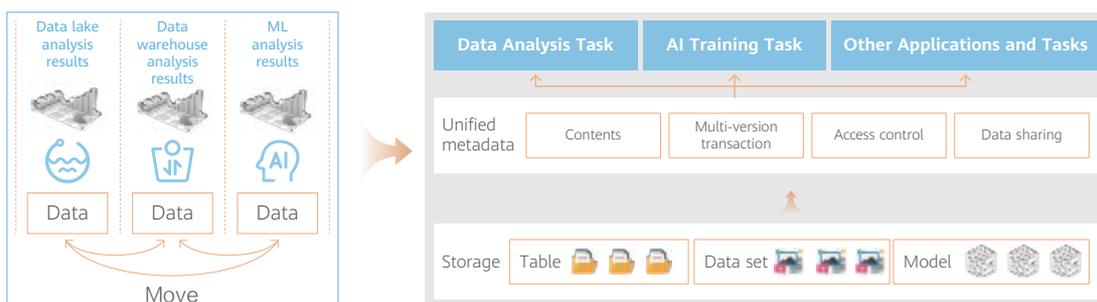
Figure 11 From lake-warehouse-AI silos to lake-warehouse integration

Thirdly, AI operating systems built on foundation models enable AI to be widely used. There are numerous scenarios in multiple industries, and as a result, AI applications are fragmented, and professional knowledge is difficult to accumulate and reuse. In traditional AI development, even if there are tools with a high degree of automation, the development process has to be carried out in an in-house manner, and manpower is invested in projects separately. This leads to an inevitably long development

period and results cannot be shared. What is more challenging is that the AI model precision depends on the number of training samples. However, data in some industry scenarios is scarce. Therefore, the performance of AI models cannot meet the production requirements, making AI unavailable in these industry scenarios. Foundation models provide a solution to these problems with AI applications no longer requiring development from the ground up. For each specific scenario, you can quickly extract a smaller model from

a pre-trained foundation model and further train it using specialized datasets. This accelerates the development cycle from months to days, allowing for industrial scale AI development. In the future, foundation models will become the operating systems of AI. They are used to manage AI hardware and support AI applications, helping with large-scale AI implementation.

Multiple sources
Enterprise
Public network
...

Multiple types
Table
Images
Video
...

100 billion
parameters

Fine-tune
downstream tasks

Multiple scenarios
Model 1
Model 2
...
Model n

Pre-trained foundation models
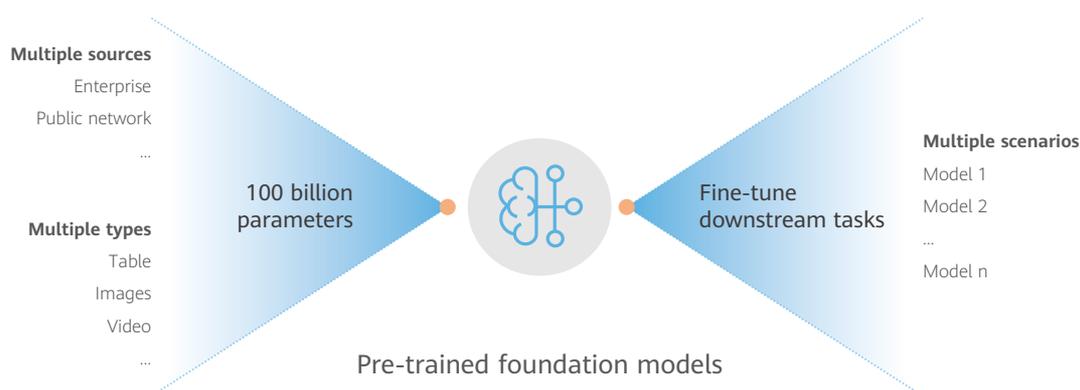
Figure 12 Foundation models

Fourthly, AI is used to support data and model development, enabling everyone to innovate. The implementation of business intelligence involves many technical processes. However, most enterprises lack data and AI personnel. This has long been hindering enterprise innovation. Data is one of the core elements of AI. The quality, breadth, and timeliness of data determine the accuracy of AI models. The separation of data and AI development platforms is another main reason that prevents enterprise innovation. Recently, several companies have began to combine DataOps and MLOps to provide an integrated development environment that masks software and hardware differences and complex underlying technologies. This environment promotes the development of using simple operations such as drag-and-drop and a small amount of code, lowering the development threshold. Companies can also apply AI technologies to multiple scenarios, such as data integration, data quality, data modeling, data security and access control, data association, and data insight. The purpose of these practices is to implement end-to-end process automation and intelligence, enable low-code development, and execute sustainable data operations.
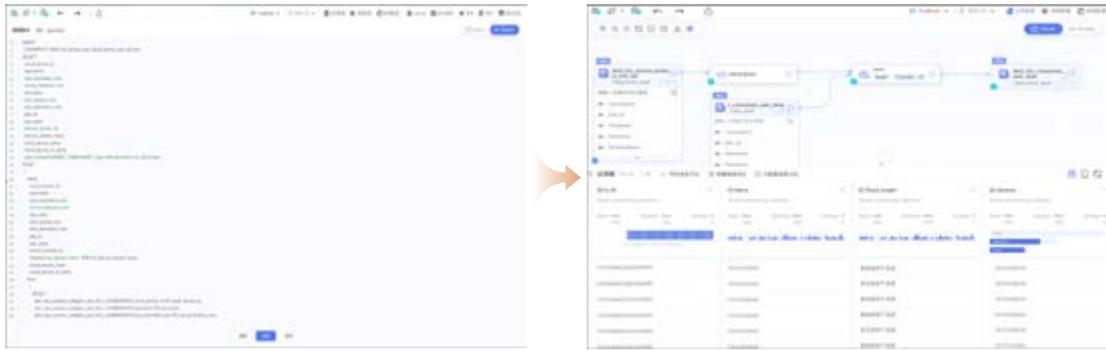
Figure 13 Shifting to low-code

3.3 Huawei Cloud Data + AI Unleashes Unlimited Data Potential

To address the pain points concerning customers' data innovation, and adapt to the changing technical trends, Huawei Cloud provides a wide range of data and AI services, including: Huawei-developed distributed relational database GaussDB, MySQL ecosystem-based GaussDB, multi-mode converged NoSQL database, AI development production line ModelArts, serverless big data platform DLI, cloud search CSS, cloud native data warehouse DWS, fully managed big data platform MRS, and time series analysis service IoTA, cross-source and cross-domain interactive analysis engine HetuEngine, trusted computing TICS, and diversified integration tools and ecosystem partner services. These services aim to meet customers' diversified data usage requirements and enable them

to focus on using data and AI to innovate their businesses, without worrying about rapid technology change, maintenance of underlying software and hardware, and security that are not directly related to their core businesses.

