openEuler-Based Operating Systems in Finance:

Applications and Ecosystem Development

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开放原子开源基金会
OPENATOM FOUNDATION

OpenEuler

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Huawei Technologies Co., Ltd.
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Foreword

In today's fast-evolving financial landscape, advancing high-quality development across key areas such as financial technology, green finance, inclusive finance, pension finance, and digital finance has become a global priority. Financial institutions, as essential pillars of the global economy, are at the forefront of this transformation. By embracing core technological innovations, they are driving digital transformation, building bridges between the financial sector and the real economy, and fostering sustainable and high-quality economic growth.

The rapid advancement of artificial intelligence (AI), particularly in foundation models, has catalyzed cross-disciplinary innovation, redefining financial services. These developments are reshaping business models, fueling product innovation, and enhancing customer experiences, resulting in smarter and more personalized financial solutions. As technology evolves, building robust digital infrastructure within the financial industry has emerged as a pressing priority. Operating systems (OSs), as critical components of the digital infrastructure, play a pivotal role in enabling the smooth and secure progression of this intelligent transformation. Technological advancements in OSs not only empower financial institutions with greater control over core technologies but also strengthen fintech resilience and information security. Together, these factors significantly enhance the strategic importance of financial technologies.

Open source technology, a cornerstone of innovation globally, has become an essential driver of industry collaboration and resource sharing. It presents vast opportunities for cross-sector collaboration between finance and other industries. Building a sustainable open source ecosystem requires balancing development with security while fostering a modern industry framework. This involves strengthening foundational technologies, driving industry growth, establishing effective governance, nurturing talent, promoting a culture of collaboration, and expanding international partnerships. To accelerate the development of the open source ecosystem, efforts must align with principles of application-driven development, innovation-driven growth, and ecosystem collaboration. Striking a balance between open source and proprietary technologies is critical. Financial institutions, as both participants and beneficiaries of the open source ecosystem, play a key role in driving innovation. By focusing on the diverse needs of businesses around the world and collaborating with industry stakeholders, they are co-creating solutions in response to the evolving demands of a connected world. These efforts will be instrumental in supporting openEuler's global expansion.

This white paper examines the strategic importance of core technologies—particularly OSs—in the financial sector. It explores openEuler's current state of development, its real-world applications, and innovative practices in the community, highlighting openEuler's role in bridging the finance and technology fields. The white paper also outlines future opportunities for openEuler in the financial sector, offering practical recommendations to inspire broader adoption of open source ecosystem. By fostering cross-sector innovation, this collaboration will empower technological transformation, enhance industrial competitiveness, and create a robust foundation for the global digital economy.

Lv Zhongtao
Chairperson, Beijing FinTech Industry Alliance

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Strategic Role of Foundational Software in Finance

1.1 Policy Background and Strategic Positioning

Operating systems are crucial to digital infrastructure. China now has a state support for homegrown operating systems, especially in areas like information security, data privacy, and service continuity. Consequently, homegrown operating systems and software are becoming the preferred industry choice.

The Chinese market now presents OS developers with a complex environment of diverse financial scenarios and requirements, which has spurred the development of an extensive application ecosystem. For China to advance self-sustainable foundational software development, a strong open source ecosystem is essential to overcome technological monopolies and barriers. China strongly supports the development of the open source ecosystem and community to enhance the technical capabilities and ecosystem influence of foundational software. Therefore, the financial industry, as a key field for the application of open source technologies, contributes to the improvement of homegrown operating systems through its open source practices.

China's large commercial banks, as leaders in financial tech innovation, are increasingly adopting homegrown operating systems, first in peripheral uses, and more recently as their core systems. For example, Industrial and Commercial Bank of China (ICBC) has actively participated in open source community development, driving R&D and implementation of key technologies, and gaining valuable experience from participating in the open source ecosystem. This white paper highlights implementations of openEuler by major banks and insurance institutions in China, and includes case studies covering openEuler's community versions, enterprise-specific versions, and commercial distributions. It illuminates how different openEuler iterations effectively support the operations of a wide range of Chinese financial institutions.

1.2 Current Situations and Trends of Homegrown Operating System Applications in the Financial Industry in China

Currently, financial institutions in China are turning towards homegrown open source systems, particularly since the discontinuation of CentOS. The gap left by CentOS has in many cases been filled by KylinOS or UOS, both of which are distributions of openEuler. Several open source communities are flourishing and showing strong potential for further development. Early misgivings related to the legal risks, service support, and compatibility of open source software have been dispelled. Financial institutions, especially commercial banks, have high quality requirements for the software that sits at the foundation of their systems and, as a result, many technical teams continue to prioritize maintaining and enhancing existing applications. Given the high costs associated with recruiting experienced teams to assemble and develop software in house, financial institutions prefer to first purchase commercial versions of operating systems or incorporate mature open source products and then pay for further services or custom development. This approach offers clear commercial incentives to players in the open source ecosystem.

Financial institutions generally report high satisfaction with migrating to openEuler and other open source operating systems, particularly in terms of improved technical reliability, cost efficiency, and enhanced system performance and security. In China, the largest institutions are taking the lead in adopting such systems, while many small- and medium-sized financial institutions are still put off by challenges such as the need to improve hardware-software compatibility and support for peripheral tools, optimization of adapter drivers and multi-path software for server-storage connections in distributed architectures, and gaps in secondary and tertiary technical support capabilities. Furthermore, when selecting and evaluating new systems, testing and validation are required to ensure compatibility with existing business systems and foundational platforms.

Though openEuler and other new open source operating systems still face the aforementioned challenges, the financial industry in China is committed to these new OSs, and early adopters are already providing valuable feedback, prompting the community to begin work on new features, thus driving ongoing iteration and improvement.

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openEuler's Ecosystem Growth and Impact in Finance

2.1 openEuler OS Overview

Introduction to the openEuler Community and openEuler OS

openEuler, short for OpenAtom openEuler, is an open source community focused on operating systems for digital infrastructure, incubated and operated by the OpenAtom Foundation. Huawei officially established the openEuler open source community on December 31, 2019, with the original focus of innovating diversified computing architectures. In 2021, the project was contributed to the OpenAtom Foundation, marking its transition from enterprise-led venture to an industry-driven collaborative model. Over five years of development, the community's structure has developed into something more complete. The openEuler Committee now unites key OSVs, hardware vendors, and carriers, while the Technical Committee, Marketing Committee, and User Committee play key roles in supporting technology development, brand marketing, and userbase expansion.

Today, openEuler has released multiple community releases designed for digital infrastructure. These releases support AI, diversified computing, and a comprehensive range of other use cases, and can be deployed across servers, cloud, edge, and embedded systems, covering application scenarios such as IT, CT, and OT. Based on the openEuler community releases, OSVs and enterprises can build commercial releases and enterprise-specific versions.

Market Progress and Ecosystem Development of openEuler

openEuler has already achieved significant adoption. According to the latest IDC report, by December 2023, openEuler-based operating systems accounted for 36.8% of new server OS installations in China, surpassing Windows (19.3%) and CentOS (16.6%). This marked the first time openEuler led the new server OS deployment market. In critical infrastructure sectors, openEuler holds 70% of the market in telecommunications, 50% in finance, and 40% in both energy and public utilities. It has become an essential part of IT infrastructure in China.

Since its launch as an open source project five years ago, openEuler has seen steady growth. The community now encompasses many major OSVs, processor manufacturers, independent software vendors, universities, and research institutions. While participation was initially concentrated in China, the involvement of organizations from other countries and regions has been steadily increasing. With over 20,000 open source contributors, more than 100 special interest groups (SIGs), and over 1,700 enterprise members, openEuler has surpassed 3.5 million deployments globally, establishing itself as one of China's most vibrant open source communities and a major global player in the OS space.

Ongoing technological innovation is the foundation of openEuler's success. Community members have made significant contributions to the Linux kernel, including 896 patches in the Linux 6.6 release, ranking first in China and among the top three globally. Additionally, openEuler has incubated over 500 innovative projects, such as iSula, StratoVirt, Rubik, secGear, MICA, sysMaster, and A-Tune, covering foundational components, security, operations, and cloud-native technologies. These efforts highlight the comprehensive technological expertise within the openEuler community.

Significance of openEuler to China's Computing Industry

openEuler has pioneered the development of a fully integrated operating system for digital infrastructure. It offers a unified operating system architecture that supports multiple application scenarios, including servers, cloud, edge, and embedded systems. As an OS designed to support diversified computing power, openEuler is compatible with various architectures, including x86, Arm, RISC-V, LoongArch, SW64, and POWER. It also supports leading processors in China, including those from Intel, AMD, Kunpeng, Phytium, Zhaoxin, Loongson, Hygon, and Sunway, along with heterogeneous computing resources like NPUs, GPUs, and DPUs, establishing comprehensive hardware and software compatibility standards.

In 2023, with AI, particularly LLMs, becoming a central focus of technological development, openEuler introduced two pioneering strategies: "OS for AI" and "AI for OS". By unifying the management and scheduling of heterogeneous resources, openEuler deepens the integration of CPUs and other processors, effectively linking general-purpose computing with AI computing, significantly improving the efficiency of model training and inference. Moreover, openEuler replaces traditional command-line interactions with a new interaction system based on LLMs. This enables intelligent question answering, smart O&M, automated tuning, and intelligent scheduling, greatly enhancing both the usability and management efficiency of the OS.

openEuler always prioritizes talent development. Through participation in Intelligent Base, an initiative led by China's Ministry of Education, openEuler is promoting a new mode of IT talent cultivation. Since kicking off in 2020 with an initial batch of 72 universities and over 20 full-time advocates, it has hosted more than 10 instructor training sessions, with over 450 teachers participating in total, and over 250 involved in the course development. As part of the Intelligent Base initiative, 250 openEuler-related courses have been created. Over 40,000 students from top Chinese universities have taken these courses, strengthening the openEuler talent pool. openEuler has partnered with the Institute of Software at the Chinese Academy of Sciences, to organize internship projects as part of the Open Source Promotion Plan (OSPP). Through the OSPP, we have equipped university students and faculty with open source knowledge and skills, reaching 592 universities and benefiting over 3,000 students. Recently, we have also actively participated in the Open Source Talent Training Program of the OpenAtom Foundation, engaging more than 20 top universities, establishing openEuler technical groups, and continually integrating resources from community ecosystem partners to support learning and research within these groups.

The global influence of the openEuler community has been growing steadily. In the past years, we have partnered with international organizations such as the Linux Foundation, RISC-V International, OpenInfra Foundation, Linaro, OpenChain, SPDX, CHAOSS, and FOSSASIA. openEuler has also formed strong collaborations with major open source projects like OpenHPC, Ceph, ONNX Runtime, Bioconductor, and Apache Bigtop, focusing on mutual certification and platform integration, ensuring that each platform natively supports the other. openEuler is currently used in 2,037 cities across 153 countries and regions, with over 1,000 developers from outside China contributing to the community. This has established openEuler as a globally influential open source operating system.

2.2 Ecosystem Development and Significance of openEuler in the Financial Industry

Financial technology has become a key driver of growth in the global financial sector. As countries strengthen their financial systems, the role of technology, especially operating systems, is increasingly recognized as essential for supporting the digital infrastructure of financial institutions. This is particularly true in the context of distributed architectures, where challenges such as ecosystem compatibility and high migration costs have been common pain points.

In response to these challenges, open source operating systems such as openEuler have become important enablers for the financial sector, providing a reliable digital foundation. For many institutions, these solutions have helped address issues such as security vulnerabilities and system integration, and in China they have supported the financial industry's technological transformation.

Open source development is widely recognized globally as a key to enhancing core technological capabilities. Governments and regulatory bodies have emphasized the adoption of open source solutions to ensure security, compliance, and innovation. In line with these directives, operating systems like openEuler have successfully aligned with industry principles, offering a secure and open technology ecosystem that fosters innovation, strengthens technical control, and drives sustainable growth.

In the financial sector's digital transformation journey, open source operating systems have played a pivotal role. By offering cross-ecosystem, open, and continually evolving solutions, they have ensured robust system operation while promoting collaboration and integration within the financial ecosystem. Through shared development, business synergies, and seamless ecosystem interoperability, these operating systems have enhanced the quality and efficiency of financial services.

Looking ahead, openEuler is expected to capture over 80% of the new server OS market share in China's financial sector by 2024, with its commercial distributions already becoming the preferred choice for financial institutions. The rise of open source operating systems in the financial sector reflects the industry's commitment to innovation and the power of collaborative development in building a resilient, future-proof ecosystem.

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Implementations in the Financial Industry

3.1 Industrial and Commercial Bank of China: Cloud-Big data-AI Integrated Solution Based on openEuler

User: ICBC Software Development Center
OS: openEuler-based KylinOS
Use Case: PaaS cloud platform
Deployed: April 2023

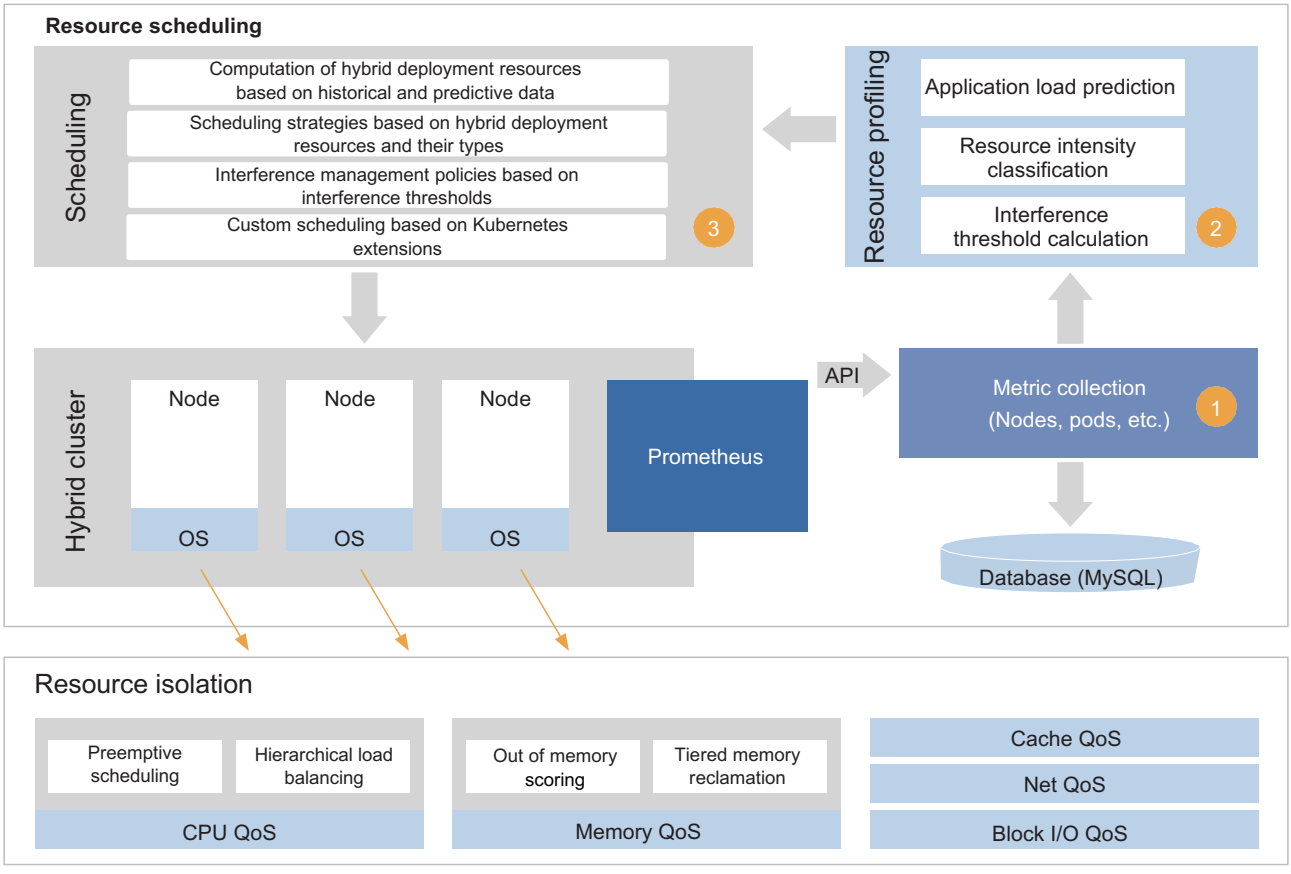
Background

The rise of cloud computing is driving structural changes in the IT architecture of the financial industry, with an increasing focus on computing power. The integration of cloud computing, big data, and AI with heterogeneous compute resources is accelerating, enabling more efficient scheduling and utilization of computing power. Like its peers, Industrial and Commercial Bank of China (ICBC) had an architecture in which cloud computing, big data, and AI each had their own dedicated compute resources. While the overall utilization of resource pools of ICBC was already leading the financial industry, the siloing of compute resources meant there was still room for improvement when compared to best-in-class standards.

Solution

ICBC built an integrated cloud-big data-AI computing ecosystem based on cloud-native technologies, becoming the first in the industry to establish a new architecture integrating general-purpose computing, big data computing, and AI computing. This initiative features cutting-edge capabilities, including normalized resource hybrid deployment, cloud-native intelligent computing infrastructure, and digital computing operations. The project has raised the bar within China's financial sector and won praise from the industry.

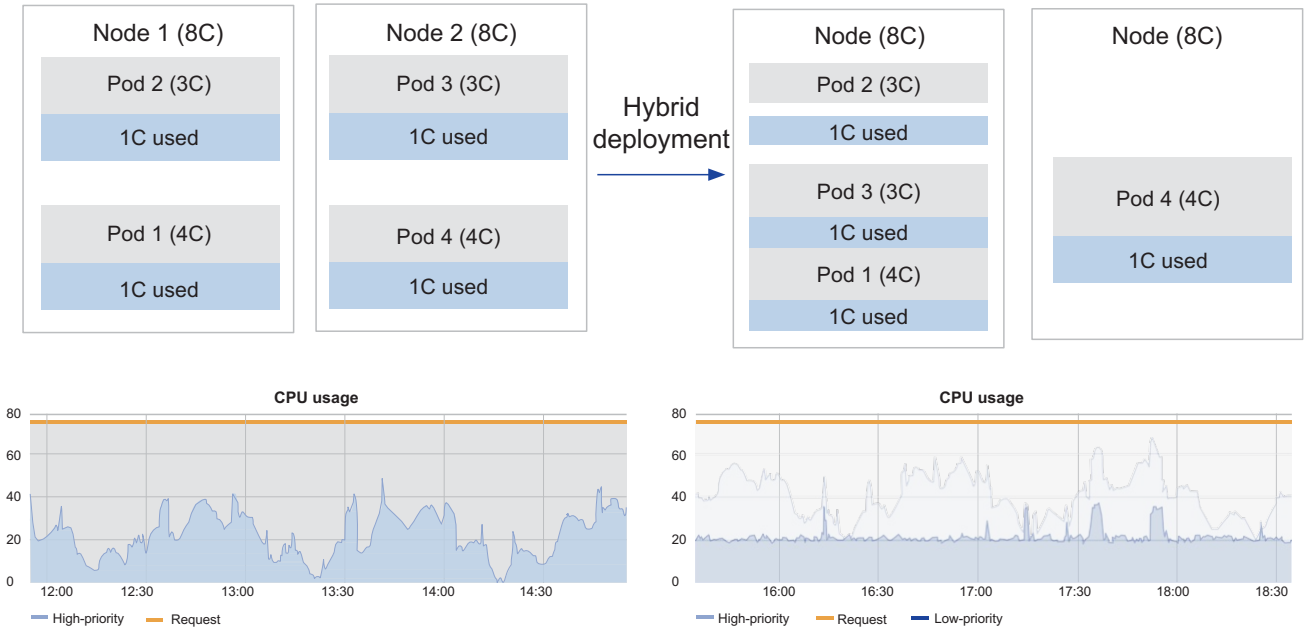
Normalized hybrid resource deployment is a core capability within ICBC's integrated cloud-big data-AI ecosystem. To enhance resource utilization in production, ICBC leveraged industry solutions and developed its own scenario-based hybrid resource deployment technology tailored to the bank's internal needs. The architecture focuses on both resource scheduling and resource isolation. In terms of resource scheduling, it includes the collection of monitoring metrics, resource profiling, and hybrid deployment scheduling. For resource isolation, ICBC utilizes the kernel isolation technology of openEuler, which provides enhanced isolation based on high- and low-priority levels, thus overcoming the container isolation challenges of hybrid deployment scenarios.



Benefits

Through the integration of cloud computing and intelligent power ecosystems, ICBC has successfully broken down the barriers between its various computing resource pools, enabling on-demand allocation of computing power. This significantly improves the flexibility and efficiency of resource usage. The key outcomes of this initiative include:

- Enhanced efficiency: By providing additional computing power in offline hybrid deployment, ICBC has significantly improved the timeliness of key processes such as data analysis, private banking customer profiling, and core customer tagging. This results in over 20% improvement in batch processing efficiency, with hybrid resource pool utilization reaching over 40%, positioning the bank as an industry leader in resource efficiency.
- Optimized balance of resource utilization and system stability: The system has maintained high resource utilization while achieving an availability rate of over 99.9999%, successfully balancing efficiency with stability. This ensures an industry-leading level of business continuity.
- Cost savings and risk reduction: Over the past two years, the project has optimized the utilization of more than 2,800 physical servers and 400 GPUs, saving over CNY300 million. Additionally, the initiative has de-risked ICBC's software supply chain by enabling comprehensive control over the operating system.



Impact before and after hybrid deployment

Future Outlook

In the future, ICBC will deepen its integrated cloud-big data-AI ecosystem. The bank plans to enhance its computing power infrastructure through the following three key initiatives:

- Build a unified computing power scheduling system, integrating general-purpose, big data, and AI computing. This will enable cross-domain flow of heterogeneous computing resources on a single cloud platform.
- Develop a fully managed AI platform with serverless GPU resource scheduling. This will allow for rapid deployment of AI applications, efficient collaboration, and flexible scaling, reducing GPU idle time and improving the flexibility and scalability of GPU resources.
- Deepen the integration of cloud, big data, AI computing power to drive the transition to digital cloud operations, offering comprehensive resource insights, cost analysis, and optimization, while extending cloud-native observability to cross-industry scenarios.

