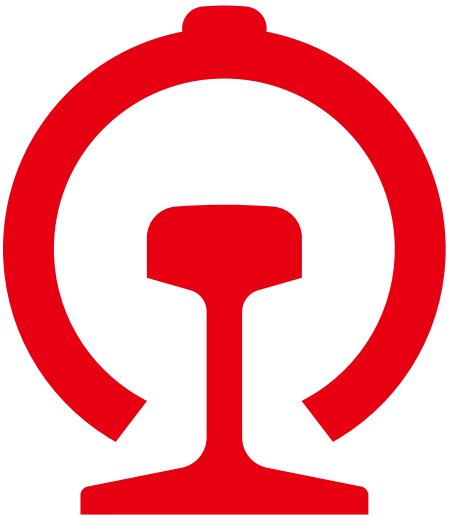
CASE STUDY

China Railway Corporation Builds OpenStack*-based Industrial Cloud to Support Modern Logistics Business Development

With the rapid development of China Railway Corporation (hereafter referred as “China Railway”) in the past two decades, China’s railway mileage in service has reached 124,000 km, of which 22,000 km is high-speed railway as of the end of 2016. This is higher than the total amount of other countries’ high-speed railway mileage combined, ranking China Railway first in the world.



Currently China Railway has already completed the construction of a “four vertical (north-south corridors) and four horizontal (east-west corridors)” high-speed railway network, which makes China the only country in the world to run a high-speed railway network. In addition, 800 billion yuan is invested into railway construction annually, and mid to long-term railway network construction plans have already been laid out for 2030. Moreover, an “eight vertical and eight horizontal” railway network is in plan.

According to a recent interview with China Railway, the booming development of China Railway not only changes the way people travel, but it also changes people’s perspective on time and space. A vast country spanning 5,200 km from east to west and over 5,500 km from north to south, China connects diverse land-forms through its railway, including plateaus, tundra, fields, hills, rivers, and ocean, and it plays a major role in promoting national economy and social integration. In 2016, China Railway’s passenger volume was 2.814 billion people, passenger turnover was 1.25793 trillion passenger-kilometers, freight volume was 3.332 billion tons, and freight turnover was 2.37923 trillion ton-kilometers. These last three indicators alone rank China Railway number one in the world. The train ticket website (WWW.12306.cn) has over 300 million registered users. During the ticket-selling period of 2017 Spring Festival travel rush, it had the highest single daily page view of 42.6 billion, which was about 4 times as much traffic as the daily average page view; daily average login count was more than 50 million, with visitors coming from over 50 countries around the world.

Such a large business scale brings about challenges for China Railway’s IT infrastructures, demanding higher performance, stability, safety, usability, and extensibility. Early on, mainframe systems were once the first choice for China Railway to run mission critical applications; then, to reduce costs, minicomputer systems were deployed in large-scale. Later, mainframe-based applications were gradually migrated into the minicomputer system.

With a wide array of technology and architecture choices before them, ultimately China Railway decided to use OpenStack, an open source platform based on x86, to build its own industrial cloud platform—the China Railway Cloud. As market demands and technology improvements reach maturity together, the path opens for giant corporations like China Railway to adopt solutions like OpenStack. The journey of China Railway’s IT development, moving from mainframe computers to minicomputers, and then into the x86-based OpenStack platform, could be regarded as a typical case study of IT development for China or even for the world, which is constantly evolving to handle the critical business systems of super users.

Not only is China Railway's choice a natural result of technology development, it also reflects the trends highlighted in the "13th Five-Year Plan for Economic and Social Development of the People's Republic of China (draft)", and it meets business and controllable safety requirements. It also allows China Railway to become a pioneer in innovation in the fields of cloud computing, big data, IoT, etc.

Toward the end of 2014, China Railway started developing an open source cloud solution based on OpenStack, releasing the China Railway Cloud OS V1.0 in 2015 and then V2.0 in July 2016 after development, testing, and verification. The private cloud is primary for China Railway, having been deployed on about 5000 physical server nodes, including about 800 KVM nodes and about 730 VMware nodes; 20PB SAN storage; and 3PB distributed storage (Ceph). An additional 2000 physical server nodes are to be deployed toward the end of 2017.

Up to now, OpenStack cloud platform, with a scale of 800 physical server nodes, has been deployed for China Railway's Phase I project; it passes the extreme pressure testing with hosting over 100,000 VMs, and there are more than 1,000 VMs in use on the production system. China Railway deployed a dozen mission critical applications in five major categories on its Cloud OS, including railway passenger and freight transport, scheduling management, locomotive management, and public infrastructure platforms. Application migration and deployment have been fully implemented, enabling production.

One of the goals of the "Belt and Road" initiative is to increase China's connections with other countries around the globe.[1] The booming development of China's railway is leading a global revolution in the transportation industry, drawing the attention of industry leaders everywhere.

Challenges faced

China Railway aims to be a world-class modern logistics company. The enormous scale and the ever increasing passenger and freight volume require solid technical support from China Railway's IT department to satisfy the demands of Internet Plus and digitalization transformation. Their IT infrastructure, with its more efficient, flexible, easy–to-deploy, secured, and controllable architecture, provides customers with more convenient information inquiries, online ticket purchasing, electronic payments, and other network services. In addition, requirements such as business innovation, application innovation, and management innovation of China Railway can be addressed internally, supporting the transformation of business management from an extensive approach to an intensive one, from the traditional plan-driven model to market-oriented one.