In 2022, Huawei Cloud uses the DataArts and ModelArts converged architecture to streamline big data and AI applications, making it easier for customers to use the data. To begin, Huawei Cloud integrates all of the data without affecting the existing system, so that customers can comprehend global data at low costs. Secondly, Huawei Cloud uses cloud native technologies, such as tenant-level fine-grained elastic resource control and separation of storage, cache, and computing to reduce the high costs associated with the long-term storage of complete data. Thirdly, Huawei Cloud absorbs the design ideas of Data Mesh, Data Farbic, and LakeHouse, and

uses unified metadata, and automatic and intelligent data governance to streamline and manage the entire data lifecycle. Fourthly, Huawei Cloud integrates DataOps and MLOps to enable personnel from different departments and with different roles in an enterprise to perform agile development in a way that they can excel at.
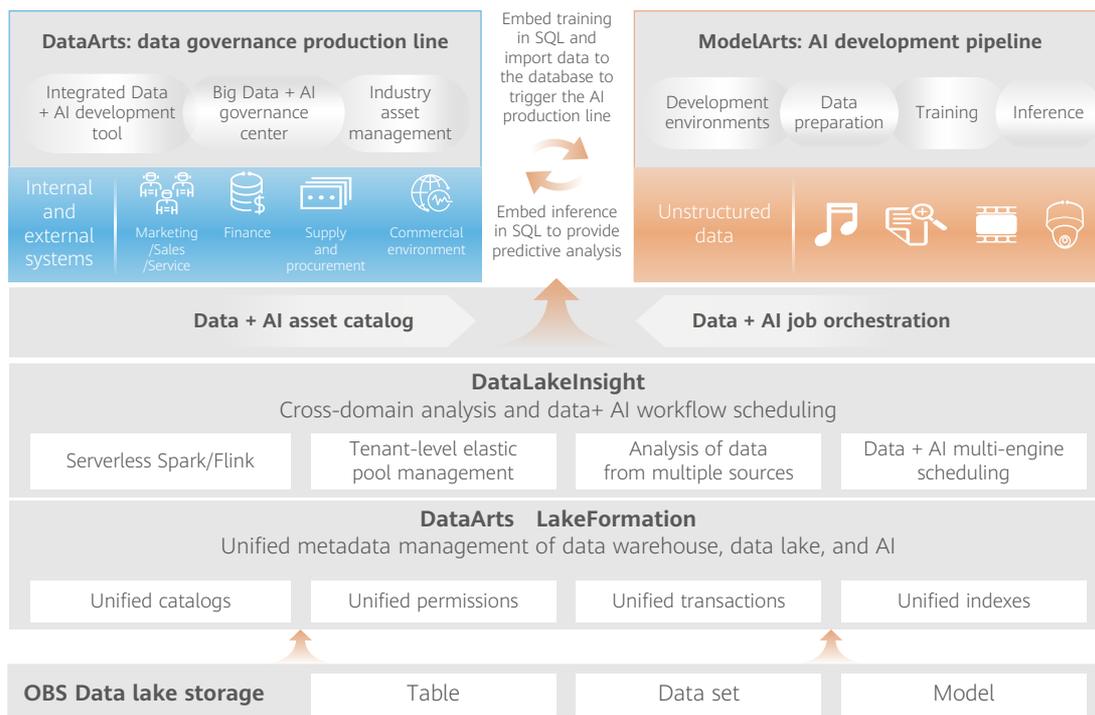
Figure 14 Huawei Cloud data + AI solution

For AI model training, the Huawei Cloud Pangu foundation model extracts effective knowledge representations from significantly large amounts of data to train a large-scale model. Take natural language processing as an example. The Pangu NLP foundation model increases the model parameters from hundreds of millions to hundreds of billions, which enables knowledge extraction from a larger database, and enables a wider range of downstream tasks. In addition to the NLP foundation model, the Pangu series also includes the CV foundation model, multi-

modal foundation model, scientific computing foundation model, and graph network foundation model. This knowledge base enables large-scale replication through the fine-tuning of small-sample and lightweight data models. Therefore, the problems of large data volumes and high technical requirements that restrict AI applications can be solved.

NLP foundation model	
Content generation	Content understanding

CV foundation model		
Classification	Segmentation	Inspection

Multimodal foundation model		
Cross-modal retrieval	Cross-modal generation	Show and tell

Scientific computing foundation model		
Molecular models	Finance models	Air models

Pretrained models

Generalization Copy

Scenario 1 ▶ Model 1 · Pipeline
Scenario 2 ▶ Model 2 · Pipeline
Scenario 3 ▶ Model 3 · Pipeline

Pretraining → Tuning & deployment

Iteration

Figure 15 Huawei Cloud Pangu foundation models

04

Media Services

4.1 Media Industry: Integrating the Virtual and Physical Worlds in the Metaverse

Investment in the metaverse has exceeded USD120 billion, with 79 percent of active consumers on the metaverse having made a purchase in 2022, according to research by McKinsey[6]. The metaverse is set to become the biggest new growth opportunity for several industries in the coming decade, including consumer goods, retail, finance, technology, manufacturing and healthcare. 25% of executives estimate that more than 15% of corporate revenue will derive from the metaverse in the next five years. By 2030, the value of the metaverse is predicted to reach a staggering USD5 trillion.

Even though the metaverse is still being defined, it is already known that it will evolve

in two directions: a digitalized physical world and a real digital world. Despite how the two may sound similar, there are distinct differences. In a digitalized physical world, the physical world is integrated with the digital world to facilitate interaction and boost productivity for a better physical world. In a real digital world, diverse digital native content is created on digital content production platforms (with technologies such as 3D modeling, simulation, rendering, AI, and NFT). Such content unlocks an immersive experience in an intelligent and open digital world. This virtual-physical integration will permeate more facets of live and work and benefit both consumers and businesses (Figure 16):

- For consumers, innovative applications are being released in an endless stream, providing a completely new experience. Physical concerts are evolving into virtual

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[6] McKinsey & Company, Value Creation in the Metaverse

reality (VR) concerts, where the audience can attend in avatar form. Online stores are going virtual so that buyers can communicate with sales personnel in real time to try out and purchase products in a digital space. The future will bring an almost unlimited number of applications that integrate the virtual and physical worlds, such as in variety shows, socialization, e-commerce, and gaming.