3.2 Agricultural Bank of China: Next-Gen Cloud Computing Platform Solution

User: ABC Data Center

Solution: ABC's infrastructure solution based on KylinOS

Use Case: Full range of business scenarios across headquarters, branches, and subsidiaries

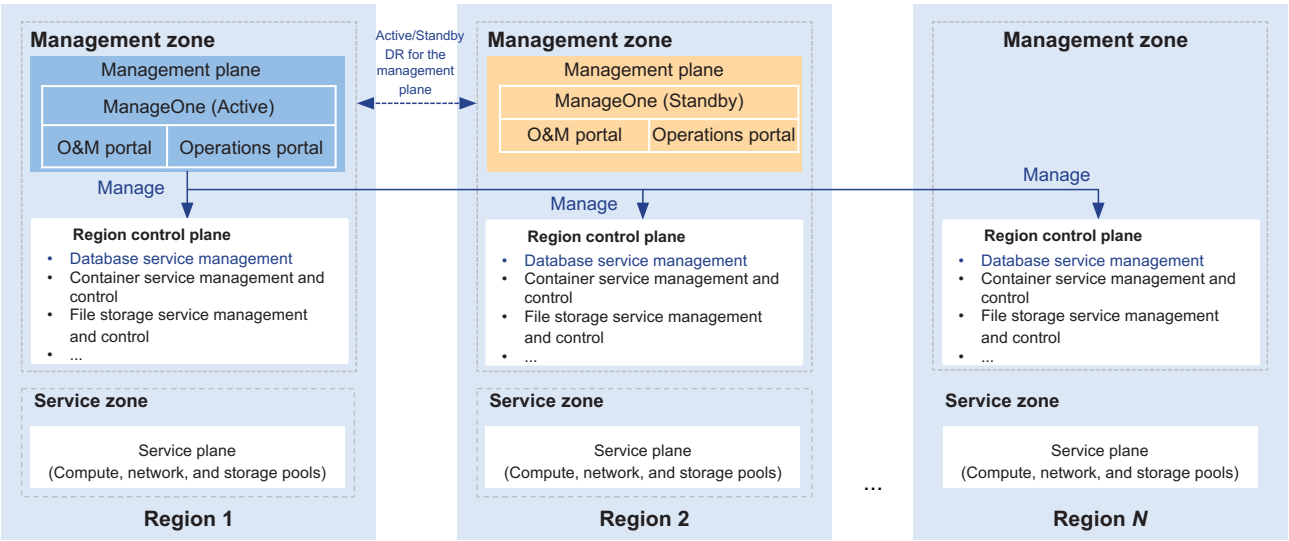
Deployed: June 2022

Background

Agricultural Bank of China (ABC) was in the process of accelerating its financial technology R&D and digital transformation, and decided to build a distributed architecture based on an integrated cloud platform and a distributed database to meet the robustness needs of core services for infrastructure. This architecture would further provide essential cloud services—such as virtualization, containers, databases, and application middleware—through a distributed core system, supporting the bank's application ecosystem.

Solution

ABC implemented an integrated infrastructure solution by unifying KylinOS (based on openEuler), a hybrid cloud platform, and distributed database technologies. This involved three key initiatives: replacing legacy operating systems with KylinOS to optimize hardware efficiency, building a multi-architecture cloud platform (supporting Arm, Hygon x86, and Intel x86) with a unified hybrid resource pool, and adapting KylinOS to foundational software stacks for full-stack compatibility—delivering solutions for bare-metal server, VM, container, distributed database, and compute-storage decoupled big data system. The deployment scaled to over 5,000 container nodes, 3,000 database nodes, and 600 application modules, achieving centralized management of heterogeneous resources.



Technical architecture of the homegrown cloud platform

Benefits

KylinOS serves as a bridge between the underlying hardware and upper-layer foundational software, effectively addressing hardware discrepancies. The cloud platform and database meet the high-performance, high-concurrency, and high-availability requirements of financial applications. The new cloud-native technology stack has been adopted in 6 DCs across 3 regions.

Future Outlook

With its technical solution that integrates KylinOS, cloud platform, and distributed database, ABC will leverage its expertise to further improve the platform's performance and reliability. By joint collaboration and in-house innovation, the bank will boost the O&M and R&D capabilities to strengthen the stability and security of KylinOS and foster digital transformation.

3.3 Bank of China's Distributed Basic Technology Platform: Honghu Platform

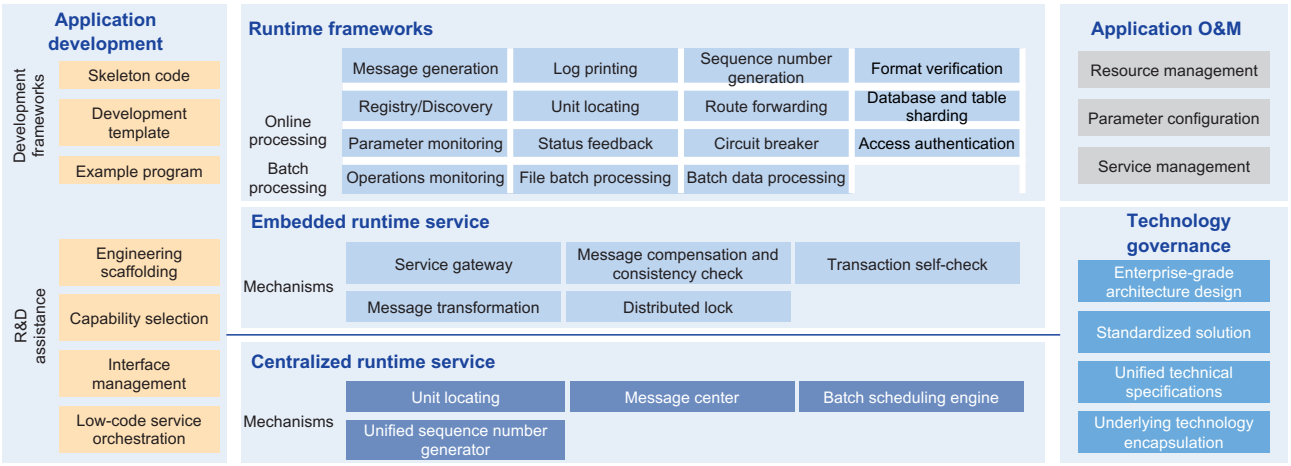
User: Software Center, Bank of China
OS: openEuler-based KylinOS
Use Case: Distributed basic technology platform
Deployed: October 2021

Background

Bank of China (BoC) found that its existing IT architecture could not support the online services, diversified scenarios, precise analysis, and real-time risk control that were becoming increasingly important in the banking sector. Furthermore, BoC wanted to be able to respond to new requirements in a more agile manner. The bank resolved to implement a more open, resilient, and broadly compatible distributed architecture. The situation was complicated by strict restrictions on tech imports in some key fields, which left BoC motivated to enhance its independent R&D capabilities.

Solution

KylinOS (a commercial distribution of openEuler) was chosen as the operating system for a distributed basic technical platform called Honghu. Honghu provides technical capabilities that support technology governance, runtime transaction scheduling, distributed application development, and distributed application O&M.



Currently, the Honghu platform supports over 12,000 application deployment groups and more than 60,000 application service instances. The technical execution success rate is 100%. It provides enough service transaction processing capacity to support concurrent access by over a billion customers and over 100,000 transactions per second for upper-layer application systems. Honghu platform also lowers the difficulty and workload of BoC's R&D efforts.

Future Outlook

In the future, the Honghu platform will continue to support the architecture transformation of application systems, including core systems. Certain existing functions will be adapted and reconstructed based on the core cell-based architecture. A simulation function will be added to comprehensively verify the functions and performance of the new system applications and databases. In addition, support for cloud-native technologies such as containers will be enhanced to provide a foundation with advanced technologies, comprehensive functionality, and stable and reliable operations for BoC's applications.

3.4 Postal Savings Bank of China's Core System OS Localization

User: Postal Savings Bank of China (PSBC)

OS: openEuler-based KylinOS

Use Case: Corporate banking services

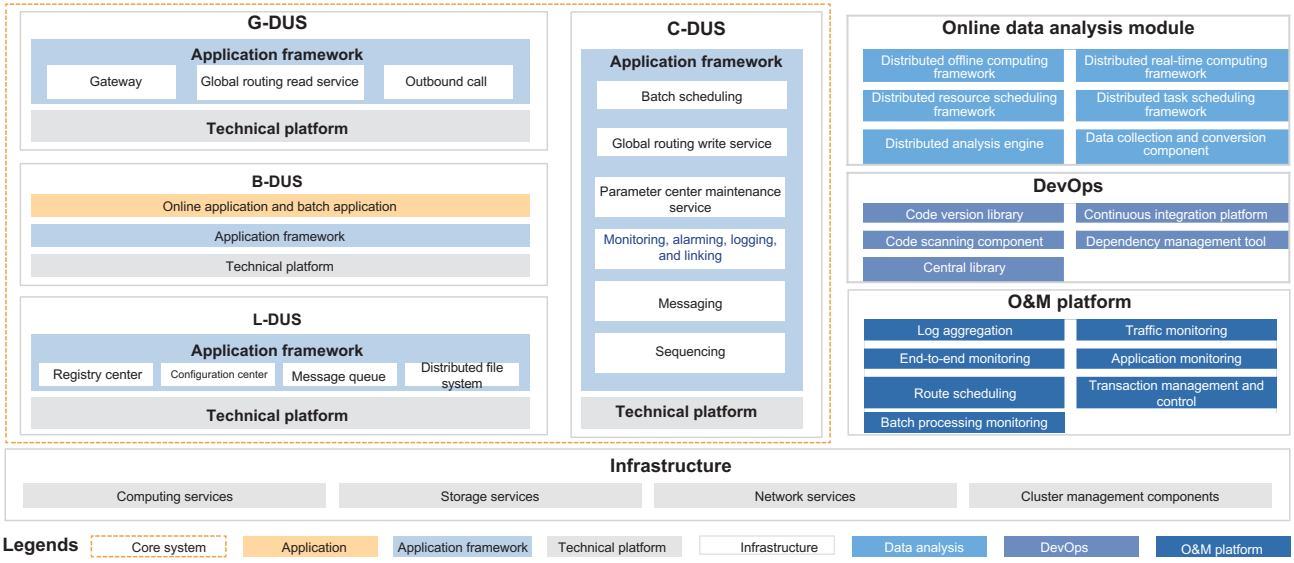
Deployed: January 2024

Background

As a leading commercial bank in China, PSBC actively pursues IT application innovation and security. The bank set about de-risking its full stack of enterprise-level core systems. To this end, PSBC sought to replace many of its existing systems with homegrown open source alternatives.

Solution

Following the implementation strategy of "unified planning, phased execution, and seamless migration," the system was launched in March 2022, achieved full production deployment by January 2024, and completed 100% customer migration by October 2024—spanning a total of 2.5 years. The resulting architecture, built on KylinOS, openGauss database, and Arm-based hardware platforms, operates as a cloud-native distributed core system across three data centers in Fengtai, Yizhuang, and Hefei. This infrastructure now reliably supports mission-critical operations, including deposit services, cash management, and interbank remittance, ensuring both stability and high performance.



Benefits

This system effectively supports the stable and efficient operation of key service modules, including deposits, cash management, and bank remittances. Based on KylinOS, this system provides various service architectures, such as distributed microservices, distributed middleware, and high-performance databases, for core banking service systems and related applications. These architectures support high concurrency ensure secure and stable operation of the system under any and all conditions.

Future Outlook

With the widespread adoption of microservice architecture, there is a growing shift from VMs towards container clusters for financial systems. In the future, the performance and stability of virtual environments will be enhanced through deep optimization of the virtualization layer, improving compatibility with various mainstream platforms. At the same time, PSBC will explore the gradual implementation of containerized rapid deployment, flexible upgrades, convenient O&M, and fine-grained management, all on KylinOS. This will be done while maintaining service continuity, significantly improving the efficiency and flexibility of both development and O&M.

3.5 China UnionPay's UPEL2

User: China UnionPay
OS: openEuler-based UPEL2
Use Case: Online, batch, database, and big data scenarios in finance
Deployed: June 2023

Background

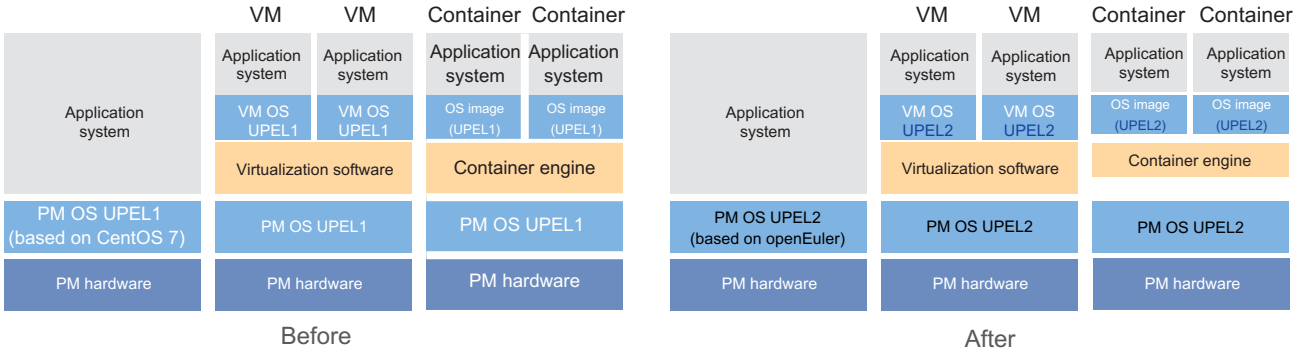
UPEL is UnionPay's internal Linux distribution and a key component of the UP product stack. The first version, UPEL1, which was based on CentOS 7, was released in 2017. In 2020, following the CentOS community's announcement of its EOS, UnionPay actively explored alternatives and ultimately decided to update the system to UPEL2 based on openEuler. The transition from CentOS to UPEL2 would involve adapting the cloud management platform, container management platform, and other foundational platforms.

Solution

The UPEL2 was implemented in the following phases:

- Verification: R&D was performed, foundational software elements such as databases were selected, and service systems were tested for feasibility.
- Infrastructure adaptation: The adaptation of infrastructure such as cloud management was completed and service adaptation work continued.
- Production and wider adoption: The service systems were put into use.

Currently, the project is in the wider adoption stage. New systems adopt UPEL2, while existing service systems will ultimately migrate to UPEL2 following the new resource migration plan.



Benefits

- China UnionPay is no longer reliant on the now discontinued CentOS, which enhances its system security.
- With UPEL2, China UnionPay has significantly de-risked its supply chain.
- By joining the openEuler community, UnionPay has strengthened collaboration with industry peers and established an efficient feedback mechanism. When new requirements arise, UnionPay actively shares insights with the community and receives prompt responses, enabling continuous optimization of its systems.

Future Outlook

To address the rising costs of OS migration driven by chip diversification and evolving technical approaches, China UnionPay aims to enhance compatibility assessment capabilities, particularly for scenarios where function interfaces remain unchanged but behavioral changes occur. While the openEuler ecosystem has matured to meet current business needs, further refinement is required to transition certain products from "functional" to "user-friendly." Moving forward, China UnionPay will prioritize collaboration and knowledge-sharing within the industry to accelerate this evolution.

3.6 China Everbright Bank's Full-Stack Cloud Digital Infrastructure

Applicant: China Everbright Bank

OS: openEuler-based KylinOS

Use Case: Full-stack cloud infrastructure construction, supporting stable and agile cloud migration of application services

Deployed: January 2021

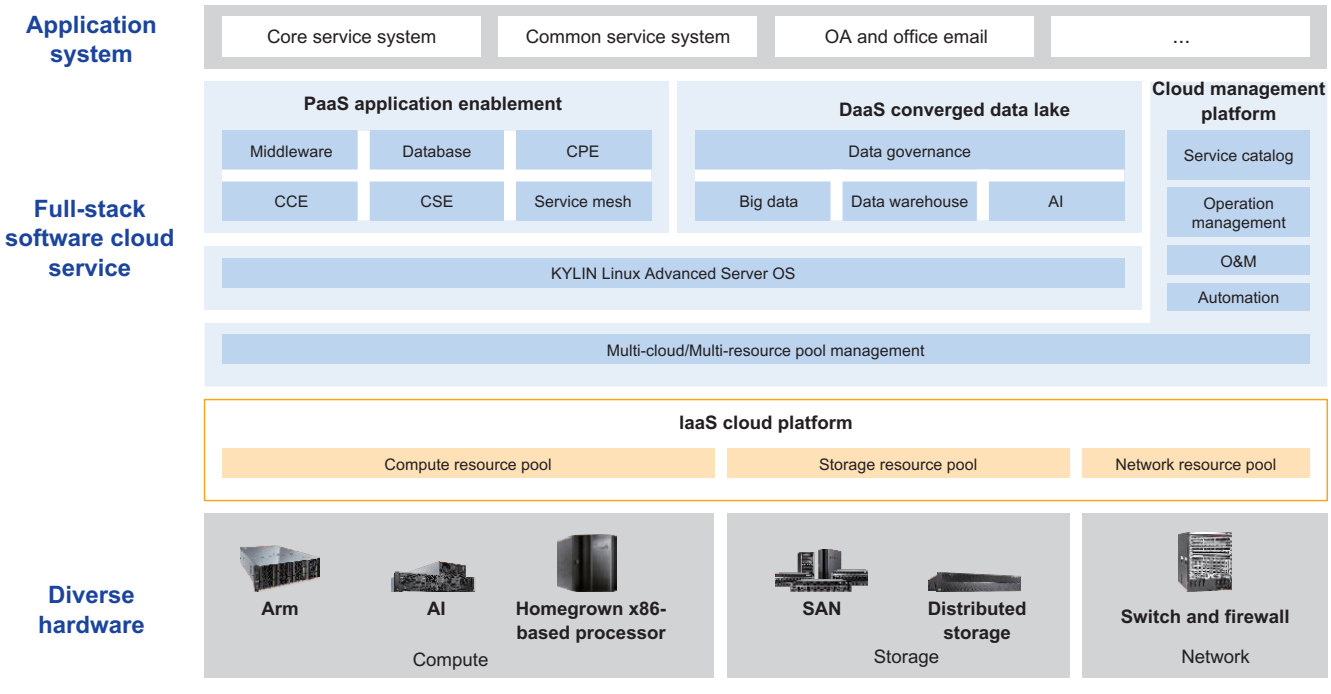
Background

With the rapid development of fintech in recent years, cloud computing platforms have gradually become the core driving force behind the digital transformation of the financial industry. To better meet the requirements of diverse financial service scenarios, China Everbright Bank set out to enhance the O&M capabilities of its digital infrastructure. This would include the construction of a distributed cloud platform to support the distributed architecture transformation of next-gen core systems and other related projects.

Solution

This project is based on the technical architecture that integrates dual-stack collaboration and single-stack heterogeneous computing. The dual-stack resource pool of x86 and Arm is used to support Hygon and Kunpeng hardware processors. In addition, the openEuler-based KylinOS is used to support the full-stack software infrastructure of homegrown databases, middleware, and application systems, reducing the dependency on commercial and closed source hardware and software and building a reliable cloud technology ecosystem.

Benefits



- The dual-stack approach insulates Everbright from potential supply chain shocks. Importantly, this resilience extends to the bank's network infrastructure, cloud platform, foundational software, and upper-layer application system.
- The architecture that integrates dual-stack collaboration and single-stack heterogeneous computing ensures both stacks being equally planned, constructed, managed, and developed, maintaining unified capabilities and consistent function performance. Technical differences between the two stacks are abstracted away through unified multi-cloud management. The unified cloud migration solution supports cross-stack deployment of service systems, allowing unified network access and security isolation. Additionally, one-stack heterogeneous computing addresses compatibility and stability challenges across diverse computing architectures.
- The full-stack cloud infrastructure is implemented to support applications across production, testing, and R&D scenarios, providing environment support for distributed reconstruction of important systems, including the next-gen core systems and integrated credit card services.

Future Outlook

In the process of project advancement, there is still room for technical improvement in homegrown hardware and software's compatibility, adaptation, functionality, and performance. Some new hardware and software platforms require tuning and verification in specific scenarios to improve resource utilization. Therefore, it is recommended that the industry should intensify its efforts in technological accumulation, and keep optimizing the hardware and software ecosystem, promoting the high-quality development of technical services.

In the future, China Everbright Bank will accelerate the migration of application systems to the cloud to achieve containerized, microservice-based, and distributed deployment of systems, meeting high concurrency and usability requirements.

3.7 Ping An Bank's Adoption of Open Source OS Applications

User: Ping An Bank
OS: openEuler LTS

Use Case: Container, database, big data, and other basic OS environments
Deployed: June 2024

Background

With both the cost of commercial OSs and the number of OS instances Ping An needed to deploy rising inexorably, the bank decided to gradually transition to open source OSs to achieve more efficient and cost-effective financial service operations.

Solution

This project involved the survey of different open source OSs, the comparison between open source OSs and commercial OSs, compatibility verification between open source OSs and basic components of containers/databases/big data, and overall migration planning. After comprehensive survey, testing, and evaluation, Ping An Bank decided to expand the use of openEuler LTS OSs.

Currently, the compatibility and performance testing for the openEuler OS have been completed, meeting the deployment requirements. At the same time, the openEuler OS has achieved 100% incremental integration with big data tasks, with over 700 production cases. Additionally, database and container technologies are also under pilot testing, laying the foundation for further promotion.

Benefits

The application of openEuler OS has significantly reduced Ping An Bank's OS software costs while also insulating the bank against potential supply chain risks. Furthermore, collaboration with the open source community promises to drive technical innovation.

Future Outlook

Open source OS communities lag behind commercial OS vendors in terms of problem response and issue resolution, which may bring challenges to the financial industry's security and stability. To address this, the following suggestions are provided:

- Conduct thorough testing and verification, from piloting in non-key service scenarios to gradual expansion to key scenarios.
- Purchase technical support from qualified third-party vendors, mitigating the issue of delayed responses from open source communities.
- Enhance collaboration with open source OS communities.

In the future, the scope and scale of open source OS pilots will continue to expand in production.

3.8 Ping An Insurance Cloud Project

User: Ping An
OS: openEuler-based KylinOS
Use case: Ping An Cloud for financial service migration
Deployed: January 2021

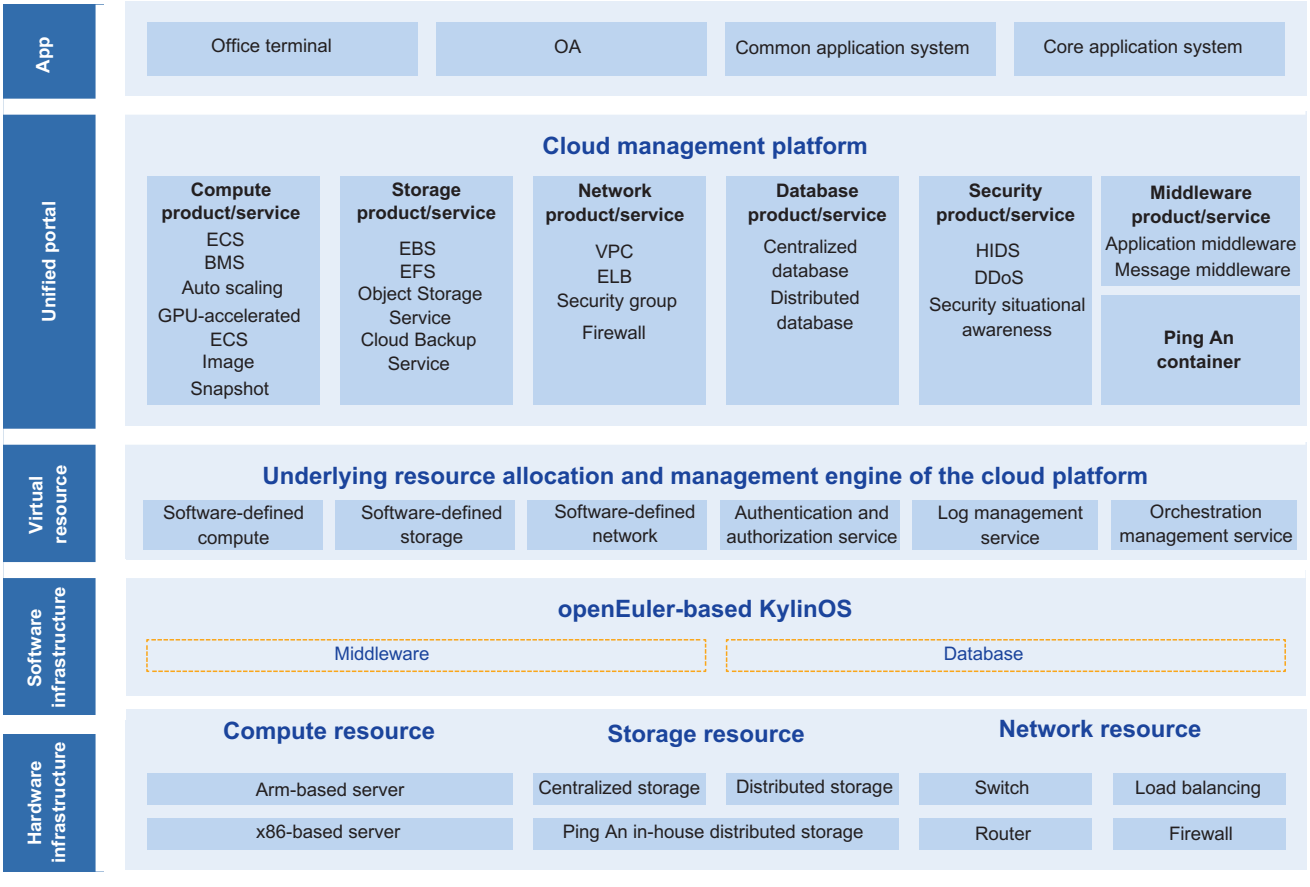
Background

As the IT foundations of the financial industry evolve, the demands for high concurrency, high availability, and agile delivery under different application architectures are increasing. Faced with these challenges and pressure to de-risk its IT systems and ensure business continuity, Ping An Insurance decided to build a cloud computing platform that used domestically produced processors and open-source OSs. The application stack of this platform would need to be compatible with both the new and legacy resource pool architectures. The platform would also have to deliver unified monitoring, scheduling and allocation of data center resources, facilitating the migration and construction of financial services.