- When it comes to businesses, virtual-physical integration completely transforms

the world we live and work in. People are well connected in a shared space, regardless of their physical locations. Employees around the world can attend conferences, collaborate, and receive training together; enterprises can launch and demonstrate new products to customers, and customers can verify project results remotely. The remote office and intelligent physical environment are reshaping enterprise production, and the virtual world is making the real world a better place to live in.

New B2B models	
Web page official websites	Metaverse official websites

| Manufacturing simulation | Media production | Virtual exhibitions | Industry-specific digital twins |
| AR retail | Smart agriculture | Smart city | Smart education |

New B2C experience	
Physical concerts	VR concerts

| Variety shows of virtual-physical interaction | Virtual socialization | XR shopping | XR fitness |
| Digital asset transactions | XR gaming | Virtual idols | Family metaverse |

Figure 16 Virtual-physical integration brings new changes to B2B and B2C applications

This change in media applications, however, means greater consumption of infrastructure resources. Growing traffic demands pose new challenges to service latency, access bandwidth, and hardware computing power. Resource requirements also vary significantly in different phases of virtual-physical integration (Figure 17). In the current XR entertainment scenario, a smooth VR experience requires a

latency less than 20 ms. Such latency is built on a 1 Gbit/s access bandwidth for each user through technologies such as 5G, Wi-Fi 6, and edge computing. In a world featuring virtual-physical integration, the industrial digital twins demand for a latency as low as 10 ms, which can be possible only with the 5G+ or even 6G network that delivers a 10 Gbit/s access bandwidth. In the future, the highly accessible

holographic communication network will unlock brand-new system capabilities, such as quantum computing for an E2E latency of less than 1 ms.

ICT Requirement	Phase 1 XR: Socialization + entertainment	Phase 2 Virtual-physical integration	Phase 3 Holographic digital universe
Latency	20–50 ms	1–10 ms	< 1 ms
Bandwidth	100 Mbit/s–1 Gbit/s	10+ Gbit/s	100+ Gbit/s
DOU traffic	10–100 GB	1,000–10,000 GB	100,000–1,000,000 GB
Compute demands	30–60 FPS for rendering	60–120 FPS	Quantum computing
Network /Key technologies	5G/Wi-Fi 6/10G-PON, cloud/edge/AI, VR/AR/wearable devices/mobile phones	6G/Wi-Fi 7/50/100G-PON, distributed cloud/AI MR/tactile/gesture operation	Holographic communication /Natural interaction/AI

Figure 17 Infrastructure resource requirements in different phases

A huge demand for computing power will also drive the reconstruction of data centers. For example, in a virtual world, 264 graphics cards are needed to render clothing at a sub-millimeter resolution, and it takes 60 hours to process a video of 60 frames per second (FPS). Offline computing power is insufficient for such demanding tasks. Cloud-based applications or device-cloud synergy will become the normal. Data centers will be reconstructed to streamline scenario-specific computing power on a new cloud bus. A GPU-centered heterogeneous computing system is built to dynamically schedule computing power across devices, edge, and cloud, as well as memory resources by tier. Unified computing centers need to be built in cities and campuses to fuel the future cloud journey of enterprises.

The metaverse that spans many fields and has high technical requirements is still in its infancy. Despite the many uncertainties ahead, industries are accelerating the adoption of media content to ensure happier customers. In the long run, the best way for enterprises to explore the metaverse is to apply mature technologies to existing scenarios, such as virtual human livestreaming, 3D virtual live rooms, and virtual cloud conferencing. Media content consumes a massive number of network, storage, and compute resources. The easier and more intuitive it is to understand the information, the more resources will be needed. As a result, enterprises need to adopt lightweight cloud native at the beginning to reduce the pressure on media content and to take steps towards achieving the digitalization of tomorrow.

4.2 New Service Stacks on the Cloud: Key to the Evolution of Media Applications

In addition to the unlimited resources for media applications, cloud native services also provide new service stacks.

First, leading cloud vendors have moved digital content production to the cloud, including movie, animation, and virtual content production, as well as the creation of virtual humans. Content production on the cloud boosts computing power thousands of times and allows for professional development management and remote collaboration

(Figure 18). Digital content production on the cloud has four features. First, one-stop content distribution, which allows designers worldwide to collaborate with one another. Second, the real-time and iterative workflow for cloud native and fully shared digital content production without requiring any copies. Third, a parallel computing framework that is capable of parallel simulation and rendering, which uses tens of thousands of cores for rendering a single image and leverages diverse computing power (CPUs, GPUs, and NPUs) without affecting services. Fourth, the powerful read and write of hundreds of high-concurrency files support fast and secure HA content access at a low cost.

Explosive data growth

10 years ago
· Rendering duration of Avatar: 150 million hours
· Number of iris polygons: 25,000
· Hair quantity: hundreds of thousands

Now
· Rendering duration of Alita: 550 million hours
· Number of iris polygons: 8.3 million
· Hair quantity: 10 million

Unstructured data (text, images, voice, video, etc.) requires GPU and NPU computing power

Structured data (processed using the two-dimensional table structure of databases)

Source: IDC, Huawei GIV

>80% Unstructured data

Structured data

1990   2000   2010   2020   2030

2030 1 YB annual data amount, up by 23 times

Content production on the cloud boosts computing power by thousands of times

Real-time and iterative workflow

Shooting → Editing → Modeling → Rigging → Motion control → Rendering → Compositing → Distribution

A cloud native and fully shared digital content production pipeline without requiring any copies

Digital content production platform

Parallel simulation and rendering framework, tens of thousands of cores for rendering a single image

Powerful read and write of hundreds of high-concurrency files

Parallel computing framework

High-speed read/write bus

Massive heterogeneous CPU/GPU/NPU computing power without affecting services

Fast and secure HA content access at a low cost

Diverse computing power

High-speed file storage

Cloud native digital content production platform

Figure 18 Digital content production on the cloud, the answer to exponential data growth

Second, the distributed network provides the low latency needed for virtual-physical integration (Figure 19). The future world of virtual-physical integration is built on the distributed cloud.