Solution

This solution represented a full-stack reconstruction of the Ping An cloud computing platform. At the IaaS layer, a hybrid resource pool compatible with both Arm and x86 was built to achieve unified management of heterogeneous compute resources. The foundational software of the platform, such as cloud management and virtualization software, was developed based on the KylinOS, and the applications at the PaaS layer were adapted to the OS. Launched in January 2021, the project has facilitated the construction and optimization of cloud platforms for banking, insurance, securities, and other financial services.

Solution architecture



Benefits

- Through this project, maturity models for selecting foundational hardware and software have been developed. Lessons learned during platform reconstruction experience were documented in a cloud computing platform adaptation and migration guide that informed later efforts to develop the data infrastructure for various financial services scenarios.
- The project has supported the reconstruction of more than 300 financial service systems covering office, general, and core financial services.
- This project won the openEuler Pioneer Award, jointly issued by the China Industrial Control Systems Cyber Emergency Response Team (CICS-CERT) and the openEuler community.

Future Outlook

When this project was carried out, the primary challenges during project construction revolved around ecosystem compatibility and the scalability of foundational hardware and software. For instance, the latest server component drivers were not supported, or the new OS lacked public drivers for some components, resulting in the inability to deliver servers as planned. In the years since, the issues revealed by this project have been tackled and resolved. Subsequent deployments have been proceeded much more smoothly.

Ping An will transform its services from traditional system architecture to cloud native architecture to achieve high agility and scalability. In addition, the company will develop a cloud-native container platform to achieve the migration and construction of new agile financial services.

3.9 Migration from CentOS to KylinOS for Hunan Rural Credit Cooperatives Union

User: Hunan Rural Credit Cooperatives Union & KylinSoft
Field: Server OS
OS: KylinOS

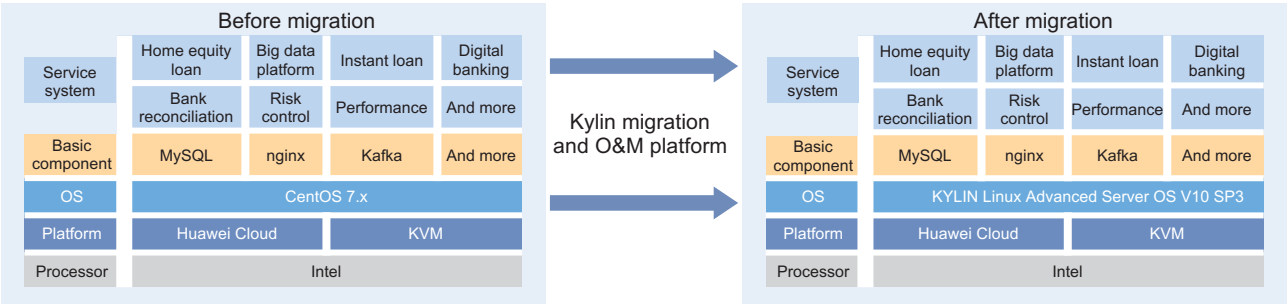
Use Case: CentOS migration for rural credit cooperatives in Hunan
Deployed: January–September 2024

Background

In 2020, the CentOS community announced that support for CentOS would be discontinued in June 2024. The lack of patch support after this point would put CentOS users such as Hunan Rural Credit Cooperatives Union (HNRCC) at risk of service interruption and data leakage. HNRCC set about finding an alternative OS, and eventually settled on KylinOS, which is a distribution of openEuler. As a general rule, OS migration interrupts the operation of service systems that are not deployed in a cluster, and this was a concern for HNRCC.

Solution

To meet the service requirements of HNRCC after the EOS of CentOS, KylinSoft and HNRCC developed a CentOS replacement solution and an automatic migration script based on the Kylin migration and O&M platform to achieve in-place replacement of CentOS in batches. More than 550 sets of OSs have been replaced, involving 87 service systems of over 40 rural commercial banks in Hunan. Migration in batches minimized the disruption to services.



Migration solution

Benefits

- Potential service interruption and data leakage resulting from the discontinuation of CentOS support was averted.
- The solution enables smooth and seamless OS migration and the service systems have been running stably and reliably since migration was completed.
- This solution allows automated OS migration in batches, improving migration efficiency and slashing the costs.
- HNRCC's exposure to software supply chain risks has been greatly reduced.

Future Outlook

- HNRCC intends to adopt KylinOS for new service systems.
- KylinSoft will continue to optimize the migration solution and improve the ecosystem compatibility with HNRCC.
- The two parties intend to publish a document about the migration process, so that others can benefit from lessons learned during the process.

3.10 Migration from CentOS to UOS for Guizhou Rural Credit Union

User: UnionTech
Field: Server OS
OS: openEuler-based UOS

User Case: Qian Nong Yun (enterprise e-banking platform)
Deployed: 2021

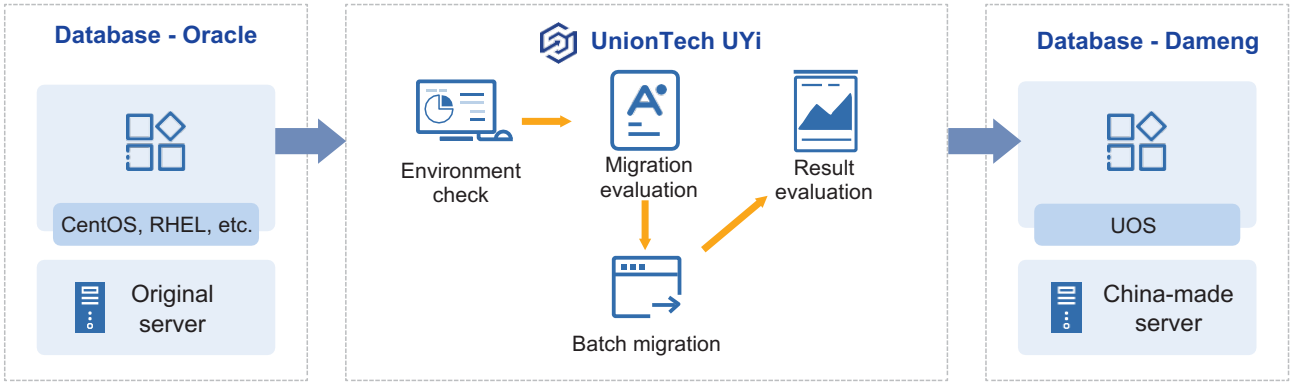
Background

Guizhou Rural Credit Union (GZRCU), established on December 30, 2003 and managed by the Guizhou provincial government, is the largest financial institution in Guizhou province. With the aim of de-risking its supply chain for foundational hardware and software, GZRCU decided to migrate its e-banking platform to a distribution of openEuler called UOS.

The e-banking platform serves as a capability and resource center supporting service development, operations, marketing, and delivery. It boasts over 136,000 users and facilitates an average of 65,000 transactions daily. There is 20 to 30 concurrent transactions per second on average, and more than 700,000 data records are processed per day.

Solution

The database server host, operating system, and database software of the enterprise e-banking platform were all replaced with domestically developed software. Targeted tuning was performed to maintain the performance of financial services. In addition, a comprehensive backup solution for financial data was implemented during the migration.



Benefits

All service modules within the reconstructed system have demonstrated efficiency and stability in verification tests.

- On the service side, the performance of service query and transaction processing have been improved and interfaces remain largely unchanged to ensure a consistent user experience.
- From the perspective of IT procurement, GZRCU now feels much more confident in its supply chain security, O&M costs have been reduced, and the maintenance life cycle of core systems has been prolonged.

Future Outlook

This project extracts an intensive CentOS replacement solution for large financial enterprises. The solution, which facilitates large-scale deployment of OSs in production systems while ensuring supply chain security of core systems, will serve as an exemplary model for promoting China-made OSs in the financial industry.

3.11 Phytium Platform Solution Based on New Insurance Contract Standards (IFRS 17 & CAS 25)

User: Phytium and Beiming Software
OS: openEuler-based KylinOS
Use Case: Platform based on IFRS 17
Deployed: Not yet deployed as of time of writing

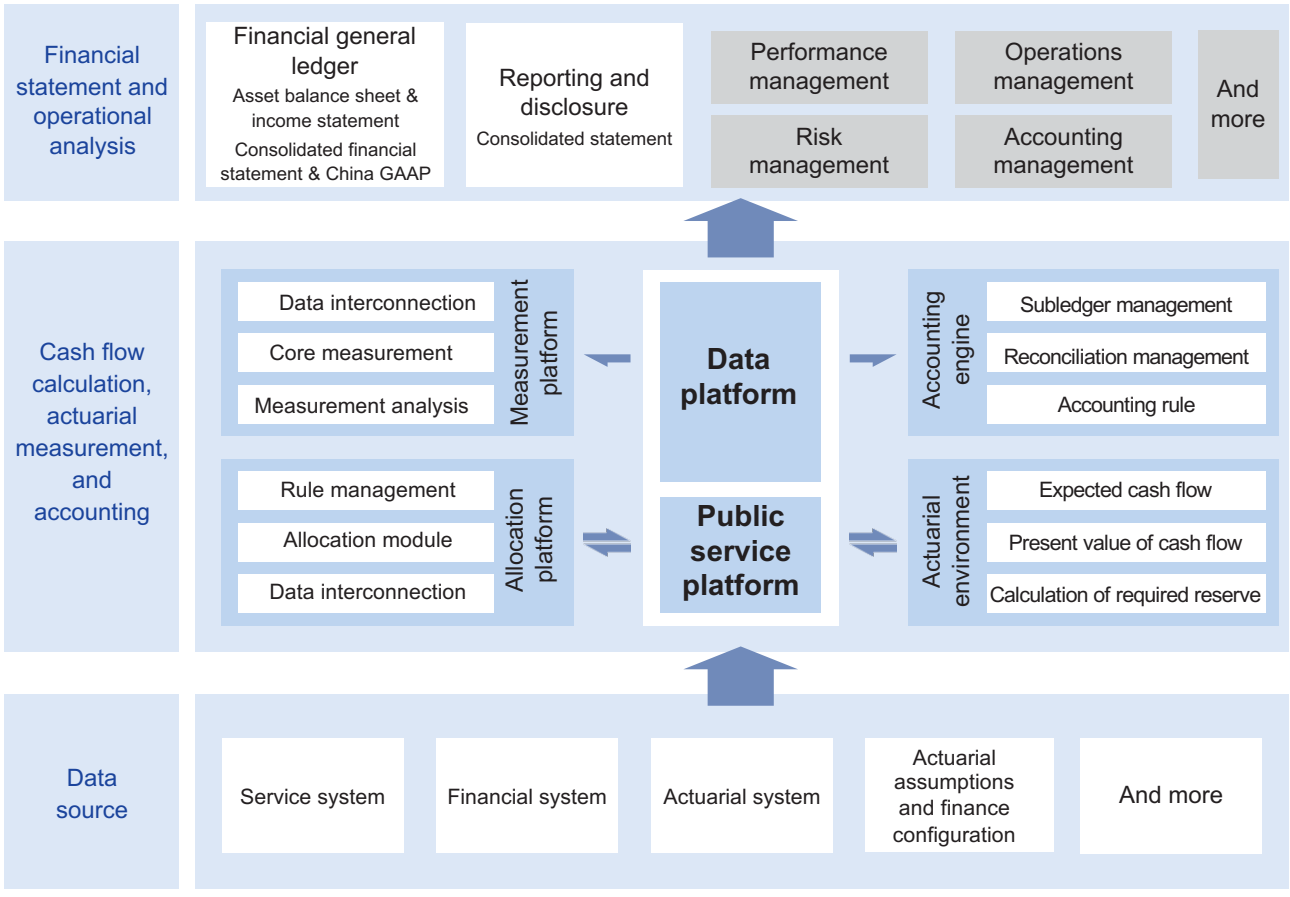
Background

International Financial Reporting Standard 17 Insurance Contracts (IFRS 17), issued in May 2017, provides a unified accounting model applicable to all types of insurance contracts, addressing inconsistencies in accounting treatments across different countries and types of insurance contracts. In December 2020, after the comprehensive implementation of IFRS 17, China's Ministry of Finance released *Accounting Standard for Business Enterprises No. 25 - Insurance Contracts* (CAS 25), to enhance enterprise accounting standards and maintain alignment with international standards. CAS 25 will co-exist with previous standards from the beginning of 2025. Insurance companies were required to complete consultations as well as system development and reconstruction by the end of 2024.

To help address these challenges, chipmaker Phytium and software developer Beiming, developed a platform construction solution based on IFRS 17.

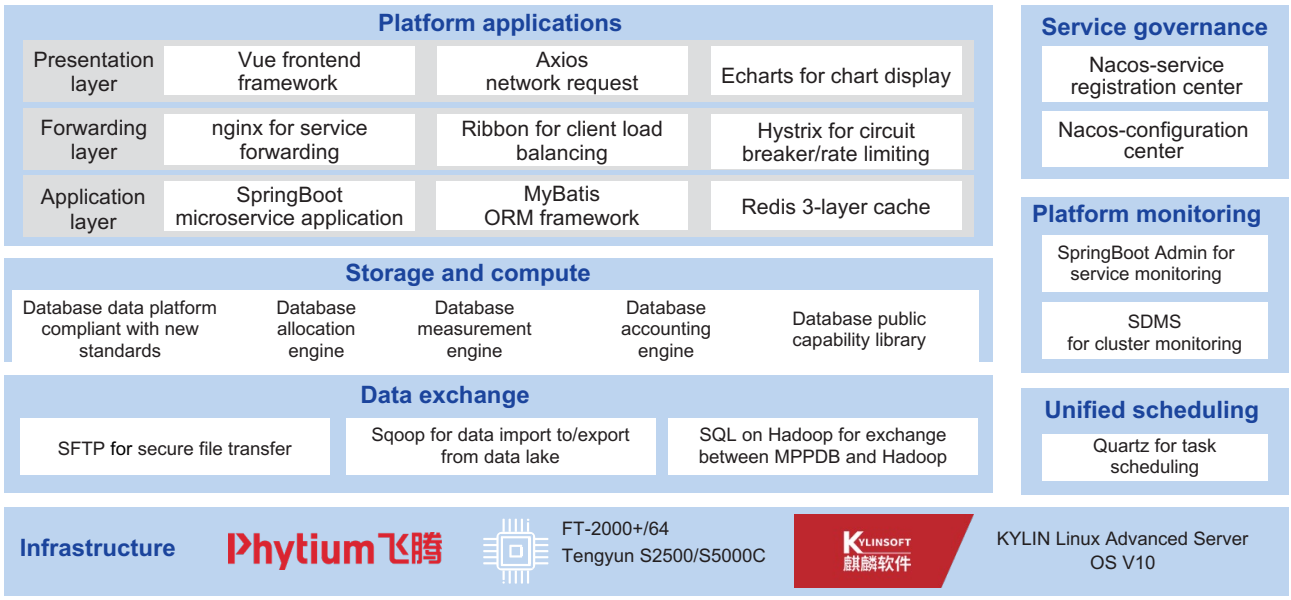
Solution

The proposed solution uses lakehouses, layered data design, and functional architecture to integrate insurance business data across all domains and generate financial statements compliant with the requirements of the new insurance contract accounting standards. This will address challenges such as model processing for massive amounts of data, end-to-end task monitoring, and data tracing.



Architecture of the IFRS17 (CAS 25)-based platform

The solution incorporates Phytium's Tengyun S5000C and KylinOS (a distribution of openEuler) as the foundation to build three major components: the data platform, measurement platform, and accounting engine.



Technical architecture of the IFRS 17 (CAS 25)-based platform

Benefits

The solution will help insurance companies efficiently and cost-effectively address industry challenges and rapidly convert visible value into revenue. The implementation of the standard will entail data synchronization from source systems, data processing, accounting, and subledger processing, and faces challenges such as insufficient calculation times, large data volumes, and strict data consistency demand. The solution will power insurance companies by tackling these challenges. The solution should be widely applicable and will hopefully serve as a model for the platform construction in a wide range of insurance services, including life, endowment, and property insurance, as well as reinsurance for life and property.

Future Outlook

Financial institutions implementing the new insurance contract standards will face challenges such as tight schedules, complex construction, budget constraints, and the need for system de-risking. This solution promises to resolve these issues and help the insurance companies produce accurate and timely financial statements under the new standards. Additionally, it could provide data collection and analysis for internal operational management including performance management, risk management, and operational analysis in the future.

3.12 Reconstruction of CZBank's Distributed Microservice Platform

User: China Zheshang Bank (CZBank)
OS: openEuler-based KylinOS
Use Case: Distributed microservice platform
Deployed: Not yet deployed as of time of writing

Background

CZBank, a joint-stock bank, needed to upgrade its distributed microservice platform to enhance system resilience. The platform would need to provide functions such as a microservice development framework, configuration management, service governance, logging, and monitoring, supporting the bank's operations.

Solution

Incorporating domestically produced elements, including Sugon (Hygon) and Tsinghua Tongfang (Kunpeng) servers, along with KYLIN Linux Advanced Server OS V10, CZBank reconstructed the components of its distributed microservice platform, including the microservice registry center, configuration center, distributed message components, distributed locks, and microservice gateway.

Service system	Distributed microservice platform		
Software stack	Configuration center	Registry center	Message components
OS	KYLIN Linux Advanced Server OS V10		
Platform	Huawei Cloud		
Processor architecture	Hygon	Kunpeng	

Benefits

By incorporating domestically produced processors, servers, and OS, CZBank has de-risked its distributed microservice platform. The seamless reconstruction did not affect upper-layer service systems. The platform now runs stably and provides efficient and reliable underlying technical support for upper-layer service systems.

3.13 Domain Name System of Shanxi Securities

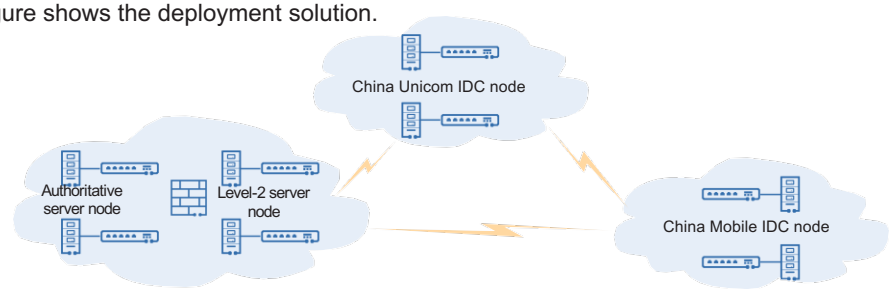
User: Shanxi Securities
OS: openEuler 22.03 LTS
Use Case: Domain name system
Deployed: December 2022

Background

Shanxi Securities needed to modernize its domain name system to accelerate IT infrastructure development. It also needed to implement centralized management and real-time remote backup of information system data together with geo-redundant 3DC DR. Shanxi Securities hoped to adopt a China's home-grown open source OS in its new system.
Shanxi Securities selected Hygon x86 servers, EasyStack cloud platform, and openEuler 22.03 LTS. The solution further incorporated BIND 9 for reliable domain name resolution, Keepalive to ensure high availability, and proprietary Python/Shell tools for enhanced management. By exclusively utilizing the openEuler community release, Shanxi Securities prioritized system resilience and maintainability.

Solution

The following figure shows the deployment solution.



Shanxi Securities' domain name system consists of the following components:

- Authoritative server node: houses an authoritative domain name server and a backup server, providing authoritative domain name data and management tools.
- Level-2 server node: consists of two high-availability servers, synchronizing domain name data to IDC nodes.
- IDC node: provides domain name resolution services for customers. This node can be linearly scaled as required.
- Internal resolution servers: deployed within data centers, provide resolution services for intranet applications in the data centers.

Benefits

The new domain name system can be accessed from multiple locations and by multiple carriers. It enables automatic domain name change distribution, unified domain name data management, and internal/external network DNS separation at the system service layer. The system supports deployment and migration on the cloud, accommodating both IPv4 and IPv6 configurations for multiple nodes. Rapid deployment and migration are also supported in testing environments.
In addition, the new domain name system utilizes the openEuler community release and provides pre-built system images to match various versions of openEuler. As a foundational service in the data center, the system facilitates openEuler deployment and upgrade for other systems.

Future Outlook

This is Shanxi Securities' first attempt to use the openEuler community release. The successful reconstruction of the domain name system sets a precedent for future migrations to openEuler. Shanxi Securities will continue to reconstruct and replace their existing CentOS-based foundational service systems.
During system reconstruction and testing, performance evaluations have shown that openEuler exhibits comparable performance to other Linux distributions on identical hardware. This deployment has also yielded lessons that will inform further adoption of the openEuler community edition.

04

Innovative Pilot Projects

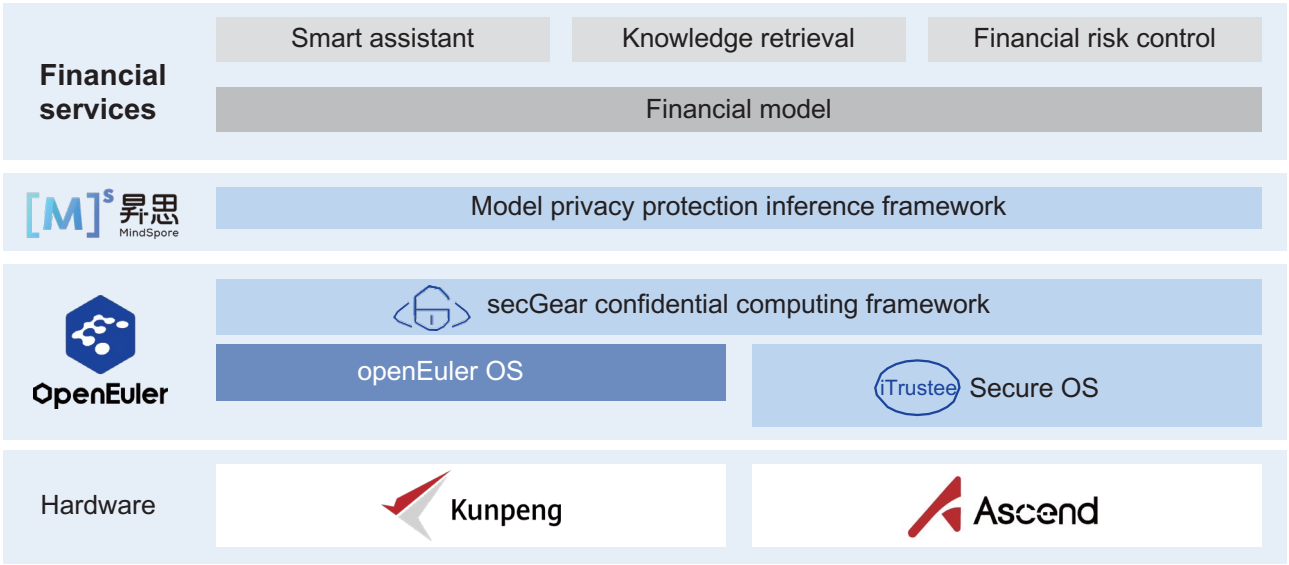
4.1 ICBC and Fudan University's Innovative openEuler-based Confidential Computing Solution for LLMs

Piloted: October 2024

Application Scenarios

Emerging AI applications are associated with significant challenges regarding regulatory compliance with data security, particularly ensuring the confidentiality and integrity of both data and models in AI services. Industrial and Commercial Bank of China (ICBC), a forward-thinking institution driving digital transformation and integrating AI technologies into its services, has proactively responded to this challenge. To address it, ICBC has partnered with Fudan University and Huawei to develop a confidential computing solution for large models. Incorporating Kunpeng and Ascend hardware, along with innovative software such as openEuler, iTrustee, and MindSpore, the joint team is working toward creating an AI-driven cloud service platform that enhances data security and privacy protection.

Solution



- secGear: It is a remote attestation framework for confidential computing on openEuler. It abstracts away the differences between each generation of Kunpeng processors, verifies iTrustee and virtCCA remote attestation reports, and allows quick deployment of the attestation service to implement mutual authentication between different Trusted Execution Environments (TEEs). In addition, it employs cross-TEE encrypted channels to implement interconnection between TEEs.
- iTrustee: It enables a hardware-based TEE. Its remote attestation technology helps to evaluate the trustworthiness of applications in real time. Its confidential container technology enables fast application migration to a confidential environment, improving service security cost-effectively.
- MindSpore: It supports heterogeneous confidential computing by integrating CPUs and NPUs resources. Furthermore, it enables secure parallelism of high-performance models and protects model integrity, and prevents confidential user data from being stolen by privileged users or attackers during inference on the cloud.

Benefits

- Supply chain security: The hardware and software components used in the innovative confidential computing solution are selected with supply chain resilience in mind.
- Robust security: The openEuler confidential computing technology strengthens data security and privacy protection in computing scenarios involving large models, as demonstrated in ICBC's smart assistant and knowledge retrieval services.
- Remarkable performance: The heterogeneous confidential computing technology powered by Kunpeng and Ascend offloads computing workload to Ascend NPUs, maximizing the computing performance.

4.2 ICBC's Hybrid Resource Deployment

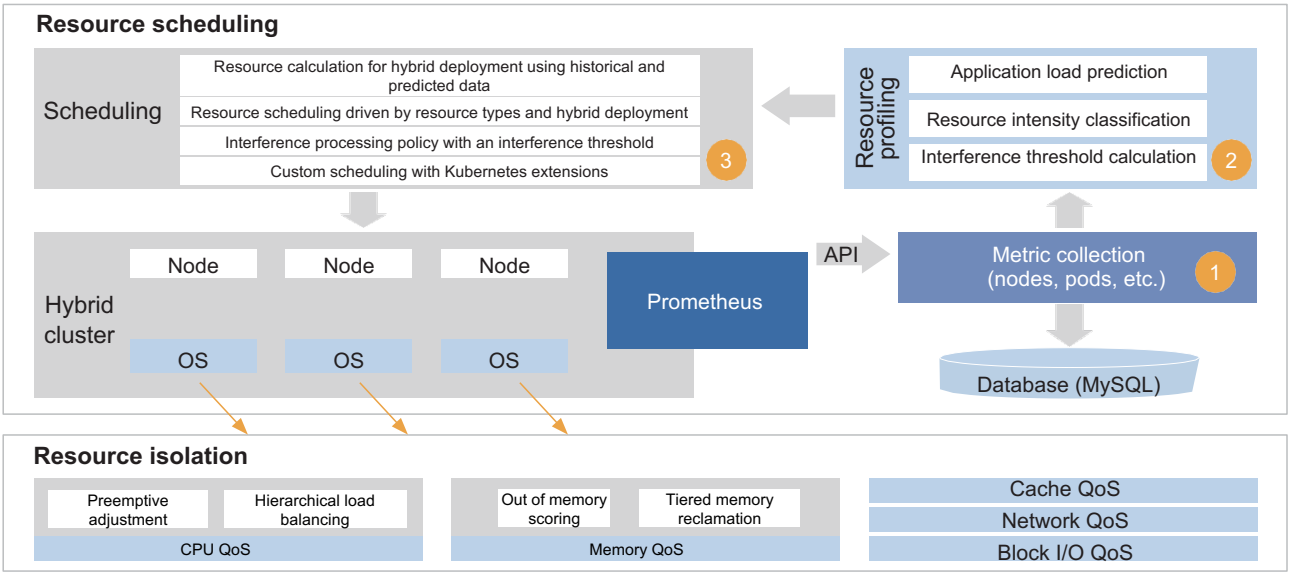
Piloted: September 2022

Application Scenarios

ICBC's in-house PaaS cloud platform hosts its core services. Each application in the large cluster has unique performance and capacity needs. Except databases and big data, all online and batch processing loads are scheduled in the same type of computing resource pools. These loads demand high resource specifications, leading to resource underutilization.

Solution

ICBC set out to create a hybrid deployment solution tailored to its service scenarios, in order to streamline resource scheduling and isolation.



Resource scheduling involves:

- Resource profiling: Statistical analysis and machine learning are used to profile application resources, including CPU, memory, and other relevant metrics, for effective hybrid scheduling.
- Hybrid deployment and scheduling: High- and low-priority applications are deployed together and are scheduled based on the idle resources and load types of high-priority applications. Real-time monitoring of high-priority application interference ensures timely workarounds to maintain the quality of service (QoS) of high-priority applications.

ICBC's cloud computing lab worked with Huawei to implement kernel isolation on openEuler. Kernel resources are managed in multiple tiers covering physical cores, caches, memory bandwidth, network bandwidth, and I/O bandwidth. The isolation and overcommitment mechanism allows for hierarchical preemption of shared resources including CPUs, memory, drives, and networks. Resource isolation improves resource utilization and ensures the QoS of high-priority applications.

Benefits

ICBC deploys services of different priorities together, such as personal e-banking, quantitative investment transaction, and asset management, valuation, and accounting. This approach increases the deployment density per node by over 50%. In scenarios where low-priority applications consume significant CPU resources, node resource utilization rises to over 35%. Additionally, the QoS impact on high-priority applications is limited to no more than 5%, thanks to effective methods such as resource isolation, interference detection, and eviction.

4.3 Low-Latency Solution for Core Transactions in the Shanghai Stock Exchange

Piloted: September 2023

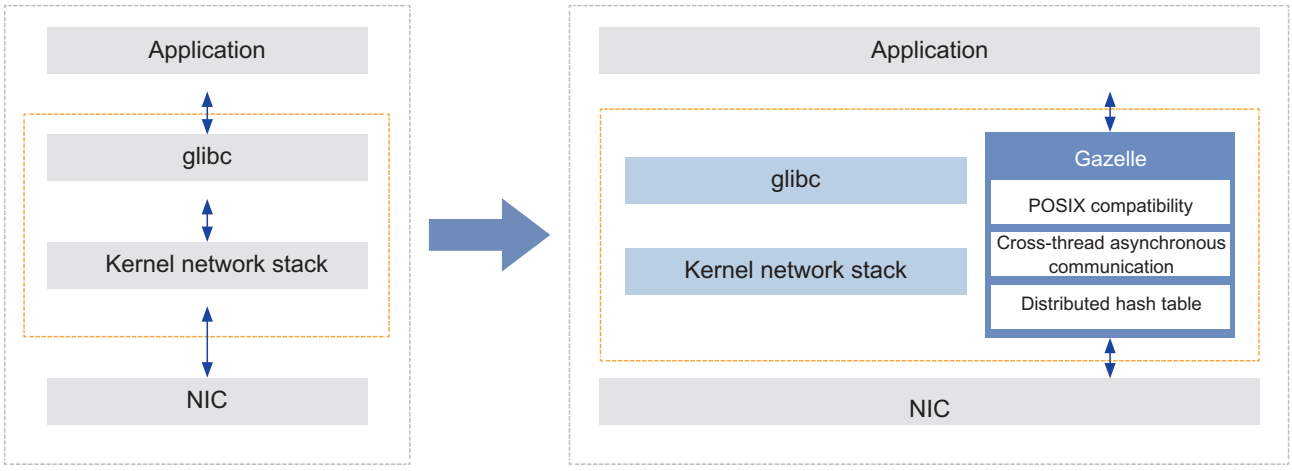
Application Scenarios

The Shanghai Stock Exchange is one of the world's three major exchanges, and its transaction system constitutes essential infrastructure for the securities industry. It matches transactions in the global market based on price and time precedence. If the latency of this transaction system is lowered and its speed is increased, this can significantly enhance price discovery, improve transaction convenience, and boost market acquisition. However, the OS kernel protocol stack of the transaction system becomes inadequate in scenarios involving numerous connections and multiple threads. In contrast, the user-mode protocol stack offers clear advantages and can significantly boost the network I/O throughput of applications.

Solution

Shanghai Stock Exchange is developing a next-generation core transaction system, which aims to provide lower transaction latency. Gazelle, the user-mode protocol stack running openEuler on Kunpeng servers, can dramatically reduce inter-node latencies in simulated scenarios of the core transaction system. This technology has been verified by the latency lab of Shanghai Stock Exchange.

Gazelle uses the kernel bypass technology. It leverages the Data Plane Development Kit (DPDK) to read and write NIC packets in user mode and shares huge pages to transfer packets. Because it works over the lightweight IP (lwIP) protocol stack, it delivers outstanding performance and availability while preserving the desired levels of universality and usability. As shown in the figure, Shanghai Stock Exchange uses Gazelle to develop low-latency transaction applications, greatly increasing the network I/O throughput of these applications.



Benefits

When the basic performance of NICs is constrained by hardware, the software protocol stack is optimized to halve the data transmission duration in the network protocol stack. Testing showed that the overall latency of order transactions was reduced by 10%. The software solution compensates for hardware limitations and enhances the competitiveness of every element in the stack.

4.4 Kmesh: China CITIC Bank's High-Performance Service Mesh

Piloted: September 2023

Application Scenarios

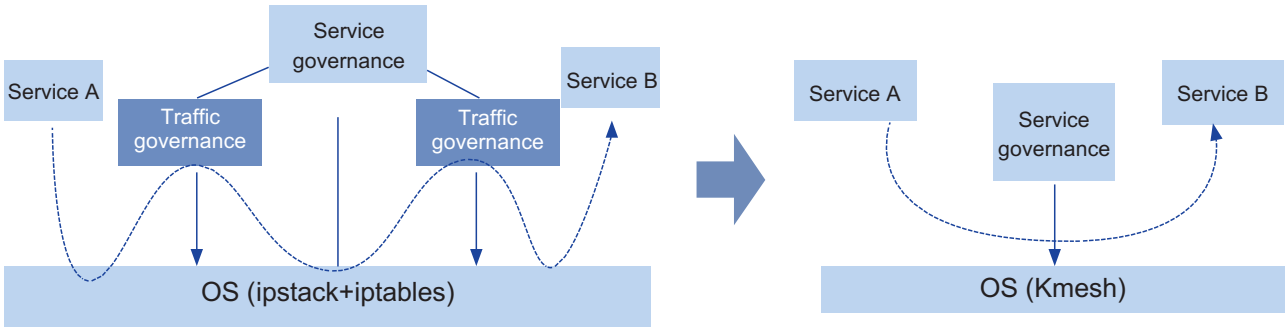
Explosive data growth and the increasing complexity of application scenarios have driven a shift from monolithic systems to distributed microservice architectures. A major challenge of these new architectures is achieving transparent and efficient service governance and interoperation.

The financial industry has high standards for service latency and performance. A financial service system typically includes a range of service software and is hindered by complex communication infrastructure. A service mesh architecture abstracts traffic governance into infrastructure so as to simplify service logic and decouple complex communication from services. However, a mesh proxy architecture generally causes an additional latency overhead of 2–3 ms per hop, which is unacceptably high in financial service scenarios.

China CITIC Bank is reconstructing its services using a service mesh architecture, and this brings challenges in terms of data-plane performance.

Solution

Kmesh is a high-performance service mesh data plane built on a programmable kernel. It is characterized by high performance, low overhead, and high reliability. By offloading L4 and L7 traffic governance to the kernel, it boosts service forwarding performance by 50% and 60%, respectively, while reducing memory overhead by 70%.



Common meshes in the industry: 3-hop communication path in the proxy architecture

(a) Typical mesh implementation

Kmesh: Only one hop along the traffic path

(b) Kmesh implementation

Kmesh offers the following features:

- Connection to a mesh control plane (such as Istiod) that complies with the x Discovery Service (xDS) protocol Application traffic orchestration
- Load balancing: various load balancing policies such as polling
- Routing: L7 routing support
- Gray: backend service policies available in percentage mode

Benefits

Kmesh enhances forwarding performance in networked transactions by 40%, enabling China CITIC Bank to develop a competitive, financial-grade service mesh architecture.

4.5 JBooster for Faster Startup of Hundsun's Microservices

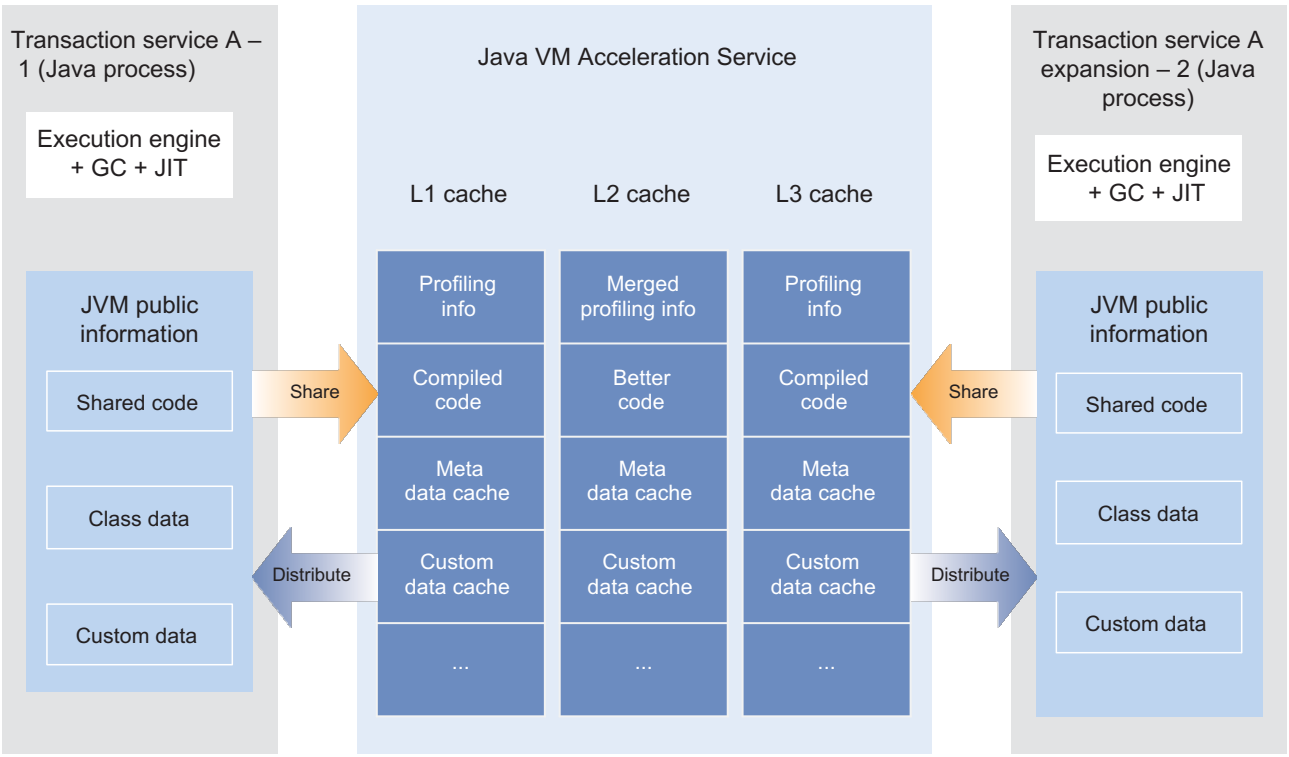
Piloted: August 2024

Application Scenarios

UF3.0, a core transaction system developed by Hundsun Technologies, is a next-generation, one-stop financial brokerage service platform with a distributed architecture. It supports rapid horizontal scaling and elastic resource allocation, and can handle hundreds of millions of requests daily. After microservices are scaled within UF3.0, the latency of the new Java instances fluctuates due to long startup times and inadequate warm-up. This issue is a common challenge across the industry.

Solution

The BiSheng Java Development Kit (JDK) was used to incubate the JBooster technology for Hundsun's distributed microservice architecture. JBooster introduces a Java server to collect and manage common framework class data and JIT code information of similar transaction services. The Java server caches, aggregates, and continuously generates acceleration packages, and shares these acceleration packages with newly started service instances. As a result, microservices are started and executed more quickly to optimize the performance of cloud-native services.



Benefits

The BiSheng JDK JBooster enables sub-features such as class loader caching, class data sharing, and remote ahead-of-time (AOT) compilation. Services on the two Hundsun UF3.0 Spring frameworks are started much more quickly.

- The startup time of the information query microservice is shortened from 53.92 seconds to 42.22 seconds.
- The startup time of the task scheduling service within the common components is reduced from 37.09 seconds to 20.95 seconds.

The overall startup time is shortened by over 20% and the service warm-up time is shortened by over 10 seconds. As a result, Hundsun UF3.0 can efficiently handle a greater volume of requests during system scaling.

4.6 A Reliable OS for a Large Bank

Piloted: October 2024

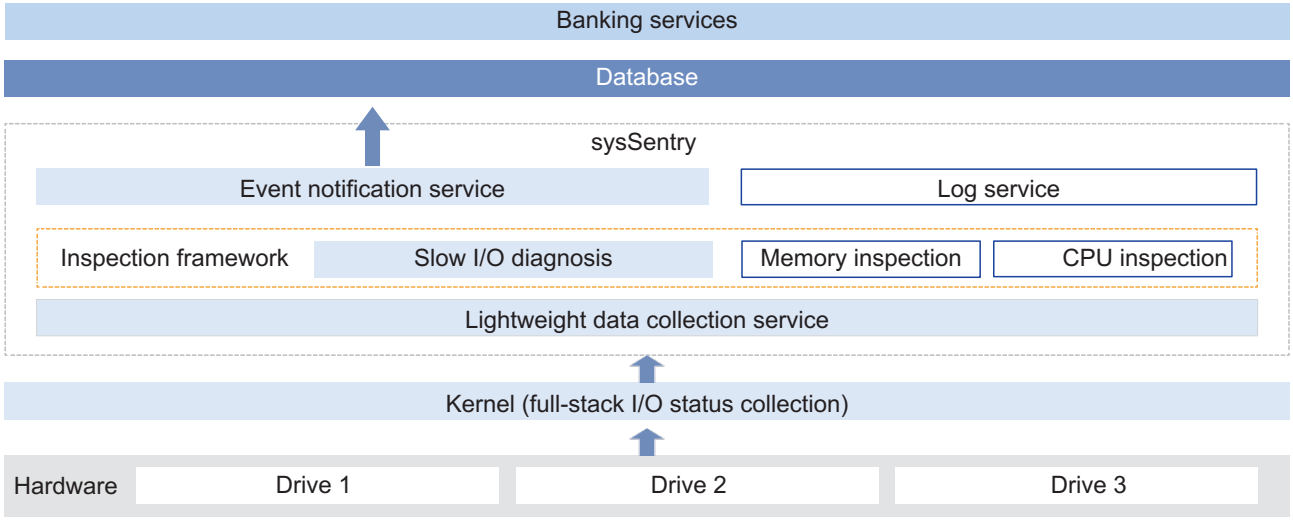
Application Scenarios

Databases are the backbone of any bank's core system and play a crucial role in ensuring service continuity. Drives are the physical foundation of databases and directly impact their availability. Therefore, if I/O detection is slow, then addressing this issue is vital to ensuring high database availability.

This is an issue that merits close collaboration between banks, database vendors, and OS developers. openEuler fosters open collaboration, allowing all parties involved to explore efficient slow I/O detection technologies and promptly address drive faults to minimize downtime.

Solution

- Kernel: The kernel supports lock-free drive I/O tracing and eBPF-based I/O collection to collect I/O stack metrics in each phase.
- sysSentry: openEuler's unified troubleshooting framework provides lightweight data collection, slow I/O diagnosis, and event notification within seconds when slow I/O is detected.
- Database and other services: Services receive slow I/O events reported by the OS, allowing for quick fault detection and service recovery. This helps minimize service interruption caused by drive faults.



Benefits

- Solid reliability: openEuler's slow I/O detection technology enables fast and precise drive fault detection. It can identify drive faults in as short as 6 seconds and achieve a detection accuracy of over 80%.
- Easy O&M: This detection technology monitors kernel I/O and detects anomalies across the stack, and logs anomalies to facilitate rapid identification and isolation of occasional I/O faults.