Numerous virtual spaces are connected through one global network to provide real-time interactivity for socialization, work, and entertainment. To this end, the following two technical requirements must be met. One is the global elastic scheduling, which assigns users to different virtual spaces deployed worldwide. Technologies such as real-time parallel rendering and spatiotemporal multiplexing significantly reduce rendering costs on the cloud. The other essential technical indicator is real-time interactivity. A large number of users interact with each other in virtual spaces at a latency of 20 to 50 ms. The real-time message interaction framework can accommodate hundreds of millions of data interactions per second.
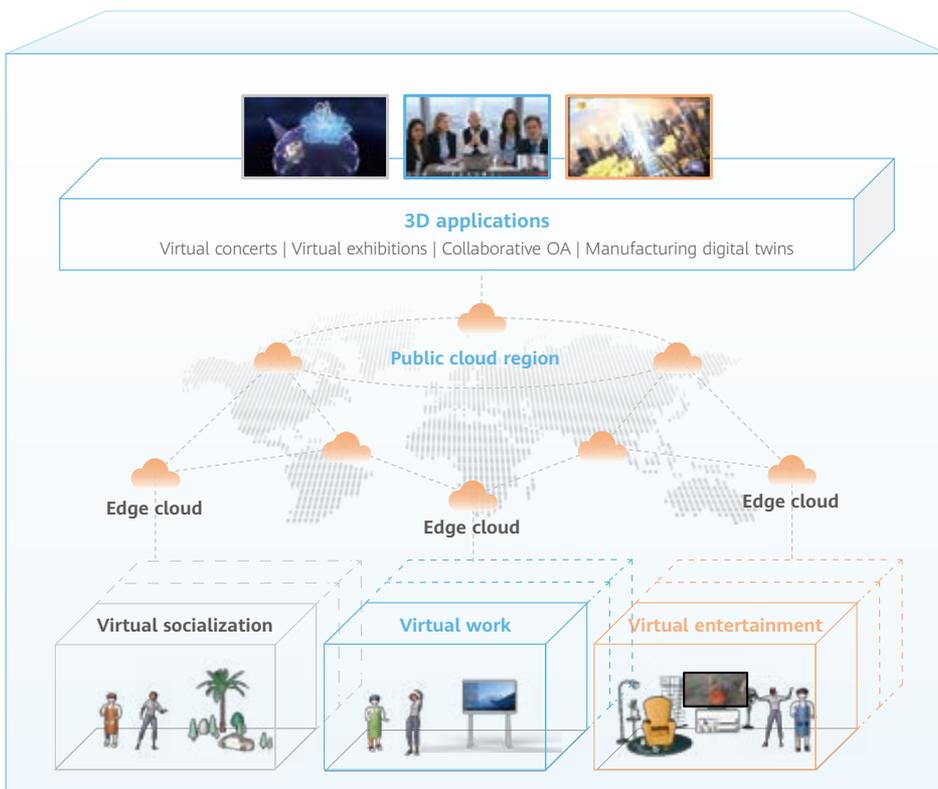
Figure 19 Low latency supported by the distributed network

Third, the capabilities required for media production are provided to enterprises as platform services to make cloud content production more available (Figure 20). Basic services include model creation, asset management, content editing, physical simulation, and cloud rendering. A series of kits can be quickly integrated and called by industry developers to build solutions tailored to different scenarios, such as manufacturing, movie production, office work, and socialization.

Media	Collaborative OA	Interactive entertainment	Socialization	Virtual livestreaming	Manufacturing
Production pipelines: Variety shows | Movies | Animation |...	Virtual exhibitions | Remote collaboration | XR conferencing |...	Virtual interactive livestreaming | Virtual concerts |...	Virtual socialization | Virtual stores |...	Virtual interactive livestreaming |...	CAD | CAE simulation analysis | CAM |...

Huawei Cloud collaborates with partners to provide scenario-specific solutions for industries.

MetaStudio: Digital content production platform

Kits	3D modeling kits	3D asset management kits	Content processing kits	Physical simulation kits	Cloud rendering kits
	· 3D object scanning · Photo modeling · Body data collection modeling · Visual control · Voice control	· Smart tag · Recommendation/Search · Encryption/Watermark · NFT/Blockchain	· Image super-resolution · AI coloring · Application streaming · Workspace	· Hair simulation · Cloth simulation · Fluid simulation · Muscle simulation	· Interactive ray tracing rendering · Device-cloud rendering · Rasterization + AI rendering · Multi-view rendering · Distributed rendering

| 5 platform services	Model creation	Asset management	Content editing	Physical simulation	Cloud rendering
	Digital space | Virtual humans | Digital objects	Asset management | Asset security	Cloud graphics workstations | Remote collaboration	Rigid body | Soft body | Hair | Water | Smoke and dust	Virtual-physical integration | Real-time rendering of large scenarios

Figure 20 Digital media content production as a service

4.3 Huawei Cloud MetaStudio Seamlessly Integrates the Virtual and Physical Worlds

Huawei Cloud embraces the digital native trend to build and provide full-stack media services and infrastructure for industries. In this way, organizations across industries can dive into the latest technologies and ideas of digital media and well prepare for the digital world of tomorrow. Huawei Cloud launched the digital content production pipeline in 2021 and is upgrading the pipeline this year. As shown in Figure 21, Huawei Cloud, together with partners, will leverage the new digital content production pipeline MetaStudio to breathe new life into virtual-physical integration. For example, SparkRTC provides real-time audio and video communication on one global network, which delivers a latency as low as 200 ms and up to 99.99% reliability across 170 countries and regions. The proprietary cloud rendering engine and space engine of MetaStudio have been put into commercial use by interior design vendors such as Sunvega. At the platform layer, Huawei collaborates with Xsuperzone to provide the industry's first 4K HD workspace that supports 60 FPS. This product can replace the Apple workstations that are widely used by designers. Huawei Cloud also provides blockchain, NFT, and media AI capabilities. These core platforms and engines enable the efficient generation of digital content in numerous industry-specific scenarios.