4.7 A Cloud-Native OS for a Large Bank

Piloted: October 2024

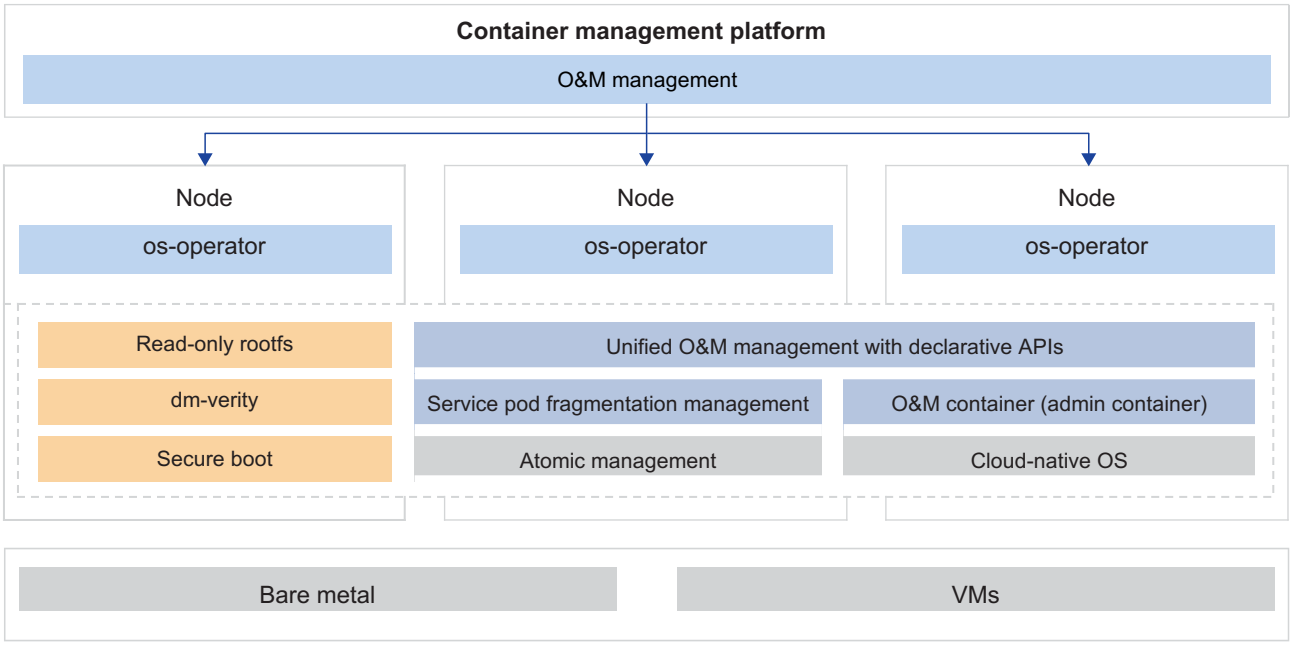
Application Scenario

In 2024, openEuler worked with a bank to develop a cloud-native OS. The aim of the bank was to tackle persistent issues related to its cloud infrastructure OS, including excessive resource consumption, maintenance inefficiencies, and slow system response times. By implementing these improvements, the bank hoped to accelerate innovation across its full software stack and strengthen its market position.

Solution

The bank partnered with the openEuler's KubeOS project to develop an immutable infrastructure OS. The project prioritized supply chain resilience and operational elasticity. This OS seamlessly integrates with the bank's cloud-native management platform, streamlining containerized application O&M.

KubeOS delivers a lightweight, secure OS specifically engineered for cloud-native environments. Its security-focused architecture employs minimal components, a read-only root file system (rootfs), and dm-verity implementation, significantly reducing vulnerabilities and potential attack surface. The management capabilities of KubeOS leverage native declarative Kubernetes APIs to automate O&M of the cluster worker node OS. This automation drastically reduces the need for manual intervention and simplifies the O&M of cloud-native environments. The following diagram illustrates how KubeOS integrates with the container cloud platform developed by the bank.



Benefits

Compared to existing cloud infrastructure, this solution quadruples OS startup speed while slashing resource consumption by 75%. It also reduces vendor lock-in with cloud infrastructure providers.

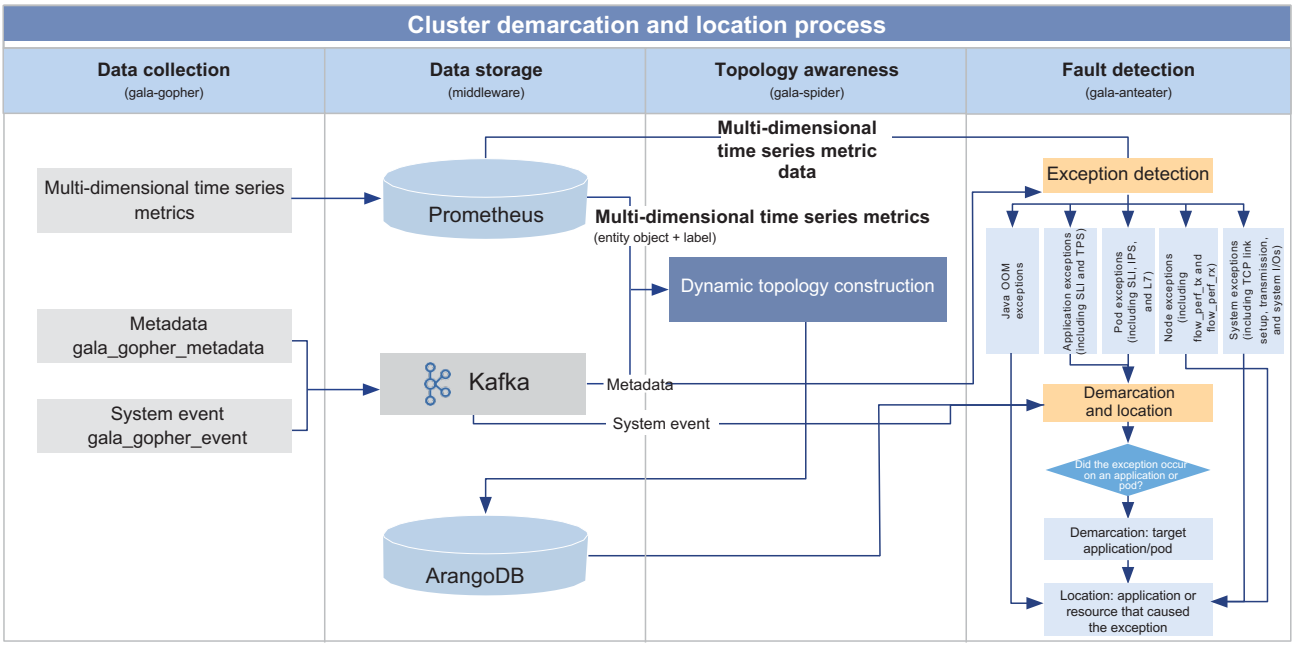
4.8 Full-Stack Observability Solution for a Large Bank

Piloted: October 2024

Application Scenario

As cloud-native technologies advance and microservice architectures mature, banks face mounting operational complexities. Struggling with challenges including performance bottlenecks from resource contention, difficulties in rapid process-level anomaly detection, and complex node relationship management in dynamic environments, one bank turned to openEuler as a potential solution. The bank and openEuler came up with a solution that would increase visibility across the length and breadth of the bank's tech stack. The planned solution would accelerate demarcation and location of common failures (such as TCP and I/O issues). It would work in conjunction with existing monitoring tools to achieve what bank called its "1-5-10" target. That is, incidents should be detected within 1 minute, root causes identified within 5 minutes, and services restored within 10 minutes.

Solution



A comprehensive full-stack observability framework was developed. It was integrated using a hardware-software integration solution from Huawei. This integration bridges the operational gap between IaaS and PaaS layers, creating a unified monitoring and diagnostic pipeline. Key technical aspects include:

- Process-level anomaly detection: This leverages system memory and CPU metrics to monitor process-specific pods in real time. Upon detecting system anomalies, the solution instantly identifies affected pods, pinpoints their associated containers and applications, and performs root cause analysis. This comprehensive monitoring ensures immediate detection of system irregularities, enabling swift incident response and resolution.
- Pod node correlation tracking: Using non-intrusive collection methods, pod state metrics are collected and stored. Maintaining such a detailed pod state history addresses challenges in dynamic environments where pod migrations can break metric correlations, enabling precise operational control and thorough post-incident analysis.

Benefits

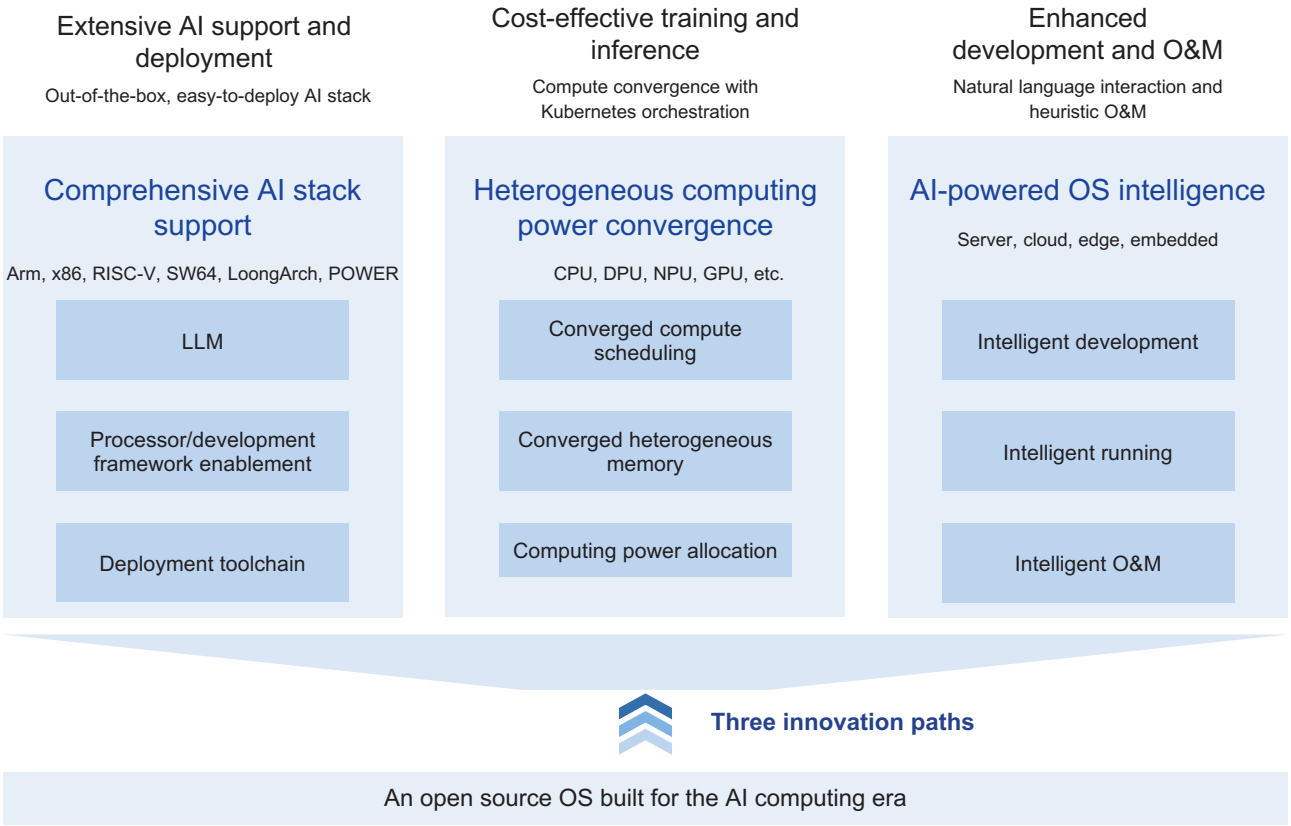
Initial pilot deployments in core banking operations validated the effectiveness of the technology and established a foundation for broader implementation. The solution shows potential for enterprise-wide deployment. Such a deployment is projected to bring a 15% improvement in operational efficiency.

05

AI-Native Advancements

The rapid advancement of LLMs has catalyzed widespread adoption of generative AI capabilities. In finance this is taking the form of applications for knowledge retrieval, customer service, meeting assistance, data analytics, report generation, credit assessment, and code development. Leading enterprises actively implement AI solutions across business and IT domains, with AI agents emerging as the primary focus for practical LLM deployment.

The launch of openEuler 24.03 LTS, on June 6, 2024, marked the debut of the first AI-native open source OS. By September, the openEuler community had expanded its innovative collaboration in computing acceleration, cost-effectiveness, and ISV modernization. The platform enhances intelligence through AI integration across OS development, deployment, and O&M workflows. openEuler is exceptionally versatile, supporting several major computing architectures—x86, Arm, RISC-V, LoongArch, SW64, and Power. It is a pioneer in its support for key AI processors from brands such as NVIDIA and Ascend, and provides a unified framework for the convergence of heterogeneous OSs, memory, and compute. This comprehensive approach enables seamless device integration and unified evolution of general and AI computing, positioning openEuler as a preferred OS for AI computing environments.



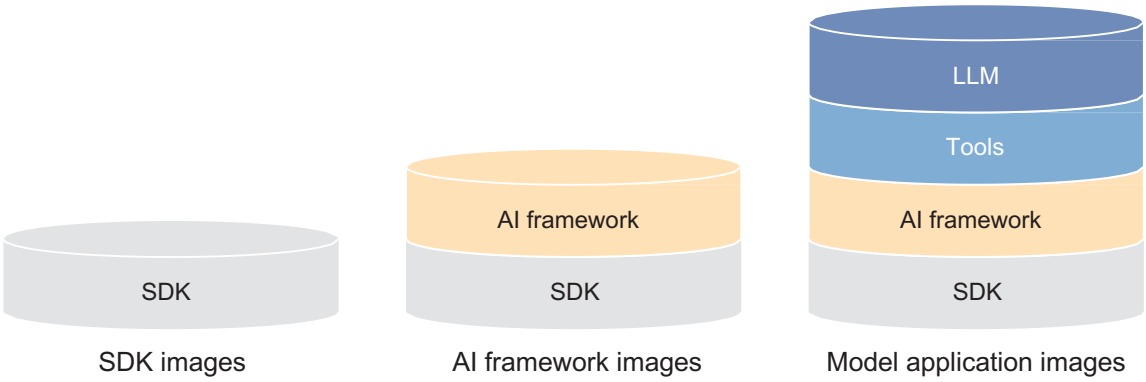
5.1 Ready-to-Use AI Stacks

Application Scenario

openEuler offers an efficient development and runtime environment that containerizes software stacks of AI platforms and makes deployment easy. It also provides various AI frameworks to facilitate AI development.

Solution

- openEuler supports TensorFlow, PyTorch, and MindSpore frameworks and software development kits (SDKs) of major computing architectures such as Compute Architecture for Neural Networks (CANN) and Compute Unified Architecture (CUDA), to make it easy to develop and run AI applications.
- Environment setup is further simplified by the containerization of software stacks. openEuler provides three types of container images:



- SDK images use openEuler as the base image and install the SDK of a computing architecture, for example, Ascend CANN and NVIDIA CUDA.
- AI framework images use an SDK image as the base and install AI framework software, such as PyTorch and TensorFlow.
- Model application images provide a complete toolchain and model applications.

For details, see the openEuler AI Container Image User Guide.

Benefit

openEuler uses AI container images to simplify deployment of runtime environments. You can select the container image that best suits your requirements and complete the deployment in a few simple steps.

- SDK images: You can develop and debug Ascend CANN or NVIDIA CUDA applications using an SDK image, which provides a compute acceleration toolkit and a development environment. These containers offer an easy solution for high-performance computing (HPC) tasks, such as large-scale data processing and parallel computing.
- AI framework images: This type of container is designed to support AI model development, training, and inference.
- Model application images: These images contain a complete AI software stack, including purpose-built models for model inference and fine-tuning.

5.2 openEuler Copilot System

Application Scenario

The openEuler Copilot System is an advanced LLM interaction platform featuring a standardized northbound semantic interface, comprehensive toolchain, and accelerated runtime for AI deployments. LLMs have the potential to revolutionize OSs, and openEuler Copilot System unleashes that potential through natural language interactions, agents for intelligent Q&A, diagnostics, optimization, deployment, and operations. The platform also drives industry transformation by facilitating enterprise ISV application upgrades across the stages of generative AI evolution, enabling enterprises to procure custom agents.

Intelligent Q&A Agent

Application Scenarios

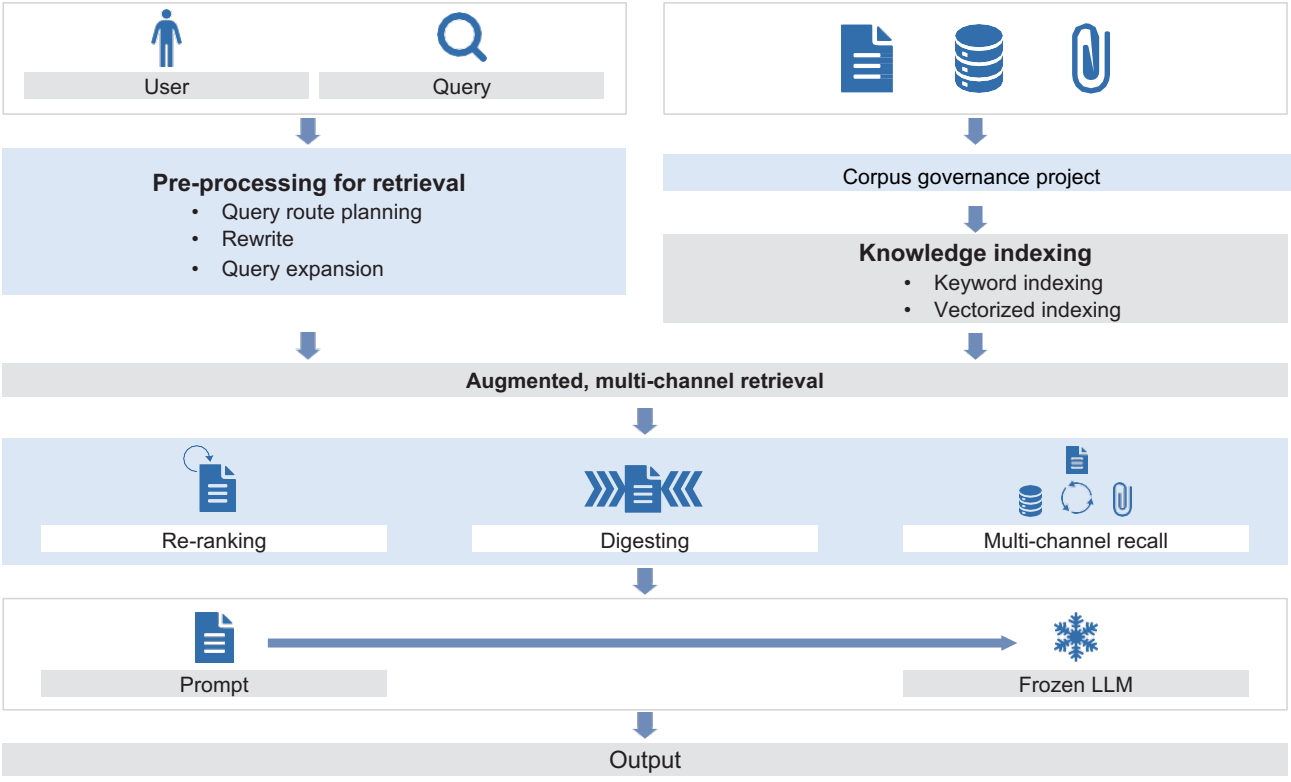
- Common users who are seeking best practices for things such as migrating services to openEuler
- Developers who want to learn about the contribution processes, key features, project development of openEuler
- O&M personnel who are using the Q&A system to solve common problems and improve system management

For details, see the openEuler Copilot System Intelligent Q&A Service User Guide.

Feature Description

The openEuler Copilot System is accessible via web or shell.

- Web: Provides essential OS knowledge, openEuler data, and O&M, project, and usage information.
- Shell: Delivers intuitive user experience when accessed using natural languages.



Retrieval-augmented generation (RAG) is a technique for enhancing the long-term memory capability of LLMs. RAG Used by the openEuler Copilot System is essential to reducing model training costs and has the following highlights:

- Pre-processing for retrieval: User queries are allocated to the most appropriate information source through route planning for document retrieval. Complex queries may be disassembled into their component parts to expand the retrieval coverage. After that, user queries are rewritten based on historical information to increase the retrieval hit rate.
- Knowledge indexing: In the corpus governance project, fragments are extracted from the documents to be stored into the knowledge base. Then derivatives are generated for complex fragments like code snippets and optical character recognition (OCR)-generated text, replacing fragments in subsequent retrieval. After that, based on the fragments and fragment derivatives, keywords are extracted and vector features are generated to construct data structures for retrieval.
- Multi-channel recall: For queries generated during pre-processing, target fragments are retrieved using vectorized retrieval, keyword retrieval, and Chat2DB. Then the retrieval results are re-ranked based on the user query. Finally, digesting, polishing, and other techniques are employed to process the key content of the retrieved results, compress the token length, and enhance natural language features.

These capabilities enable RAG for the openEuler Copilot System to accommodate to more document formats and content, and enhance Q&A services without increasing system load.

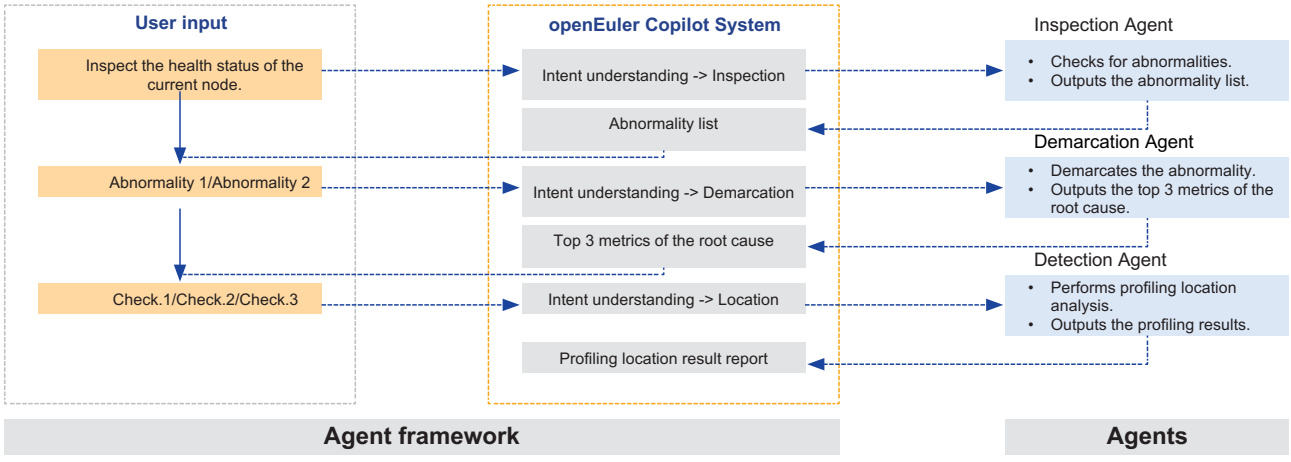
Corpus governance is one of the basic RAG capabilities in the openEuler Copilot System. It imports corpuses into the knowledge base in a supported format using fragment relationship extraction, fragment derivative construction, and OCR, increasing the retrieval hit rate.

- Fragment relationship extraction: This represents the abstract relationship between fragments and between fragments and their derivatives. After a user's query hits the target fragment, the system retrieves related fragments (such as context) based on the fragment relationship, enhancing the integrity of the final retrieval result.
- Fragment derivative generation: For complex fragments (such as code snippets), digests, descriptions, and case questions (raised by users about the fragments) are generated to replace these complicated fragments in searches. This significantly alleviates the impact of complex fragments in the retrieval process and enhances the accuracy and integrity of the retrieval result.
- OCR: Images in a document are extracted as fragment derivatives using image-to-text conversion to ensure that queries hit fragment derivatives associated with the original images. OCR greatly compensates for retrieval results that contain no images.

The preceding corpus governance methods can enhance the Q&A service experience in multi-round dialogs, content integrity, and image-text display.

Agentic Intelligent Diagnosis

Feature Description



- Inspection: The Inspection Agent checks for abnormalities of designated IP addresses and provides an abnormality list that contains associated container IDs and abnormal metrics (such as CPU and memory).
- Demarcation: The Demarcation Agent analyzes and demarcates a specified abnormality contained in the inspection result and outputs the top 3 metrics of the root cause.