Digital media services					Seamless integration of the virtual and physical worlds

N application scenarios

3 platforms

2 core service engines

1 global media network

	Metaverse for enterprises			Metaverse for consumers	
Application scenarios	**Digital China** Live China and digital cities	**Collaborative OA** Virtual exhibition halls and cloud meetings	**Content production** Movies/Variety shows	**Video** Interaction and livestreaming	**XR** VPS and cloud rendering
Media experience	Virtual humans	3D space	Livestreaming	VOD	RTC	Virtual exhibitions	Cloud AR	More

MetaStudio

Media production & operating	**Connected on the cloud** Original images | 3D modeling | Motion control | Rendering	**Growing on the cloud** Skill | Knowledge | Understanding | Interaction	**Empowering cloud apps** TV | Exhibitions | Live | Gaming

Media platforms	**Communications & Collaboration** Cloud conferencing | Workspace	**Digital asset management** BCS | NFT	**Intelligent media** Computer vision | AI

Media engines	**Graphics engine** 3D modeling | Physical simulation | Interactive media | Rendering	**Space engine** Spatial computing | Cloud anchor

SparkRTC

Media network

Personal terminals	Mobile phones	Computers	Tablets	Head units	VR	Workplace terminals	Telepresence	Smart boards	Smart TVs	TCs	Cameras	NVR

Seamless integration of the virtual and physical worlds:

- **Virtual hosting** Xiaoyang of Hunan Television
- **Cloud interior design** Sunvega
- **Cloud content production** Mirror Pictures
- **Virtual exhibitions** Huawei Cloud

Figure 21 Huawei Cloud MetaStudio

05

**Application
Modernization**

5.1 Cloud Native Empowers Application Modernization

For each organization, applications are the main focus for digital transformation because they present some special challenges. For example, every organization has a large number of legacy applications that cannot meet the requirements of this new era. These applications were developed based on technologies from more than 10 years ago. They do not use cloud native architecture and technologies, which makes them difficult to upgrade. In 2022, we noticed that leading enterprises have started modernizing their application architecture for many reasons.

– They encountered rapid traffic growth due to the explosion of some new concept, so architecture needs to be improved and existing resources are no longer sufficient.

– They want to decouple service modules, so they can adjust their business in a simpler, faster, more efficient and sustainable manner.

– They hope to use new technologies such as big data, AI, and metaverse to gain in-depth insights into the industry and into their customers. They hope to improve efficiency and user experience, to maintain a leading position in the face of increasingly fierce competition.

Application modernization in the cloud native era is not simply lifting and shifting offline applications to the cloud. Resource elasticity and simplified O&M are still critically important, but deepening digital transformation has resulted in more diverse, more complicated applications of digital technologies. Cloud services are still far from meeting enterprise requirements. To maximize their value, they need to be fully integrated with new cloud native capabilities such as big data and AI.

Looking at application modernization around the world, the US market is leading the industry. Based on an analysis of existing enterprises[7], application modernization provides significant benefits.

Application modernization has benefited thousands of enterprises:

31% average infrastructure **cost savings**

43% fewer **security** incidents per year

44% improved **quality** of service

62% **more efficient** IT infrastructure management

3x more **features** delivered per year

40% improved user **experience** and satisfaction
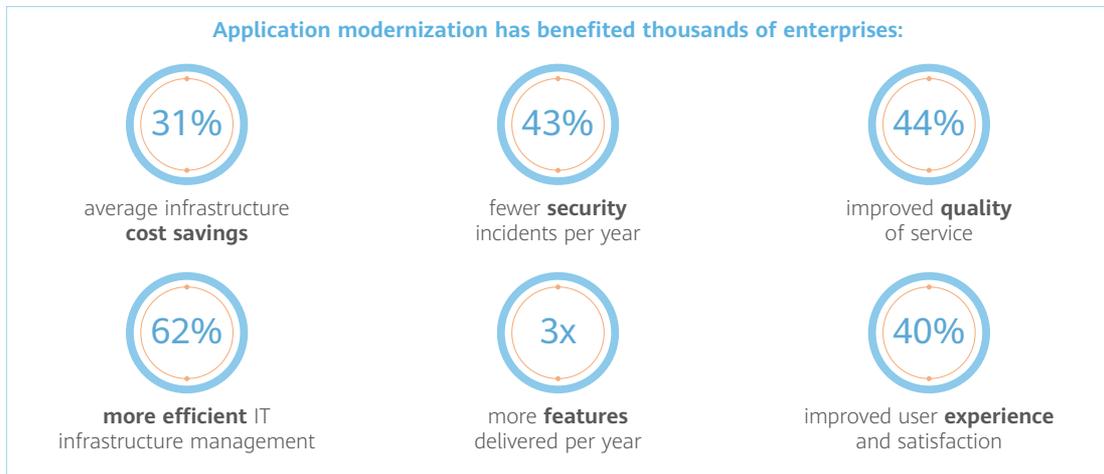
Figure 22 Benefits of application modernization in the US market

The way we think about application modernization will evolve, but the core goal of application modernization remains unchanged, that is, applying the latest technologies to achieve business success. In the preceding chapters, we saw that the basic technologies required for digital transformation have never been so complete. Both traditional businesses and new innovators can use cloud and on-cloud technologies to transform traditional applications into more modern applications (Figure 23).
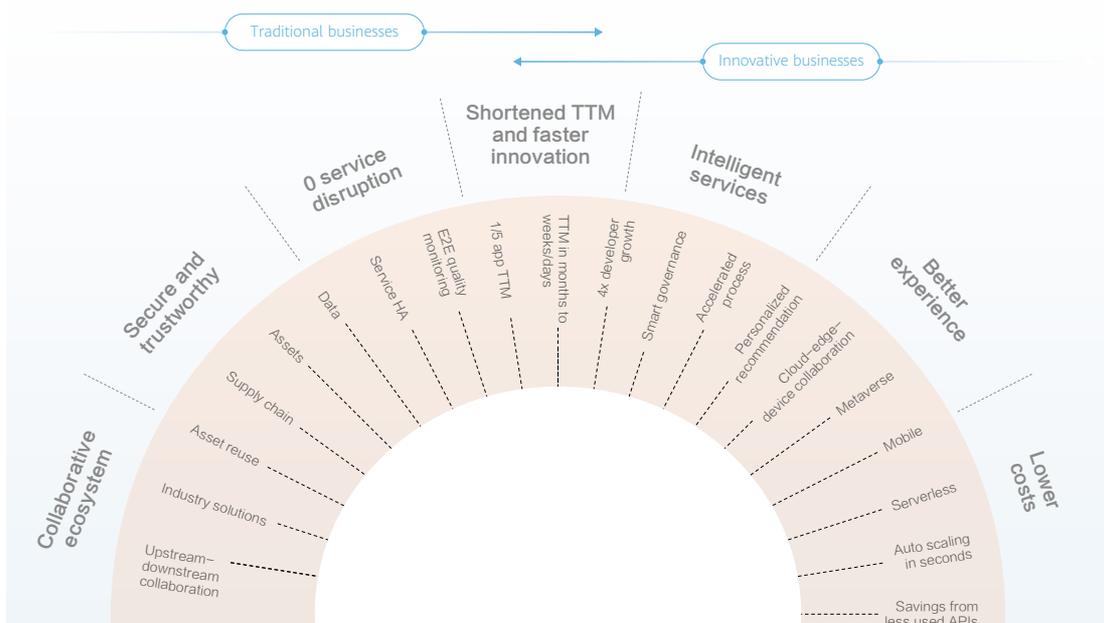
Figure 23 Application modernization requirements

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[7] Based on analysis of data from IDC, Nucleus Research, and ZDNet

Just like when applications needed to be modernized for the information revolution era, enterprises today may feel that such transformation is risky. But the market will evolve regardless, and we will have no choice but to transform. Now, we need to stand at the forefront of the industry and of the times. We need to reflect on our weaknesses and on what direction we are headed and take action. Although application modernization is reflected by cloud-native application migration and reconstruction, there is still a lot of work left to be done.