- The Detection Agent performs profiling location on the root cause, and provides useful hotspot information such as the stack, system time, and performance metrics related to the root cause.

Application Scenarios

In openEuler 24.09, the intelligent shell entry enables capabilities like single-node anomaly detection, demarcation, and profiling location.

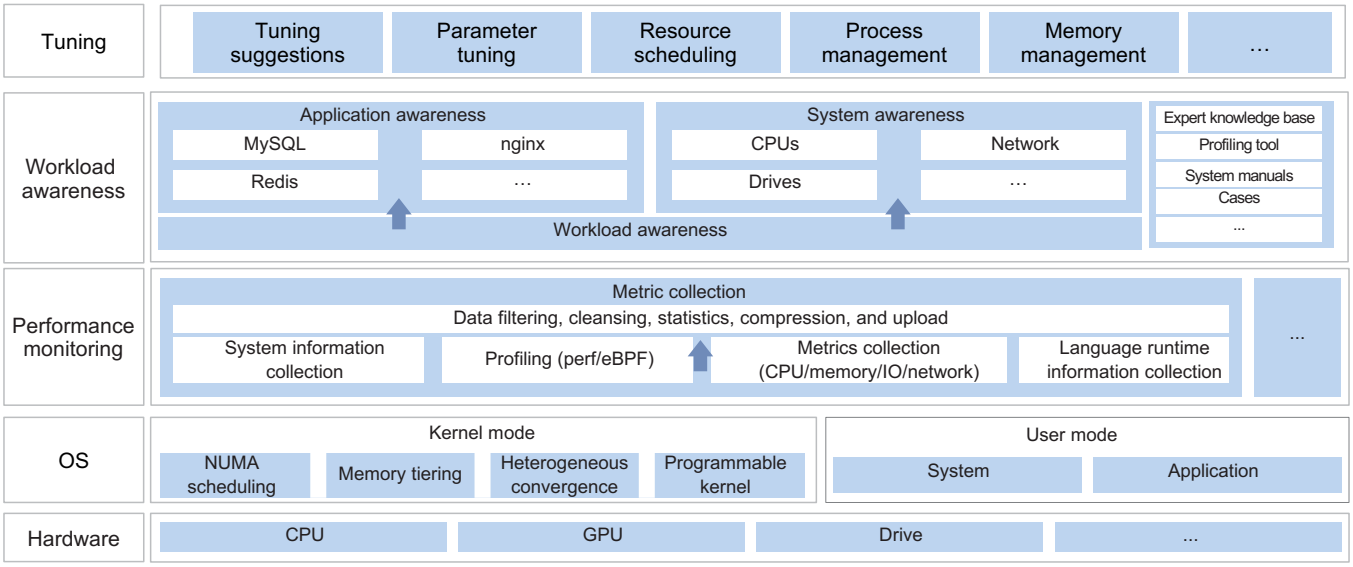
- The inspection capability is used for single-node performance metric collection, performance profiling, and anomaly detection.
- The demarcation capability is used to locate the root cause based on the anomaly detection results and output the top 3 root-cause metrics.
- The detection capability refers to using a profiling tool to locate the faulty modules (code snippets) related to the root-cause metrics.

Intelligent Tuning Agent

Feature Description

openEuler Copilot System can be accessed through a shell portal or web portal.

Users can interact with openEuler Copilot System using natural language and perform heuristic tuning operations such as performance data collection, system performance profiling, and system performance tuning.



Performance metrics are profiled by using perf and system tools.

System profiling combines conventional machine learning algorithms (such as clustering) with large language models (LLMs) to detect loads and identify bottlenecks.

During system performance tuning, technologies like RAG are employed to intelligently recommend tuning policies based on the expert knowledge base and performance profiling reports.

Application Scenarios

Single-node system performance profiling and tuning suggestions

- **Insights from key performance metrics**: Users can learn about the system performance based on collected performance metrics like CPU, I/O, drive, network, and application.
- **System performance analysis**: Performance profiling reports are generated, making it easier to locate performance bottlenecks across the entire system and in individual applications.
- **Performance tuning suggestions**: openEuler Copilot System generates a performance tuning script, which can be executed with one click to tune the system and specific applications.

Intelligent Deployment Agent

Feature Description

openEuler Copilot System can invoke environment resources through natural language, assist in pulling container images for local physical resources, and establish a development environment suitable for debugging on existing compute devices.

This system supports three types of containers, and container images have been released on Docker Hub. You can manually pull and run these container images.

- SDKs: This image encapsulates only the component libraries that enable AI hardware resources, such as CUDA and CANN.
- SDKs + training/inference frameworks: This image includes TensorFlow, PyTorch, and other frameworks (for example, tensorflow2.15.0-cuda12.2.0 and pytorch2.1.0.a1-cann7.0.RC1) in addition to SDKs.
- SDKs + training/inference frameworks + LLMs: This image encapsulates several models (for example, Llama-2-7b and ChatGLM2-13B) based on the second type of container image.

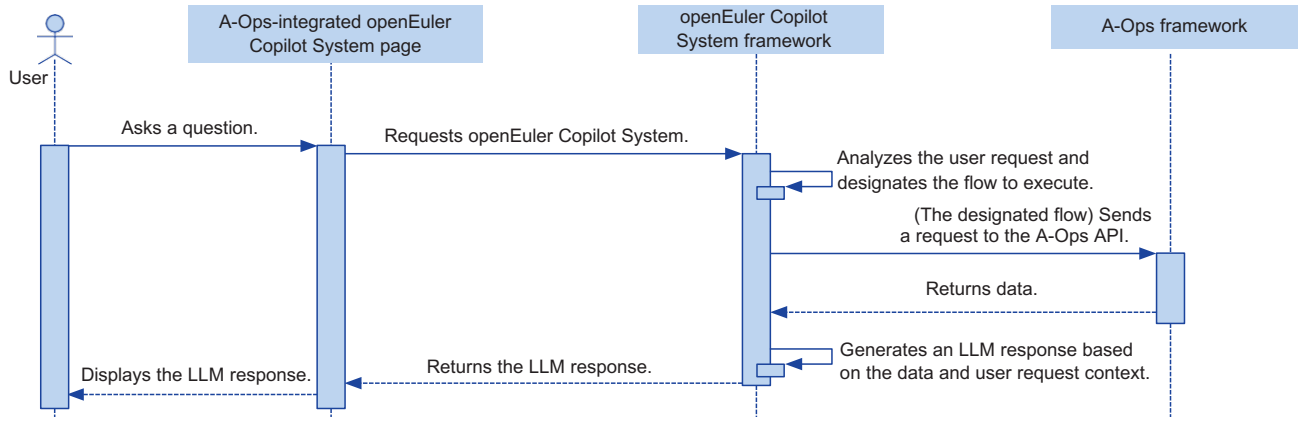
Application Scenarios

openEuler Copilot System enables container deployment using natural language, so users are not required to learn so many container commands.

Intelligent O&M Agent

Feature Description

A-Ops leverages openEuler Copilot System plugins to provide an intelligent O&M assistant. This assistant allows users to perform CVE inspection and configuration tracing through natural language.



Application Scenarios

The intelligent O&M assistant simplifies complex operations by allowing users to interact using natural language. This streamlines the workflow for CVE inspection and configuration tracing, ultimately enhancing user experience.

Benefits

In terms of AI enablement within the OS, A-Ops enables application deployment through natural language interaction, boosts performance by over 10% in typical intelligent tuning scenarios, and improves configuration tracing and CVE inspection efficiency by 30% in intelligent diagnosis scenarios.

From the perspective of industry intelligent transformation, it accelerates the intelligent upgrade of enterprise-grade ISV applications, improves the accuracy of enterprise knowledge Q&A to 90%, and shortens the TTM of LLM applications from months to weeks.

06

Standards and Services

6.1 Technical Specifications for the Application of openEuler in the Financial Industry

This section outlines the capabilities and characteristics that financial institutions require in an OS. Drawing on surveys, pilot trials, and other methods, this section aims to address the issues encountered during implementation, and consider how such issues may be resolved. These insights will support the development of future standards and the implementation of upcoming OS releases.

- Hardware compatibility
- System management tools
- Development tools
- File systems
- Databases
- Security
- Supplementary standards

To promote the adoption of openEuler in the financial industry, it is of great significance to set up security standards for OSs and establish a security system and specifications.

Hardware Compatibility

- Support for a broad range of mainstream CPUs, such as Kunpeng, x86, Arm, AMD, Phytium, Hygon, Zhaoxin, Sunway, and Loongson
- Compatibility with popular servers, workstations, and storage products from China and abroad
- Support for mainstream graphics cards, network devices and technical architectures, and middleware and databases from China and abroad
- Support for cloud-native applications and intelligent, elastic service deployment

With the rapid development of the ICT and financial industries, mainstream processors like x86, Arm, AMD and LoongArch, along with various servers, databases, and middleware, are driving diverse software and hardware combinations. This demands broad compatibility from the OS to manage the foundational software and hardware of the financial cloud platform.

System Management Tools

- Financial institutions require tools that allow them to:
- View the current system version information, including the system version, kernel version, CPU, memory, and more.
- Check system load, including CPU, memory, drive, and network usage.
- Query, install, and uninstall packages.
- Maintain logs, including remote logs.
- Manage common devices.
- Query, create, and delete accounts.

Development Tools

Financial institutions require a range of tools:

- Text editors, such as Vim and Emacs
- Compilation and development tools, such as GCC, binutils, GDB, Make, and CMake
- Development environments for GNU C, GNU C++, Java, Qt, GTK+, OpenGL, Perl, Python, Ruby, Rust, and Golang

Institutions also require support for mainstream programming languages and runtime management environments, such as Java, Python, Vue, Node, C++, C#, Maven, and npm.

File Systems

OSs are required to support:

- Common file systems such as FAT32, ext3, ext4, XFS, ReiserFS, and BTRFS
- Virtual file systems such as procfs, sysfs, and tmpfs

While ensuring security and stability, an OS must also support performance tuning to maximize resource utilization, including but not limited to I/O throughput, system resource usage, memory read/write speed, and system response time.

Databases

When it comes to databases, financial institutions require:

- Support for popular database software such as Oracle, MySQL, MariaDB, PostgreSQL, MongoDB, openGauss, GaussDB, Dameng, Kingbase, OceanBase, PolarDB, and HighGoDB
- Shell package managers such as DNF, Yum, pip, and RPM
- Compliance with the deployment requirements of mainstream financial system databases

Additionally, among Chinese financial institutions, there is demand for OS support for software developed by Yonyou, Kingdee, SuperMap, FanRuan, and other developers in China.

Security

Security requirements of financial institutions vary, but may include any of the following:

- Support for user identification and identity authentication
- Discretionary access control
- Support for labeling and mandatory access control
- Support for security audit, records security events, provides log query, log analysis, and alarm functions
- Data integrity protection
- Prevention of object reuse
- Encryption of stored data
- Support for initial login for both local and remote users, and the establishment of trusted paths between the OS and users
- Support for trusted channels
- Network security protection
- Provision of security protection during operation
- Prompt patch support to fix vulnerabilities in the OS
- Fault tolerance and restoration of faulty or interrupted OSs with minimal damage

- Support for service priority configuration
- Resource allocation
- User login access control
- Trusted measurement
- Support for trusted recovery
- Support for configuration of security policies

Standards

- Trusted open source community certification: openEuler has earned the highest level of certification among 20 well-known open source communities in China.

The certification is evaluated from three dimensions: community governance, community operation, and community development capabilities.

- OpenChain open source compliance certification: openEuler has obtained OpenChain ISO 5230 compliance certification.
- Financial Industry Open Source Software Evaluation Specification, a Chinese national standard implemented on August 6, 2023

GB-T 42927-2023 Financial industry open source software evaluation specifications

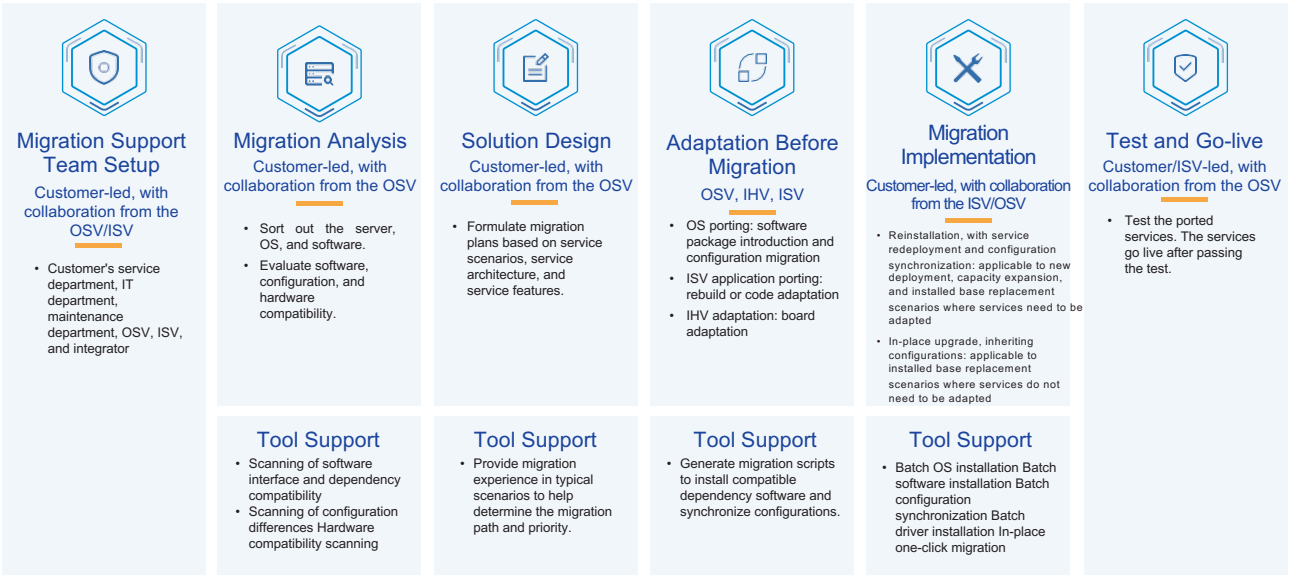
6.2 Native Development of openEuler

x2openEuler Migration Service

When applications an enterprise expects to continue to make use of for years are running on an OS approaching its EOM, for the original OS approaches, migration to a new OS becomes imperative to ensure service continuity and security. Enterprises must adopt future-oriented strategies, with a focus on comprehensive support, reliability, and stability to drive sustainable development, product innovation, and digital transformation. openEuler provides an efficient and reliable platform for seamless OS migration and porting.

x2openEuler is a migration tool that streamlines the move from an enterprise's legacy OSs to openEuler. It provides an easy-to-use UI for performing in-place upgrade of OSs in batches. You can batch add nodes to be upgraded for analysis, planning, and compatibility tests. Then batch upgrade the adapted nodes to achieve an end-to-end seamless migration.

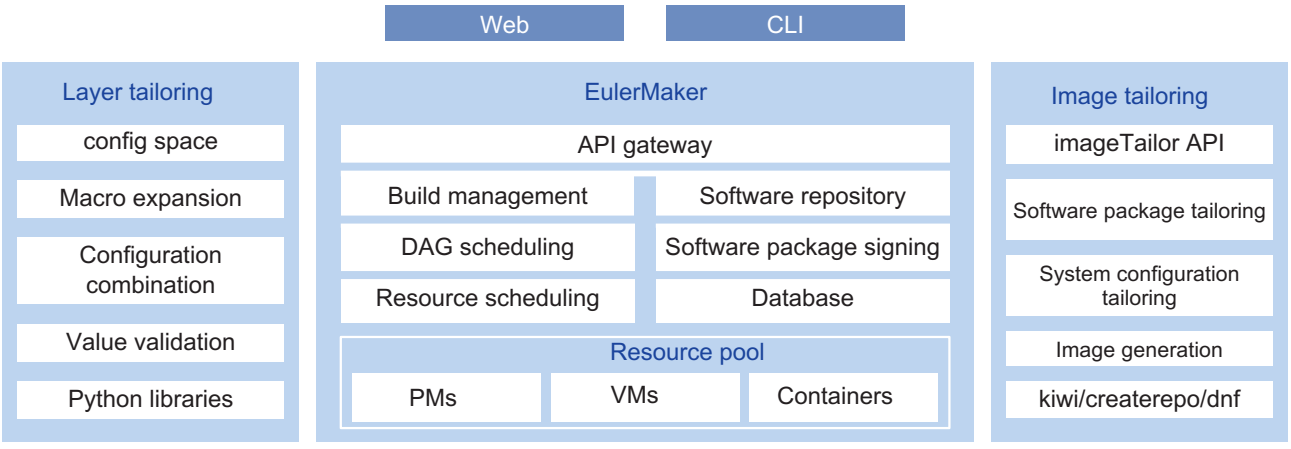
With x2openEuler, migration is completed in just six steps: create a migration support team, analyze migration needs, design a plan, adapt software, migrate the OS, and perform testing and rollout.



x2openEuler helps financial industry users upgrade the OSs of existing clusters to openEuler in batches. The software provides a user-friendly UI and compatibility suggestions, enabling users to quickly complete migration.

EulerMaker

EulerMaker is a package build system that converts source code into binary packages. It enables developers to assemble and tailor scenario-specific OSs thanks to incremental/full build, layer tailoring, and image tailoring capabilities. Community developers and partners can build their own repositories, OS core repositories, and create OSs tailored to particular scenarios.



Feature Description

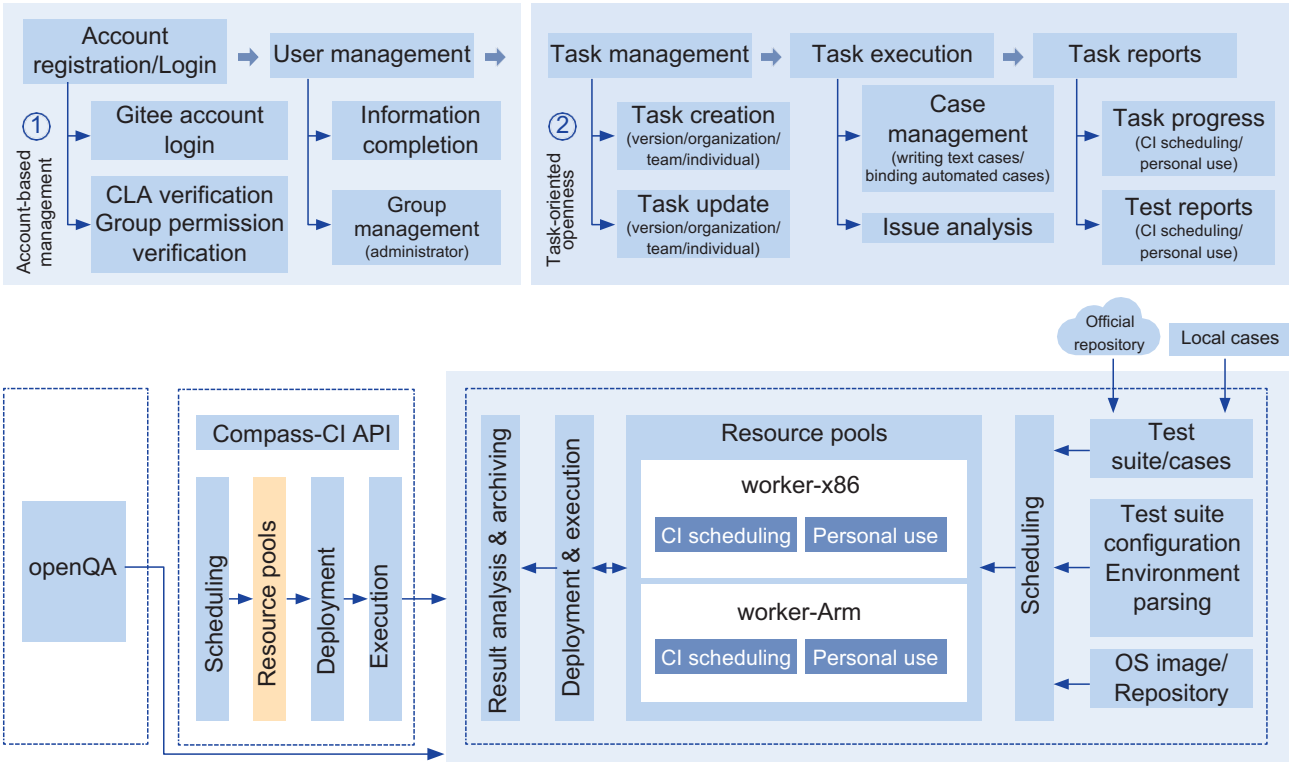
- Incremental/Full build: Analyzes the impact of the changes to software and dependencies, obtains the list of packages to be built, and delivers parallel build tasks based on the dependency sequence.
- Build dependency query: Provides a software package build dependency table in a project, and collects statistics on software package dependencies.
- Layer tailoring: Customizes build projects with SPEC or YAML-based layer models to create patches, build and installation dependencies, and compilation options for software packages.
- Image tailoring: Developers can configure repositories to generate ISO, QCOW2, and container OS images, and tailor the list of software packages for the images.

- Local task reproduction: Reproduces a build task locally using commands, facilitating build issue location.
- Easy project creation: Creates projects based on YAML configurations and adds packages in batches, greatly simplifying user operations.

With EulerMaker, financial industry users can quickly build their own OSs from source code to software packages and then to OS images based on their requirements. EulerMaker can create images in a range of formats to support various scenarios.

EulerTest

The EulerTest management platform carries end-to-end test activities in the openEuler community. Its key component is the web-based data mid-end, which streamlines testing and makes community version tests traceable. It also provides plugins for resource management and automated testing, enabling integration with multiple test engines.