Hardware facilities need to be built, software architecture designed, processes developed, and governance needs to be modernized. Enterprises need to learn effective methodologies and identify reference architectures in the industry. They need to select corresponding paths and solutions based on application characteristics and phases. If necessary, enterprises can purchase consulting services and professional services to ensure smooth modernization.

5.2 Four Pillars of Application Modernizations

Analysis of industry-leading enterprise application modernization experience shows that there are four main aspects that need to be modernized: infrastructure, architecture, development and maintenance, and governance and operations (Figure 24).
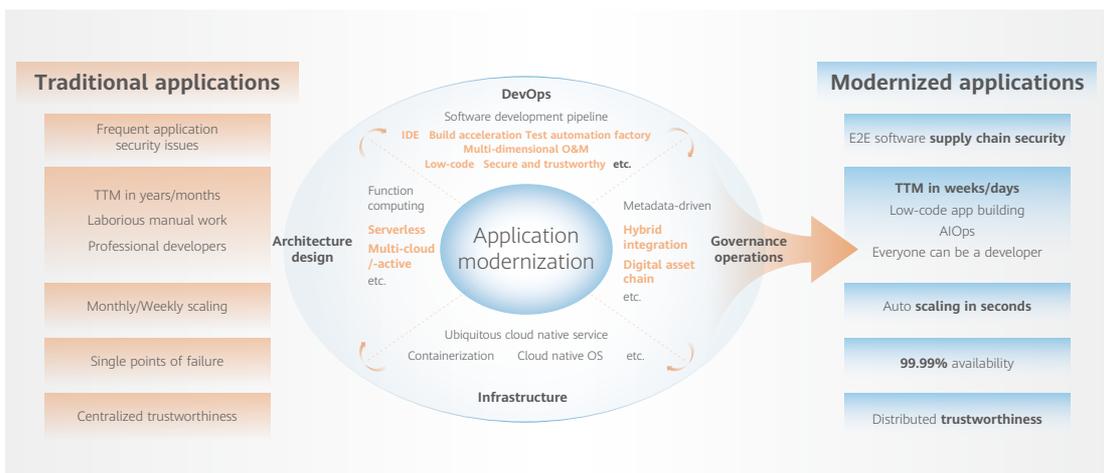

Figure 24 Four modernizations

– Infrastructure modernization ensures high availability and provides elasticity. It reduces the cost of O&M and frees enterprise technical personnel from constantly spending time on complex resource maintenance.

– Architecture design modernization decouples reusable functions from business logic (Figure 25). By reconstructing the application architecture means using microservice and serverless architectures. Applications are split into independent modules that can be released and run independently, allowing enterprise technical personnel to innovate more efficiently.
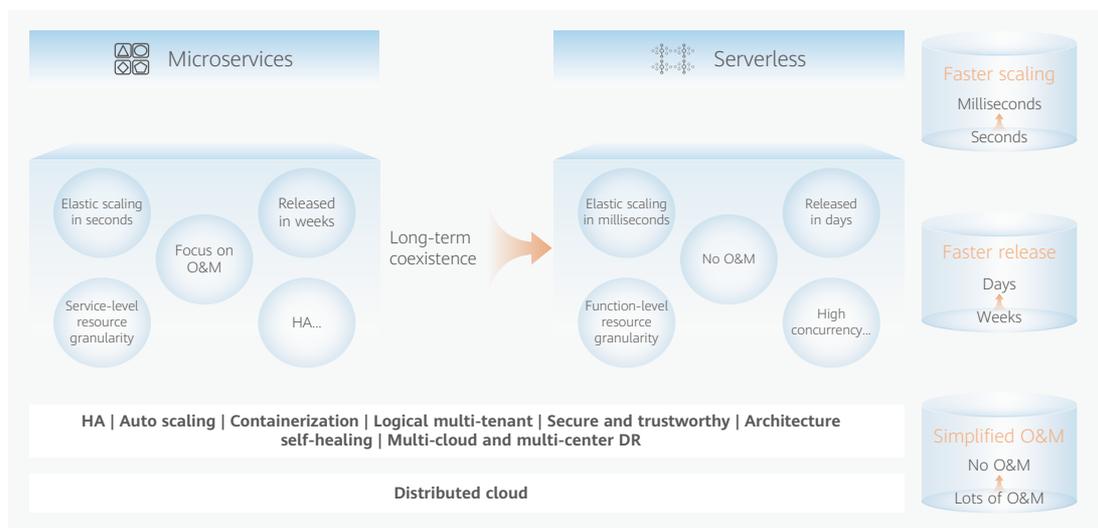
Figure 25 Typical target architecture

– Development and maintenance modernization calls for pipelined software production, and builds security into the entire process, from development to use and O&M to achieve full-lifecycle security of applications (Figure 26). Methods and practices for professional developers to modernize development and O&M include highly automated CI/CD pipelines, secure and trusted development management, multi-dimensional intelligent O&M, and efficient human-machine/human collaboration. For individual developers (non-professionals), a one-stop low-code development platform is required to help them develop applications consisting of user UIs, service logic, workflows, and data services in drag-and-drop mode, so professional programming skills are not necessary.

| Microservices | API | Mobile apps | Web apps | Serverless apps | Embedded apps |
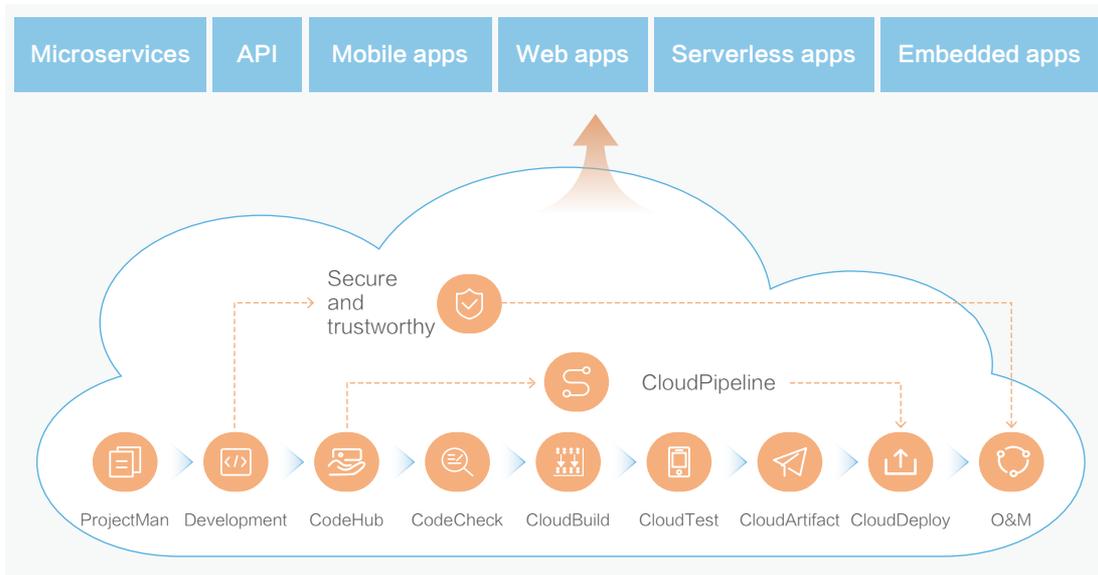
Figure 26 Cloud-based development and O&M

– Governance and operation modernization considers the actual situation of an organization, so that a smooth transition between legacy and new applications can be ensured and legacy investments can be protected. This modernization leverages the agility of cloud native for organic collaboration between legacy and new applications, but existing systems do not need to be abandoned and a smooth evolution of the enterprise IT architecture can be ensured. In addition, the reuse of digital assets simplifies the development of enterprise applications, reduces costs and risks associated with trial-and-error development, and maximizes the value of new and legacy applications and assets. Methods and practices for modernizing governance operations include API governance, service-oriented architecture governance, cloud deployment governance, and data and application delivery.

5.3 Huawei Cloud Software Development Pipeline Accelerates Application Modernization

Along with the birth of Huawei Cloud, the software development pipeline benefits from Huawei's years of digital experience serving customers around the world. It has integrated a set of methods based on

industry-leading application modernization concepts and shares these methods with the industry as services. In 2022, Huawei Cloud made advances in a number of aspects of application modernization.

- Infrastructure modernization has been described in the preceding sections and will not be described here.

- Architecture design modernization:

  – FunctionGraph has been upgraded to V2.0. It has integrated storage, multimedia, CDN, and IoT services to provide more than 30 out-of-the-box function templates and over 50 mainstream cloud service function triggers.

  – Cloud Application Engine (CAE), a serverless application hosting engine, provides one-stop hosting and governance.

  – Cloud Application Model (CAM), a cloud application model, unifies description specifications for serverless applications.

  – EventGrid efficiently routes standard events among cloud services, applications, and SaaS partners.

  – Multi-cloud high Availability Service (MAS) helps enterprises build multi-active architectures to redirect application traffic to different clouds in seconds to prevent service failures.

- Development and O&M modernization:

– Binary analysis was released for trusted development management. Security scanning and analysis can be performed on applications even if the source code is unavailable, greatly reducing security risks introduced during program development.

– Mobile application security service allows developers to use real devices to simulate different scenarios, so they can incorporate security into the development of their mobile applications.

– In terms of software development efficiency, Huawei launched a build acceleration service to provide distributed, precise incremental build acceleration capabilities, breaking through the physical limitations of a single PC and helping developers greatly improve build efficiency.

– In terms of automatic testing, Huawei offers the first product ever to manage hundreds of millions of test cases with high performance delivered for tens of millions of test requests, and 24/7 continuous EchoTest testing available. The automated factory testing capabilities are great for large enterprises, especially in manufacturing.

–In terms of IDE, Huawei launched CodeArts, a Huawei Cloud desktop IDE, to provide developers with a more convenient and intelligent desktop development experience.

–In terms of low code, Huawei launched

AppCube, a low-code development service that provides developers with a large number of page components, Business Process Management (BPM), a model orchestration tool, and baseline application templates. AppCube encapsulates complex services, such as AI, video, GIS, Building Information Modeling (BIM), and IoT services. Developers can invoke existing services and only need to compile a small amount of code to create their own application systems.

- Governance and operation modernization: Huawei Cloud believes that enterprise digital assets (applications and data) should be converged and integrated in all domains. Enterprises should break through old boundaries to connect new and legacy applications, enable smooth evolution, and mobilize digital assets. Huawei Cloud has integrated the ROMA solution developed by Huawei's BP&IT department based on years of digital construction experience into the cloud. This solution provides a series of cloud services, such as ROMA Connect for application integration, ROMA Exchange for digital asset operations management, and ROMA BCS for blockchain, securing governance and operation of digital assets in all domains.

06

aPaaS

6.1 Composable Architecture for Sharing Industry Experience

In 2020, Gartner first proposed "Composable Enterprise" (Figure 27), combining self-development, outsourcing, and procurement to form packaged business capabilities (PBCs).
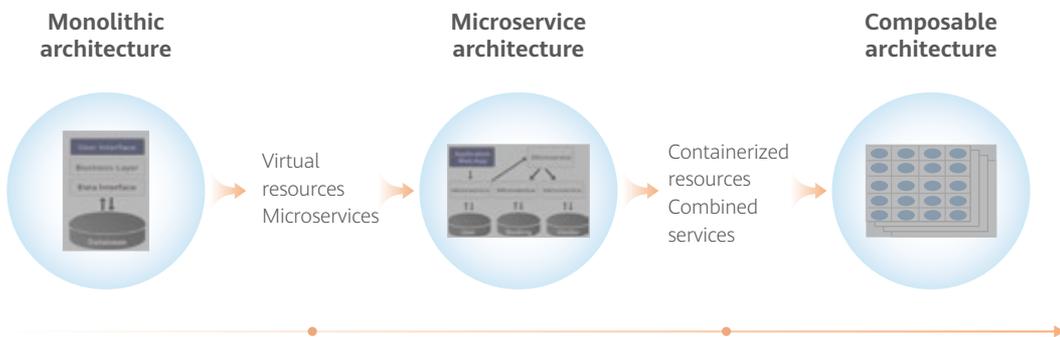

<div align="center">Figure 27 Composable enterprise application architecture</div>

The cloud shares cloud native applications among enterprises, who in turn share their industry experience and SaaS capabilities to accelerate innovation. The cloud both unifies internal/external data and systems into a collaborative ecosystem, and channels cutting-edge technologies for easy developer access.