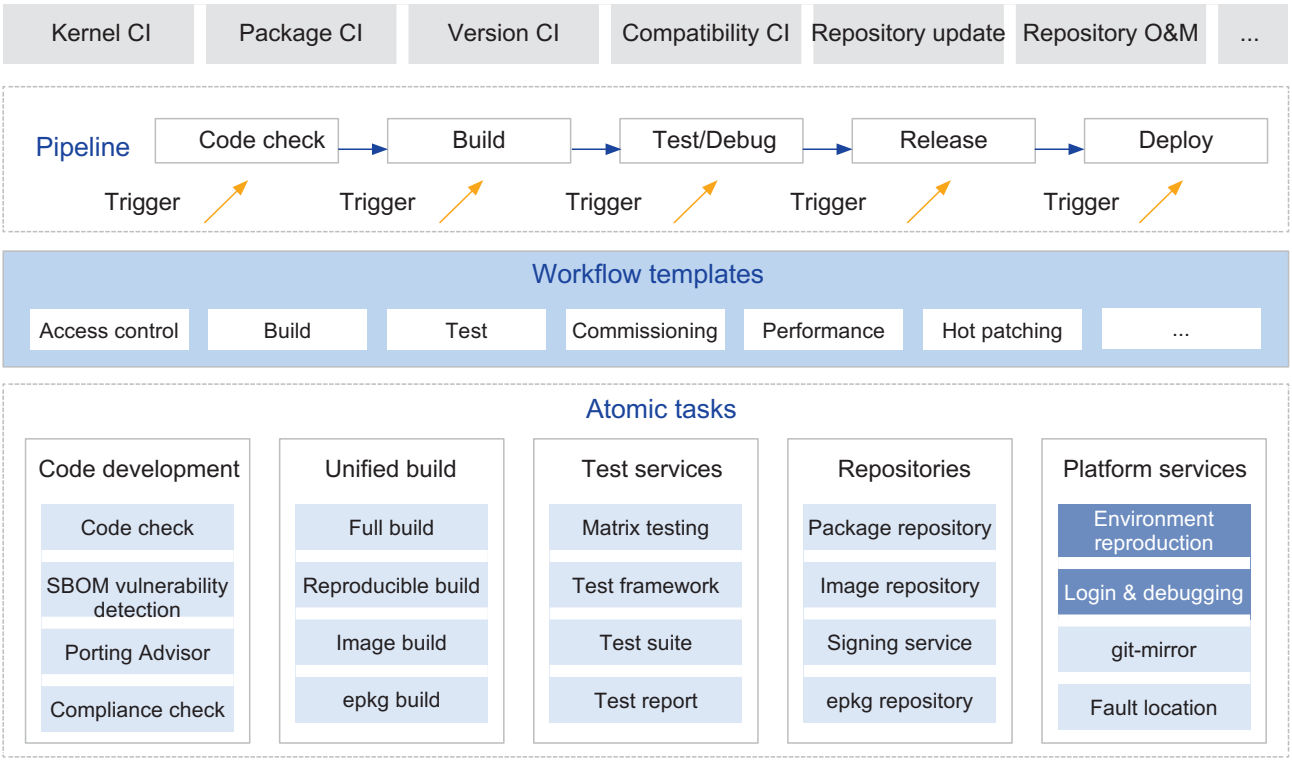
Feature Description

- Static resource management for PMs, including key change, resource occupation and release, and system reinstallation
- Dynamic resource management for VMs, including hot modification of NIC and drive configurations and a web console
- Text case data management, version case baseline formulation, and case review
- Product and milestone data management, data synchronization with Gitee's code repositories, quality dashboards, and trusted tests
- Test task data management, automated testing triggering, and IT-based management of manual test cases. Log splitting, analysis, and labeling by test step
- Automatic reading of the execution result matrix from platforms such as openQA and Compass-CI, and generation of a version test report based on the specified template of the community

Financial industry users can use EulerTest to verify their self-deployed test OS images and obtain test result reports, which realize traceable tests and ensure high-quality OS releases.

EulerPipeline

EulerPipeline is designed for community developers to build multi-architecture and high-quality source code and binary repositories. EulerPipeline supports six templates: Package-CI, Code-CI, Repo-CI, ISO-CI, single-package test-CI, and version test-CI. It implements on-demand orchestration of templates and tasks, and provides more than 40 atomic SaaS services, simplifying OS and software package development. It also supports pipeline orchestration, matrix testing, environment reproduction, and joint commissioning.



Feature Description

- Pipeline orchestration: Allows pipeline customization and orchestration using domain-specific languages (DSLs).
- Matrix testing: Allows single declaration, multiple combinations running in parallel. A matrix summary view is provided to help learn the running results of multiple OSs and architectures at a glance.
- Environment reproduction: Enables users to log in to the reproduction environment through a web console for commissioning and allows users to use their own terminal software to log in to the reproduction environment using the public key.
- Joint commissioning: Allows multiple users to share a terminal in the web console provided by the pipeline service.

With EulerPipeline, users can quickly invoke build, test, and other internal systems through simple configurations, and add test suites to facilitate access to existing systems. In addition, EulerPipeline can be triggered by external events or scheduled tasks, improving end-to-end development efficiency.

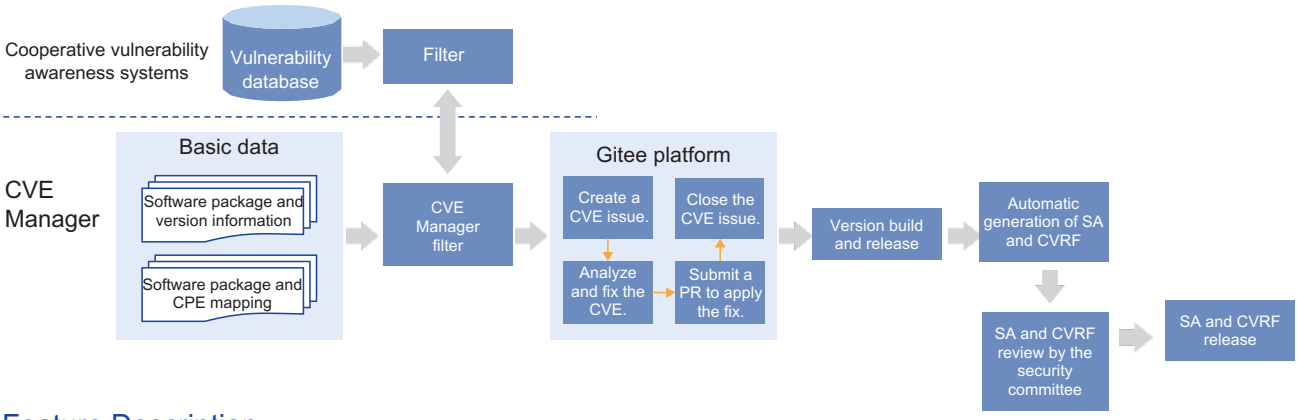
CVE Manager

Vulnerability management is a general term for the processes, tools, and mechanisms used by the openEuler community to detect, collect, handle, and disclose security vulnerabilities.

CVE Manager obtains public vulnerability awareness information from cooperative vulnerability awareness systems, and ci-bot creates and maintains vulnerability records in software package repositories on Gitee. After vulnerabilities are fixed, it starts the general version build and release process and then the security advisory release process.

openEuler uses CVSS v3 for vulnerability scoring.

For the security of openEuler users, the openEuler community will not discuss, confirm, or disclose any security issues until related vulnerabilities are investigated and fixed and security advisories are issued.



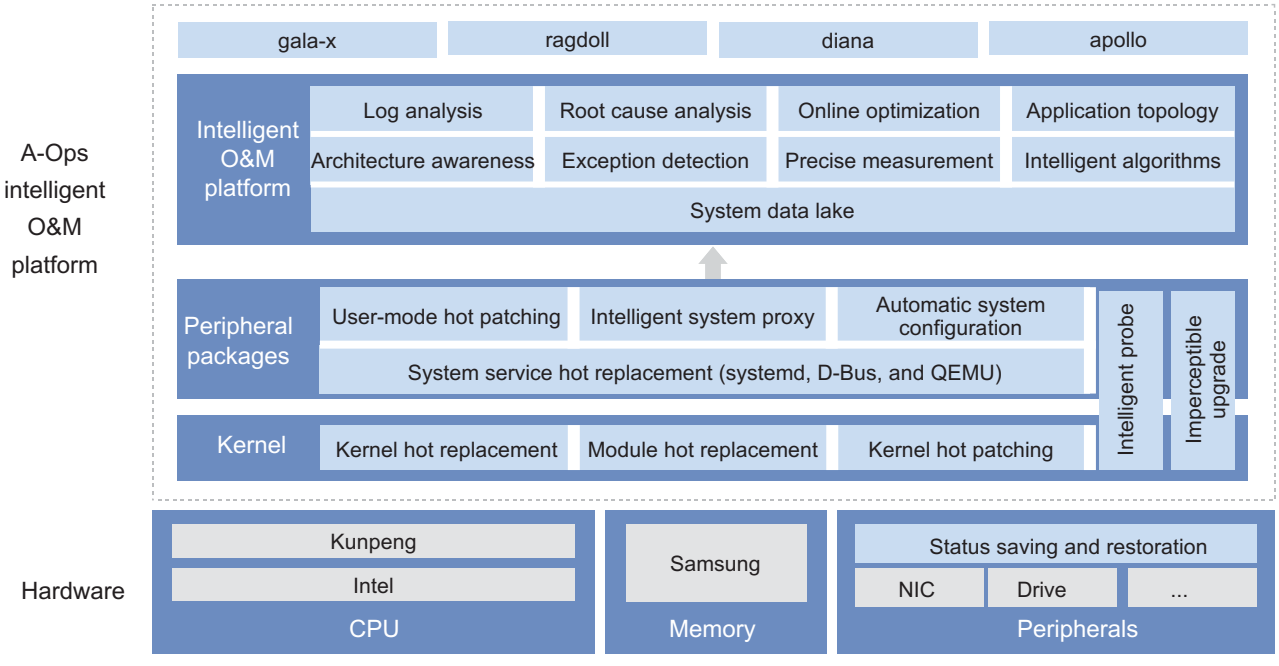
Feature Description

- Security advisory: A security advisory contains information related to a vulnerability, including the technical details, CVE ID, CVSS rating, severity, affected versions, and fixed versions.
- Subscription by email: The community also provides security advisories in CVRF format.

With CVE Manager, financial industry users can quickly and accurately obtain security vulnerability details, CVE IDs, and CVSS ratings of software in the current system, and fix risky vulnerabilities in a timely manner to ensure secure and stable running of the system.

A-Ops

A-Ops is an intelligent O&M platform that covers data collection, health check, and fault diagnosis and rectification.



A-Ops software architecture

The A-Ops project includes the following sub-projects: fault detection (gala), fault location (X-diagnosis), and vulnerability rectification (apollo). The following describes the sub-projects:

- gala: gala utilizes a non-intrusive observation technology based on the eBPF + Java agent and provides intelligent assistance to diagnose sub-health faults, such as performance jitter, increased error rate, and slow system response.
- X-diagnosis: X-diagnosis is an O&M suite for Linux, providing fault location, system exception inspection, and enhanced ftrace functions.
- apollo: The apollo project is an intelligent patch management framework. It provides real-time inspection of CVEs and bugs and cold and hot patching, in order to implement automatic discovery and zero-interruption bug fixing.
- ragdoll: More than 50% of OS faults are caused by incorrect configurations. ragdoll can monitor system configurations to detect real-time configuration changes and quickly locate incorrect configurations.

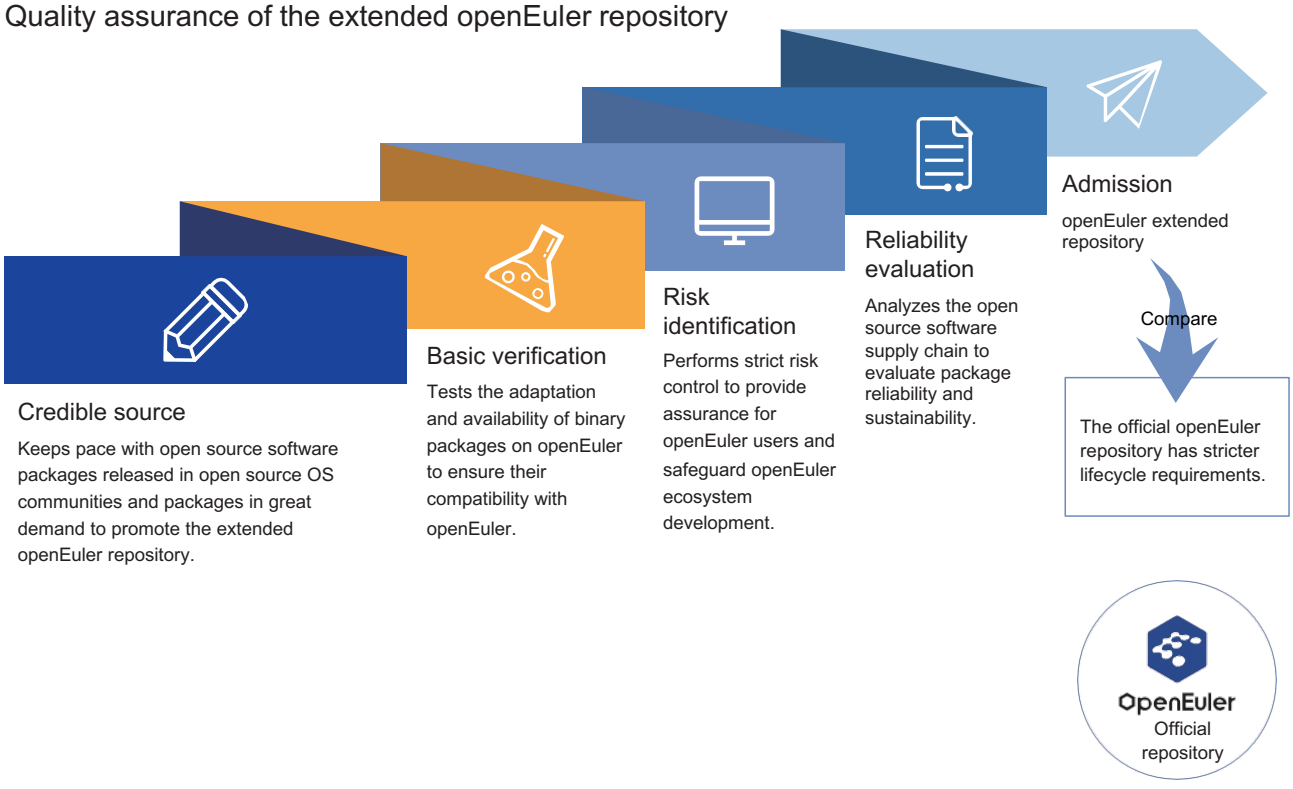
A-Ops is applicable to openEuler and other Linux distributions in database, distributed storage, virtualization, and cloud-native scenarios. A-Ops provides full-stack monitoring capabilities for users in industries such as finance, telecom, and Internet to diagnose sub-health faults, and promptly checks configuration errors caused by manual operations in cluster scenarios. In addition, A-Ops manages cold and hot patches in a unified manner to streamline patch management and directly provides hot patches for high-severity kernel CVEs to prevent the system from being restarted when dealing with emergent kernel issues.

A-Ops has passed POC tests of customers. It is compatible with multiple openEuler commercial releases and applies to a wide range of core banking service scenarios. Through end-to-end observation and intelligent fault analysis, the solution enables fault demarcation in core banking services to be completed in just minutes. It represents a step towards the greater goal of fault detection within 1 minute, demarcation within 5 minutes, and rectification within 10 minutes.

Official and Extended Repositories of openEuler

The openEuler ecosystem provides more than 30,000 source packages and millions of binary packages. It provides compatible software packages, file query, download, and reliability evaluation of open source software packages for developers, OSVs, and enterprises who migrate from CentOS, Fedora, or other OSs to openEuler.

Quality assurance of the extended openEuler repository



Feature Description

- For developers: Provides a platform for quickly introducing software packages and building RPM packages for upstream projects.
- For common users: Supports command-based search for software packages compatible with openEuler.
- For enterprise users: Provides a one-stop platform for detecting open source software activeness, compliance, and vulnerabilities.
- For enterprise users: Provides closed source software distribution channels to support direct access to enterprise software.

The official and extended repositories of openEuler provide a platform for enterprise developers to detect open source software vulnerabilities, ensuring compliance. In addition, the closed source software distribution capabilities allow enterprise software to be directly distributed to users.

6.3 Service Capability Standards

Basic Services

Service	Requirement	Result
Installation and deployment	• Cover mainstream deployment modes, including PMs, VMs, and containers. • Support mainstream hardware such as x86- and Arm-based hardware, and install required drivers during OS installation. • Support the setting of the user name, password, language, time and time zone, partitioning, and network. • (Optional) Batch install the OS if the network environment allows it.	• Qualified: User feedback describes the installation and deployment as "qualified", and the following criteria are met: - The installed OS can be powered on/off, remotely connected, and logged in. - The OS can identify and use connected hardware devices, such as the CD-ROM drive, RAID controller card, and NIC. - After the installation is complete, the CPU, memory, and drive I/O usage is normal (in the idle state, the resource usage does not exceed the minimum hardware/virtual resource specifications given in the installation guide). Common operation commands are available. - The OS supports test software installation. - Login options (CLI or GUI) can be selected as required. • Unqualified: User feedback describes the installation and deployment as "unqualified" and/or the above criteria are not met.
Migration and upgrade	• Provide compatibility check methods and tools to identify the compatibility of hardware, basic libraries, and applications. • Handle hardware and OS compatibility differences. If the application software is incompatible with the target OS interface, adapt the application software. If any dependency package is missing, assist users in searching for dependency packages in the community or introducing open source software to community repositories. • Execute migration or upgrade tasks. Task rollback is supported if an exception occurs during the process, including but not limited to rollback using the upgrade tool, snapshot, or other backups. • Inspect the target OS after the migration.	• Qualified: User feedback describes the migration and upgrade as "qualified", and the following criteria are met: - Application dependency compatibility differences are identified before the migration. - After the migration, inspection procedures (determined by the service provider and the user) are performed on the target OS. - Applications adapted to the target OS can be started properly after the migration. • Unqualified: User feedback describes the migration and upgrade as "unqualified" and/or the above criteria are not met.
Diagnosis and analysis	• Fault demarcation: Diagnose and analyze faults and determine whether the faults are related to the OS. • Fault location: Analyze the root cause of OS faults. • Fault rectification solutions: Propose solutions based on the fault location results and provide precautions for the rectification. • Methods and tools: Provide log collection methods and tools. It is recommended that diagnosis and analysis methods and tools be provided. If remote access is required, obtain the user's written consent and account, and use an access tool agreed by both parties. • Response time: Respond promptly to issues, which are classified by severity (for example, warning, minor, major, and critical).	• Qualified: User feedback describes the diagnosis and analysis as "qualified", and the following criteria are met: - OS faults can be demarcated and located based on user requirements. - Workarounds or temporary solutions can be provided to recover services. - Suggestions on the solution can be provided to assist the user in preventing services from being affected. - The troubleshooting SLA complies with the service commitment or the time specified in the service contract. • Unqualified: User feedback describes the diagnosis and analysis as "unqualified" and/or the above criteria are not met.

Service	Requirement	Result
Patch update	• Periodically push vulnerability, bug, and patch information. • Provide corresponding patches with high availability. • Analyze patch compatibility. • Provide patch update or upgrade guide. • Provide patch rollback methods. • (Optional) Apply patches based on the user's network security requirements.	• Qualified: User feedback describes the patch update as "qualified", and the following criteria are met: - Timely notification of security vulnerability information is achieved in accordance with the agreement. - The patch programs are trusted, complete, and not tampered with. - After patching, the OS and applications are running properly, and no function problem occurs. - The bugs or vulnerabilities are fixed after patching. • Unqualified: User feedback describes the patch update as "unqualified" and/or the above criteria are not met.

Note: Migration and upgrade refer to either migration from a third-party OS (subject to user requirements) to openEuler or upgrade of openEuler versions.

Advanced Services

Service	Requirement	Result
Performance tuning	• Analyze performance bottlenecks. • Provide tuning guide and suggestions. • (Optional) Provide tuning tools or scripts. • Implement the tuning procedure. (Only OS tuning is covered. If application tuning requires OS analysis, assist the user in application tuning.)	• Qualified: User feedback describes the performance tuning as "qualified", and the following criteria are met: - System performance: After tuning, the system performance in stable running state is significantly improved (which can be evaluated by a pressure test tool or service volume). For example, the program startup and response speed meets the expectation. - Stability: After tuning, the system is stable. No new exception, such as a crash or breakdown, is introduced. - Security: After tuning, the system is secure. No new security vulnerability is introduced, and no system data and information is disclosed. • Unqualified: User feedback describes the performance tuning as "unqualified" and/or the above criteria are not met.
Security check and hardening	• Vulnerability check: Scan the OS to identify potential vulnerabilities and provide rectification suggestions. (Optional. Generally, the user purchases services of a third-party security vendor for scanning.) • Configuration check: Audit OS configurations, including user permission settings, account management, and network configuration. Provide rectification suggestions on detected non-compliant configuration behavior to reduce system attack risks. • Configuration hardening: Formulate system security policies based on user requirements, including password, security audit, and access control policies, to enhance system security. • Batch operations: Provide tools or scripts for batch security hardening. • Security patching: Provide security patches to reduce the impact of known attacks. • Intrusion detection and prevention: Deploy an intrusion detection and prevention system. If the user has purchased professional detection software, assist the user in deploying the software in the OS. If no such software is available, provide basic detection and prevention services, such as iptable configuration and audit configuration, to detect and prevent malicious attacks and improve system security. • Hardening verification: Cooperate with the user to check whether the hardening items affect the running of existing services. If they do, instruct the user not to implement the hardening items, or else to modify the services.	• Qualified: User feedback describes the security check and hardening as "qualified", and the following criteria are met: - Check scope: The security check service can identify all released vulnerabilities (subject to those released in the CVE database of the community) and security risks (optional. Generally, the user purchases services of a third-party security vendor for scanning). - Vulnerability fixing: Vulnerabilities that have available patches can be fixed within the vulnerability fixing scope agreed with the user (the scope is negotiable for vulnerabilities that are not serious or conflict with service applications). - Security policies: The system has comprehensive security policies, including access control, identity authentication, and data protection. These policies are adjustable to adapt to various situations and need to be audited and updated periodically. - Report and feedback: Detailed reports and suggestions are provided to help the user learn about the system security status and rectify detected faults. • Unqualified: User feedback describes the security check and hardening as "unqualified" and/or the above criteria are not met.

Service	Requirement	Result
Health check	• Resource bottleneck check: Check the CPU, memory, drive, and network of the OS to identify potential bottlenecks where resource utilization reaches 100% or user-defined limits. • Log check: Scan and analyze system logs, detect exceptions, and provide handling methods. • File system check: Verify the health and integrity of the file system and detect and repair any file damage or errors. • Hardware detection: Monitor hardware alarms and driver exceptions at the OS level.	• Qualified: User feedback describes the health check as "qualified", and the following criteria are met: - Comprehensive check scope: All relevant devices, areas, and systems are examined. Each item is thoroughly checked and recorded to ensure complete coverage. - Complete check records: Issues and exceptions identified during the health check and corresponding handling measures are recorded in detail. Results are accurately and comprehensively documented, to aid future tracking and analysis. - Informative reports and feedback: Detailed reports are generated to provide users with insights into the system's health and actionable recommendations on how to address detected issues are offered. • Unqualified: User feedback describes the health check as "unqualified" and/or the above criteria are not met.
Special assurance	Provide enhanced assurance for critical events: • Proactive check: Assess, check, and inspect the OS infrastructure to identify potential risks and vulnerabilities. • Risk elimination: Address risks through patch updates, configuration adjustments, security hardening, and other measures. • Critical assurance: Provide dedicated support during public holidays (such as the Spring Festival, Christmas, and New Year's Day) and other special events, ensuring real-time response to issues and efficient problem resolution. • Emergency preparedness: Provide emergency plans, conduct emergency drills to simulate real-world scenarios, and implement effective emergency recovery strategies for major incidents.	• Qualified: User feedback describes the special assurance as "qualified", and the following criteria are met: - Comprehensive check reports: Detailed check assessment reports and a list of problems and risks of the OS infrastructure are delivered. - Rigorous emergency drills: Emergency drills for key events are conducted and expected objectives are achieved, meeting assurance requirements. - Thorough test assessment: Detailed function and load test reports are provided, covering the system's performance under estimated activity traffic loads. - Ongoing assurance: The system's running status is monitored, issues are promptly detected and addressed, and technical support and emergency troubleshooting are provided. • Unqualified: User feedback describes the special assurance as "unqualified" and/or the above criteria are not met.