SaaS is part of the information sharing economy, an advanced stage of software industry development with performance varying by market. Take China and America as an example [8](Figure 28): the American market is already mature enough to pay for and use SaaS software, while the Chinese market is still young yet in demand since 2021.


China:
- 28.26%
- 6.08%
- 65.66%

America:
- 58.16%
- 18.53%
- 23.31%

Legend: SaaS, PaaS, IaaS
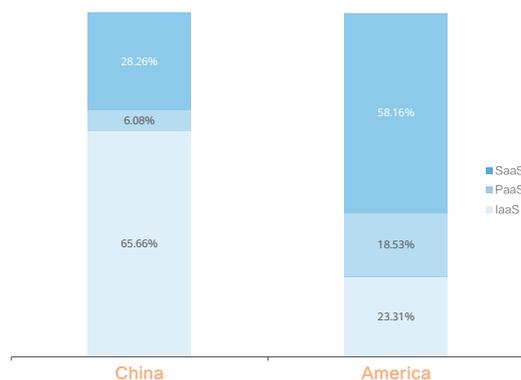
Figure 28 Cloud service types in China vs America

Services must be standardized to become SaaS. Although digital transformation diversifies scenarios and requirements with know-how specific to different industries, each industry has its own issues. Some of these issues can be addressed with cross-industry solutions, as opposed to individually tailored, time-consuming ones.

Such resource reuse is also important during industry transformation. Using mature, affordable services is more efficient, thanks to intellectual assets built up by heavy pioneer R&D that would be hard to re-develop to leading levels in time.

6.2 Aggregated Industry Expertise for Common Issues

Application Platform as a Service (aPaaS) (Figure 29) manages composable enterprise applications to keep developers focus on industry-specific experience and innovation. It accelerates application builds and seamlessly integrates industry capabilities.

[8] Based on analysis from Gartner, IDC, and Deloitte
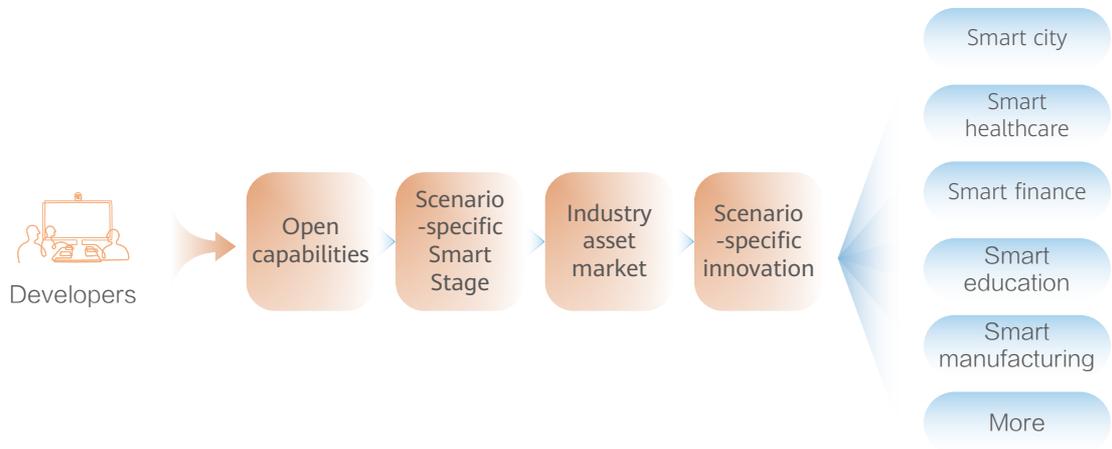
Figure 29 aPaaS workflow

Open capabilities are industry kits, APIs, SDKs, and knowledge. For example, we aggregate item display, user acquisition, and sales analysis into e-commerce kits.

Scenario-specific smart stage offers subscriptions for integration capabilities and SaaS in combination with multiple kits.

Industry asset market is an asset center that monetizes industry digital assets by selling them as APIs/SDKs, data models, and AI algorithms.

Scenario-specific innovation enables developers to respond to diverse industry needs.

Take the mining industry as an example. JYlink (Jingying Shuzhi) is a mining software solutions provider that integrates its expertise and AI into intelligent vision APIs for digging, extraction, transportation, and communication, so even small teams can operate large mines. JYlink makes it safer by replacing manual labor with office operations. Their solutions and experience are replicated to more than 4,000 coal mines in China.

In education, teachers often have to visually check for plagiarism while grading for essay content, structure, and language. Education solutions provider Tomorrow Advancing Life has combined the experience of more than 200 language experts with Optical Character Recognition into an intelligent homework checking solution, which is made available as APIs. This solution improves review efficiency and is replicated to many schools.

6.3 Accelerated Modernization and Innovation

To make both industry and Huawei expertise accessible for application innovation, Huawei Cloud launched MacroVerse aPaaS (Figure 30) in September 2021. This solution suite enables API conversion, SaaS development, and KooGallery release as virtuous circle of business.

Figure 30 Huawei Cloud MacroVerse aPaaS

This year, MacroVerse aPaaS is enhanced for the following features:

• KooMessage provides rich media messages (Business Touch and smart/5G/push messages) for 500 million devices of more than 450 types, including smartphones, tablets, PCs, and smart screens.

• KooMap provides maps for smart city, resource monitoring, logistics, and travel. With China Siwei and Changguang Satellite, KooMap provides ground observation data from more than 50 satellites. It also joins over 40 partners (including SFMap Technology and PIESAT) to provide more than 400 terrain analysis APIs.

• Industrial aPaaS distills 24 models into its Data Model Engine, including materials, electronics, requirements, and processes. Partners and developers can now access modeling and development

with instruction by the most experienced software engineers.

- Heating aPaaS joins more than 10 partners to provide 98 smart heating APIs, covering heat sources, heat exchange stations, units, and households. These APIs balance heating for every family in winter.

- Education aPaaS collaborates with partners to build more than 30 APIs in five categories, including live interactive teaching, smart scoring, and speaking evaluation. These APIs covers research, teaching, exam, evaluation, and management.

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