Consulting Services

Service	Requirement	Result
Solution planning	• System evaluation: Evaluate user requirements and existing systems to identify systems suitable for upgrades and those requiring replacement. • Version selection: Select appropriate OS versions based on service requirements and the evaluation results of the existing infrastructure.	• Qualified: User feedback describes the solution planning as "qualified", and the following criteria are met: - Function and performance: The OS solution planning and design provides a stable and efficient OS environment that meets all service requirements. - Security: The OS solution planning and design features robust security measures, including data protection and network security. - Maintainability and scalability: The OS solution is planned and designed for easy management and maintenance and high scalability to accommodate future upgrades and enhancements. - Costs: The OS solution planning and design is cost-effective and within budget constraints. - User experience: The OS solution planning and design focuses on user experience, ensuring an OS environment that is easy to use and manage. • Unqualified: User feedback describes the solution planning as "unqualified" and/or the above criteria are not met.
Technical consulting	A team of experienced OS experts, effective processes, and advanced technologies are employed in delivering the technical consulting service. We answer specific questions related to OS development, deployment, operation, and O&M, and provide technical guidance and reference documents.	• Qualified: User feedback describes the technical consulting as "qualified", confirming that our technical consulting has successfully addressed their needs and answered their questions to their satisfaction. • Unqualified: User feedback describes the technical consulting as "unqualified" and/or the above criteria are not met.

Training and Certification Services

Service	Requirement	Result
Training and enablement	• Training course design: Design training courses that align with user requirements, addressing the unique needs of different positions, skills, and knowledge levels. • Trainer team building: Assemble a team of trainers with rich practical and teaching experience. • Training execution and management: Organize, coordinate, arrange, and evaluate multiple aspects of training delivery, including class scheduling, attendance tracking, and evaluation of training effectiveness. • Training environment building: Create an immersive learning environment by providing modern classrooms, advanced equipment, and reliable networks. • Follow-up services: Provide comprehensive post-training support, including question answering and training certificate issuance, to reinforce learning and skill retention.	• Qualified: User feedback describes the training and enablement as "qualified", and the following criteria are met: - The training courses cover multiple aspects essential for OS training and certification, including fundamental knowledge, installation and configuration, system administration, troubleshooting, network and security, and practical exercises. - The training program, employing sound pedagogical methods and catering to trainees' requirements, provides online learning platforms, comprehensive learning materials, and interactive learning experiences. - Trainees provide positive feedback, highlighting the practical applicability of the knowledge and skills acquired through the training program. • Unqualified: User feedback describes the training and enablement as "unqualified" and/or the above criteria are not met.
Evaluation and certification	• Skill evaluation: Evaluate trainee performance through exams, practices, and presentations (not all forms are required) when the training is over. Successful trainees will receive corresponding certifications. • Tiered certification: Implement a tiered certification system, such as junior, intermediate, and advanced levels, or other similar levels. • Specialized certification: Offer specialized certifications in various fields, including system administration, deployment and migration, and system O&M.	• Qualified: User feedback describes the evaluation and certification as "qualified", confirms that the evaluation method is fair and transparent, and designed to accurately assess trainee mastery of the course materials. • Unqualified: User feedback describes the evaluation and certification as "unqualified" and/or the above criteria are not met.

Version Customization Service

Service	Requirement	Result
Version customization	• Software package optimization: Streamline the OS by removing unnecessary software packages to enhance system performance and security. • Preset configuration: Customize the OS with preset parameters and service start/stop status to meet specific user needs. • Secondary development: Customize the OS based on user needs, including adding specific functional modules (such as drivers), changing some default components (such as graphics and compression software), or adding specific applications (such as antivirus software). • Media packaging: Package the preceding customized configuration into media like CDs, VM images, and container images.	• Qualified: User feedback describes the version customization as "qualified", and the following criteria are met: - Functionality: The OS fulfills user requirements and can complete required tasks. - Reliability: The OS is stable and reliable, operating without breakdowns or other faults for a long time. - Security: After the OS is customized, effective security measures are put in place, including measures to prevent unauthorized access and data leakage. - Performance: The OS meets user's read/write performance and latency requirements. • Unqualified: User feedback describes the version customization as "unqualified" and/or the above criteria are not met.

Multi-Channel Support

Service	Requirement	Result
Multi-channel support	• Offer a variety of support channels to cater to different user preferences, including email, WeChat, phone, and onsite support. • Provide remote support through multiple channels, such as the TAC hotline, website, WeChat official account, and public mailbox. • Provide onsite technical support from experts of different levels to address specific needs. • Provide extended onsite support from experts of different levels for a minimum of one week. • Establish clear response time requirements for different support channels.	• Qualified: User feedback describes the multi-channel support as "qualified", and the following criteria are met: - Reliable and stable channels: Channels operate reliably, ensuring quick responses to user inquiries and a smooth interaction experience. - High-quality service: Different service channels have distinct quality standards. For example, online customer service requires swift, accurate responses and strong problem-solving capabilities, while telephone customer service requires clear communication and a positive attitude. • Unqualified: User feedback describes the multi-channel support as "unqualified" and/or the above criteria are not met.

Multi-Language Support

Service	Requirement	Result
Multi-language support	Offer services in multiple languages to accommodate users from different linguistic backgrounds.	• Qualified: User feedback describes the multi-language support as "qualified", and the following criteria are met: - Comprehensive support in English and Mandarin Chinese - Support for specific languages like Portuguese and Russian, as required by specific service scenarios • Unqualified: User feedback describes the multi-language support as "unqualified" and/or the above criteria are not met.

Service Recording

Service	Requirement	Result
Service recording	The service provider records essential service information, including but not limited to the following: • Service initiation time • Service initiator • Service start time • Service personnel • Service type • Service completion time • User contact person • Service process information, including call recording, emails, information submitted to webpages, information input and transmitted in mobile terminal applications, service support personnel information, onsite service reservations, service start/end time, and locations. • Service result	The service provider shall keep service records in accordance with the following regulations: • Service records can be stored in paper or electronic format. • Service records must be retained for a minimum of three years. • Authorized users can query service records.

Service Condition Restrictions

Conditions of Service Denial	Service Denial Procedure
The service provider may deny a service request under the following circumstances. • The requested service violates the laws of the country or region where the user is located. • The requested service conflicts with the mainstream social values of the country or region where the user is located. • The requested service may lead to improper exposure of citizens' private data. • The requested service may cause the following damages to the security of the entire or some components of the OS, including: - Disabling, blocking, or uninstalling security components - Bypassing encryption algorithms or channels - Exposing user account names, passwords, keys, signatures, and more information • The user requires the introduction of hardware that may cause information security risks. Such hardware may include: - Unauthenticated flash memory - Unauthenticated network connections - Unauthenticated storage servers - Unauthenticated network storage - Unauthenticated electromagnetic devices and environments • The user requires the introduction of software components that may cause information security risks. • The user requires the opening of network ports that are not essential for the services and may cause information security risks. • The user requires an OS version that has reached the end of its lifecycle. • After service delivery, the user modified the source code of OS components or applications without prior consultation with the service provider, leading to system failure or damage. • Hardware and application software issues that are not caused by the OS occur. • The user obtains free distributions from non-official images or unauthorized images or raises a service request beyond the valid service period.	If a service is denied, the service provider should follow the procedures below: • Onsite services: The denial of a service should be explained verbally to the user at the location. The reasons for denial should be clearly communicated and documented. Additionally, an email or paper document explaining the denial should be provided to the user either onsite or shortly thereafter. • Remote services: Denied items and the reasons for denial should be clearly explained in an electronic reply or through a voice call. The entire process of the voice call must be recordable.

07

Talent Ecosystem Development

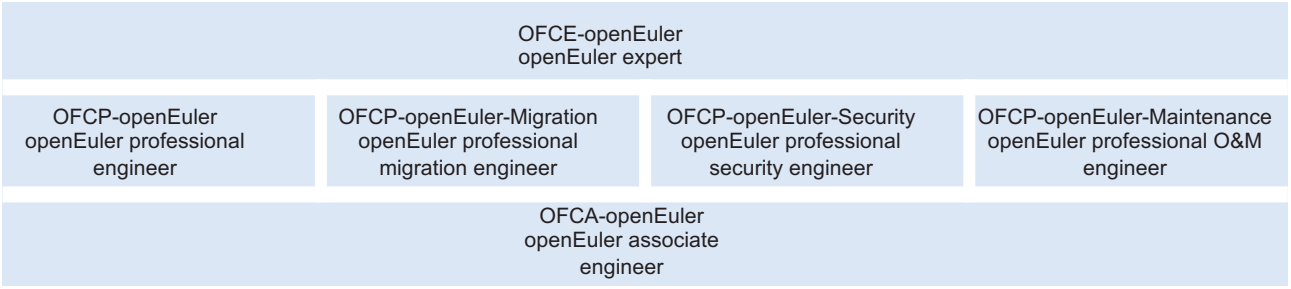
In today's fast-paced digital era, the financial industry, as the core of the economy, is undergoing profound changes. openEuler OS is increasingly being adopted in the financial sector, and the development of a talent ecosystem is becoming an urgent imperative.

7.1 openEuler Community Talent Certification

Industry development hinges on talent. openEuler is making rapid strides in the financial sector, and there is an urgent need for professionals who are skilled in openEuler.

Talent Development System

The openEuler Talent and Services SIG, responsible for talent certification within the openEuler community, has contributed to the formulation of the *Open Source Talent Evaluation Standards* jointly initiated by the Ministry of Industry and Information Technology and the OpenAtom Foundation. In collaboration with the OpenAtom Foundation, openEuler has also co-released the *openEuler Course Contribution Agreement* and *openEuler Course License Statement*. In order to standardize the talent evaluation process, openEuler has established and published the *openEuler Talent Evaluation Standards* and *openEuler Partner Qualification Requirements for Talent Evaluation*. Taken together, these publications amount to a talent system framework that spans from OFCA to OFCP to OFCE.



Talent Development Approaches

Talent certifications

Through systematic courses or training programs, individuals can take certification exams and obtain professional certification. By taking courses of varying difficulty levels, they can continually build their expertise in openEuler.

Open source contests

Contests offer platforms for engaging with cutting-edge technologies, selecting outstanding talent, showcasing innovative achievements, facilitating commercial transformation, and promoting exchange and collaboration in the open source field. They also help promote projects and improve open source skills.

University talent training programs

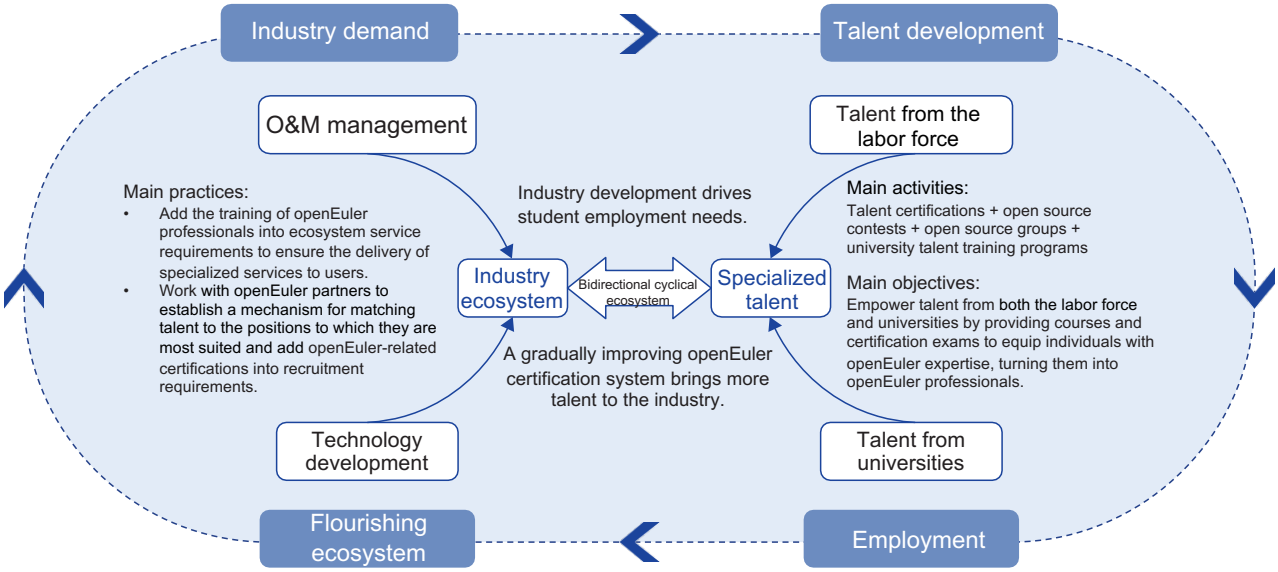
New paths for industry-education collaboration offer university students a larger platform for hands-on experience. For instance, a university's dedicated open source group can stimulate students' interest in open source and encourage them to make their contributions to open source projects.

University technical groups

openEuler technical groups are set up in universities, allowing students to learn, research, and contribute to the community centered around openEuler. In addition, openEuler and its partners provide resources to empower these groups in their learning and research activities.

Industry-Education Collaboration

Industry-education collaboration can be conceived of as one large cycle containing two smaller cycles. The two smaller cycles involve the development of industry and the cultivation of talent. Industry growth drives the demand for an educated workforce, and a well-established talent system brings more professionals into the industry, creating a self-sustaining ecosystem. This in turn accelerates the large cycle. Industry demands drive talent development, and once talent is trained, they enter the industry, spurring further ecosystem growth and further boosting industry development.



7.2 Huawei Career Certification and the University Talent Ecosystem

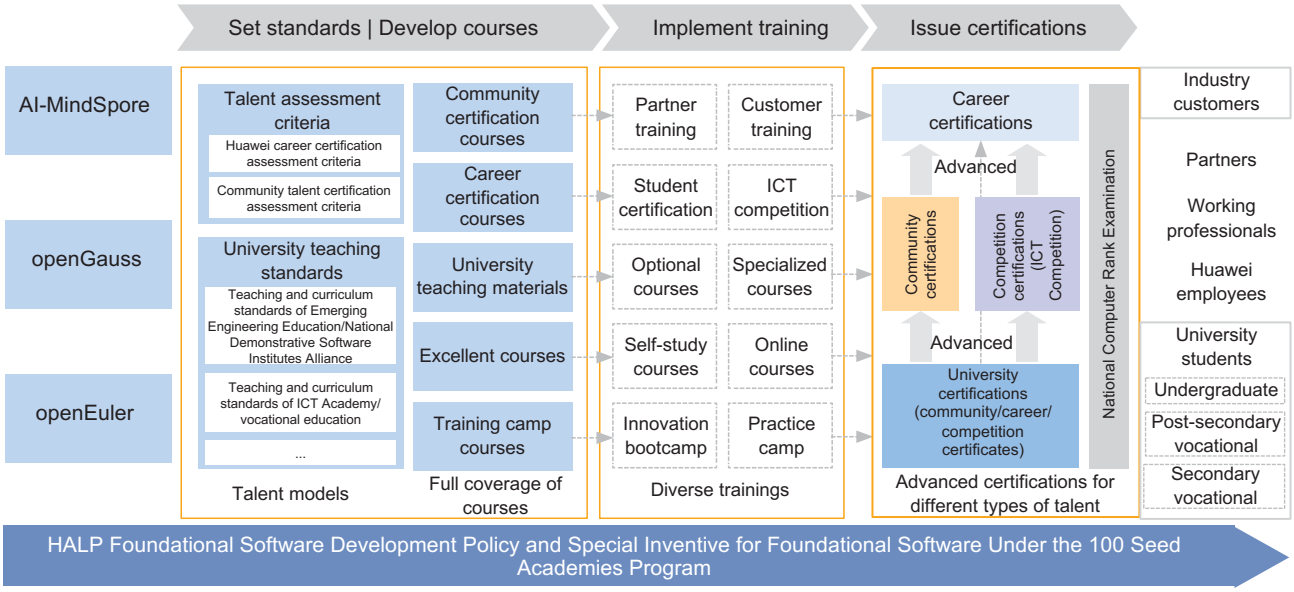
As an important member of and key contributor to the openEuler community, Huawei has been actively promoting the development of the talent certification system. Huawei's HCIA-HCIP-HCIE (HCIX for short) career certification system provides a standardized path for the training and advancement of openEuler talent in the financial industry. HCIX covers a wide range of specialized knowledge, with a strong emphasis on assessing the understanding and application of the openEuler operating system. Through this system, professionals in the financial industry can clearly assess their skill levels in openEuler and identify areas for improvement and further learning.

openEuler Certification - Knowledge, Skills, and Scenarios and Competency

	Knowledge	Skills	Scenarios and Competency
HCIE-openEuler	• Ceph management • Advanced Kubernetes • Advanced automation management and CI/CD • OpenStack cluster management • Log management system EFK • Intelligent O&M platform A-Ops	• Planning, design, installation, deployment, and maintenance of cloud computing and cloud-native computing platforms based on openEuler or migrate existing cloud platforms to openEuler.	• Be able to install, deploy, and maintain cloud storage Ceph, cloud OS OpenStack, and cloud-native platform Kubernetes, as well as use advanced features of automation management and understand O&M monitoring and log management of cloud computing. • Be a competent SRE engineer or cloud architecture expert.
HCIP-openEuler	• LAMP/LNMP architecture • Application cluster deployment • Linux security management • Automation management	• Creation, management, and maintenance of basic environments for enterprise-level applications running on openEuler.	• Be able to conduct LAMP/LNMP application cluster deployment, automatic management with Ansible or SaltStack, and system monitoring. • Be a competent senior Linux debugging engineer, senior Linux administrator, or enterprise application architect.
HCIA-openEuler	• openEuler user management • openEuler network management • openEuler permission management • openEuler storage management • Shell script basics	• Basic operations and management of core operating systems in enterprise data centers.	• Be able to perform basic operations and management of core operating systems in enterprise data centers. • Be a competent Linux system O&M engineer.

Setting clear goals and standards is the compass that guides all actions. Before establishing the openEuler career certification system, it was essential to specify the certification objectives and positioning. To this end, the "2-1-1" talent development framework (2 – setting standards and developing courses; 1 – implementing training; 1 – issuing certifications) is created.

2-1-1 architecture, a comprehensive talent development solution for foundational software



"Setting standards" is the first key step. The talent skill standards should be tailored to meet the unique needs of the financial industry while considering the specific characteristics of openEuler. The standards should cover both the basics and architecture of the operating system, as well as the practical skills required in scenarios such as financial transaction systems and risk management.

"Developing courses" is an in-depth extension based on the established standards. Focusing on openEuler, a series of comprehensive courses within the Huawei HCIX system helps students deepens their knowledge. The courses cover basic operations, system optimization, and security configuration. For example, one course may focus on performance optimization strategies for openEuler in high-concurrency financial transaction environments and explain how to use its security mechanisms to ensure financial data security.

After multiple rounds of refinement since the initiation of the openEuler career certification courses, we now have released dozens of courses across HCIA-openEuler, HCIP-openEuler, and HCIE-openEuler, along with corresponding lab manuals and setup guides. These courses provide robust resources for cultivating top-tier foundational software experts. On April 19, 2024, a teacher from Shanghai passed the HCIE-openEuler exam, becoming the world's first HCIE-openEuler expert. This marks the beginning of the openEuler expert-level talent ecosystem.

"Implementing training" brings these courses to life. University teaching staff play a key role in talent development, acting as evangelists. By increasing investment in professional training for teachers, we are building a team of openEuler experts who will inspire and mentor students, helping to cultivate more openEuler professionals to benefit the industry. As of June 2024, more than 30 training sessions had been organized, covering 500+ universities, training 1,200+ teachers, and influencing 2,300+ HCIA-openEuler certified individuals.

The openEuler community also organized training for partners in the financial sector, including National Financial Regulatory Administration, Zhongtai Securities, and CM Financial Technology. These trainings cover major focuses in the financial industry, such as system migration, image building, and AI assistants, fostering the development of professionals with the critical capabilities needed to support the adoption of openEuler's in the financial sector.

No.	Company	Time
1	CM Financial Technology	January 2024
2	CM Financial Technology	March 2024
3	Zhongtai Securities	April 2024
4	National Financial Regulatory Administration	May 2024
5	Kunpeng DevFest · Guangdong	July 2024
6	Golden Seed in Shanghai	August 2024

The development of openEuler talent ecosystem in the financial industry is a systematic effort. Through the career certification systems led by key contributors like Huawei's HCIX, and with the joint efforts of financial enterprises, industry associations, and open source communities, we are building a highly skilled talent pool. This talent foundation will ensure the widespread adoption of openEuler in the financial industry, driving the digital transformation of the financial industry.

08

Future Outlook and Recommendations

8.1 Accelerating the Improvement of the Open Source Ecosystem

The openEuler community will focus on the adaptation of upstream and downstream applications, attract more third-party vendors and developers to join the adaptation and integration efforts, and enrich openEuler's hardware and software ecosystems. By deepening cooperation with major software and big data vendors, the community will promote widespread certification and joint testing, gradually building an ISV ecosystem that covers a broad range of industry applications and fostering a more open technical collaboration environment. In response to the special requirements of the financial industry, openEuler encourages various industry participants to jointly develop more adaptable solutions and share achievements that simplify the adoption of open source operating systems. In addition, simpler adaptation processes and faster dissemination of innovations will improve the application efficiency of open source operating systems in financial scenarios. This will drive both technical innovation and ecosystem improvement, contributing to the flourishing of the open source software industry.

8.2 Ongoing Technological Innovation

In the future, innovation efforts will focus on intelligent system O&M and automated management, with the goal of improving overall performance and stability while addressing bottlenecks in big data processing and high-concurrency I/O scenarios. For example, by integrating cutting-edge technologies such as AI-driven O&M optimization and intelligent fault diagnosis, systems will have stronger self-diagnosis and self-repair capabilities. By leveraging machine learning and big data analysis, systems can automatically detect potential faults and performance bottlenecks and rectify them in the background, significantly reducing the dependency on manual intervention and improving O&M efficiency. In addition, technological innovation will enable systems to achieve higher adaptability in complex and dynamic operating environments. This will allow systems to adjust resource allocation flexibly in response to diverse service requirements and emergencies, ensuring continuous and efficient operations. Through these measures, financial institutions will be able to further optimize IT infrastructure management, improve service quality, and support ongoing service expansion.

8.3 Deeper Integration of Emerging Technologies

The widespread use of big data, cloud computing, and AI by financial institutions has posed higher requirements and challenges to server operating systems. These systems need to be improved in terms of performance optimization, distributed architecture management, real-time capabilities, security, and support for heterogeneous computing. In addition, they should offer seamless support and deep integration of emerging technologies. To meet the increasingly complex service scenarios of the financial industry, the key directions for future development of operating systems will be intelligence, independence, and security. In addition, operating systems need to further optimize compatibility across multiple platforms to ensure the interoperability between heterogeneous systems. By standardizing APIs and interface specifications, the process of porting applications can be simplified, thereby promoting smooth migration and rapid deployment of financial services across different platforms. Support for the integration of emerging technologies will empower financial institutions to take the initiative in technological transformation in this new era, driving the digital transformation of their services.

8.4 Expanding the Talent Base

For some financial institutions, relying on vendors to maintain their operating systems may be more cost-effective than managing them in-house. However, in practice, financial institutions often need to customize and optimize systems according to their specific service requirements. Having internal talent skilled in open source operating systems can accelerate the realization of these needs, help financial institutions maintain bargaining power, and reduce some external maintenance costs. Moreover, in-house talent will generally have a better understanding of the system's underlying architecture and be able to collaborate more effectively with industry partners to quickly implement cross-platform integration and optimization, enhancing overall system performance. Therefore, from the perspectives of long-term security, customization, and reliability, it is necessary to develop open source operating system talent to support the sustainable growth and stable operation of financial software.

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