Based on the features of operation, maintenance, and the demands of railways, further development of OpenStack-based China Railway cloud is required to meet the standards of stability, reliability, usability and security, solving the deficiencies in the OpenStack's modules and components and supporting the deployment and implementation of an ultra large-scale private cloud for the railway industry.

OpenStack docking with the large complicated original system: The traditional project-driven IT infrastructure construction mode is hungry for an ever growing amount of IT resources. With its costly equipment, complex and heterogeneous operation and maintenance, information isolated islands, and high resource consumption, China Railway carries a heavy burden, unable to satisfy the demands of the company's transformation plan. Even if OpenStack solutions are adopted, problems with migrating the large amount of data and applications from the minicomputer system to an open source environment with x86 servers still exist.

Loose coupling and instability of OpenStack modules: There are high requirements in terms of reliability and stability for using open architectures to power the production system. Testing and verification are required to find out how to make the OpenStack architecture much more stable and reliable.

Bottlenecks in large-scale cluster deployment: An initial China Railway Cloud Phase I deployment of 800 servers is a small part of the long-term planning. Many technical issues with open systems are supposed to be resolved at the present time.

Challenges presented for the traditional operation methods: It takes time to cultivate OpenStack technical experts and talent. The shortage of talent can limit early operation and management and slow the development of tools for daily automatic operation.

Solution

As a large industry user of OpenStack, China Railway hopes to master open source technology and put it into use in a secured and controllable way. Meanwhile, to create a mutually beneficial OpenStack-based commercial ecosystem between users and suppliers, China Railway Information Technology Center, in partnership with Beijing SinoRail Information Technology Co.,Ltd. and Beijing T2Cloud Information Technology Co., Ltd., is leading a joint development effort.

The China Railway Cloud, with its powerful and flexible resource management capability, is designed to strongly support applications that are migrated and deployed on the cloud platform, like passenger transport management, the website of WWW.95306.cn, logistics and delivery, traffic volume prediction, and train tracking. The current state of main deployed applications is as follows:

Passenger transport management: Application mainly services China Railway, the Railway Bureaus, and stations for day-to-day operations and management.

WWW.95306.cn: This is a comprehensive website for major freight service, including online freight services hall, bulk cargo, and pretty commodities trading services, goods purchasing, investment attraction services, as well as other services covering all regions and cites. Logistics and delivery are reliant on the WWW.95306.cn website as a goods express platform, which has integrated a bar-code scanning and goods tracking function, integrated receiving and delivering applications, enhanced logistics control, and extended two-way receiving and delivery services to create a full logistics service and integrated management system, supporting the above-mentioned services and covering 18 railway bureaus.

1 **https://www.theguardian.com/world/2017/may/12/the-900bn-question-what-is-the-belt-and-road-initiative**

Internal production management information system: This system involves many types of services with complicated processes. The railway transportation management information system (TMIS) is the most typical application regarded by the World Bank as the world's most complicated and largest railway system. The traffic prediction system, part of the TMIS system, is complicated and requires a large computational load, mainly used for the processing and prediction of train operation, tracking positions, etc. Accurate traffic prediction results are a crucial precondition and requirement for organizing railway transportation planning and railway traffic scheduling to improve the efficiency of freight transport and reduce transportation costs.

Train tracking and positioning is a basic requirement for railway safety and operation management, and it can be implemented by many methods, of which the Chinese Locomotive Remote Monitoring and Diagnosis System (CMD) has been online recently and plays a key role in train tracking and positioning implementation. Advanced technologies are adopted by CMD such as Wireless transmission and BeiDou Navigation Satellite System to provide train positioning, real-time status and data monitoring, real-time malfunction reporting, remote diagnosis, video broadcast, on-board electronic resume management of locomotives, expert supporting system, information sharing, function interfaces, and so forth. The CMD system has already covered nearly 5,000 locomotives (in the future this will gradually increase to 21,000) for the real-time collection of locomotive data, which has a large-scale data and a higher real-time requirement.

Many solutions are in place for large-scale industrial cloud deployment, such as single-region deployment, multi-region deployment, and multi-cell deployment. No matter which method is chosen, the fundamental one is single-region deployment. As for the China Railway Cloud, which is about to launch soon, a large-scale test environment was created by using all the equipment purchased in the engineering project. Testing and verification were completed to check the maximum scale China Railway Cloud could handle under a single-region deployment mode and to find out an efficient and optimized architecture design solution for it. The parameter configuration for this architecture was optimized to ensure the performance of cloud services in ultra large-scale deployments and heavy-load situations.

Furthermore, on the OpenStack-base China Railway cloud, 40-day black-box testing was conducted in the China Railway data center with about 800 nodes to research the normalized performance boundary. Problems in the system architecture, operation mechanism, system parameters, database configuration, OpenStack component configuration parameters, and others were discovered and were resolved through analysis, architecture adjustment, component replacement, parameter optimization, etc.

Advantages of the NVF ecosystem

As an advocate of OpenStack and a partner for providing underlying hardware platform and software optimization, Intel has also participated in the deployment and optimization of the China Railway Cloud to help enterprise users build a cloud computing platform with flexibility, efficiency, load balancing, usability, agile operations and lower cost.

Intel has made innovative contributions to the open source community, optimized the CEPH storage architecture, and developed NFV based on DPDK. With the help of Intel, China Railway is able to test products that are not yet released such as network adapter with VxLAN offload function and Intel® Optane™ SSD.

The cloud platform operation management system (OMS) based on OpenStack was developed with open source components, which is complementary to China Railway Cloud to create a comprehensive cloud solution plan. This includes the monitoring system, which has realized monitoring and alarm for physical and cloud hosts; automated task management system, which has realized automated patrol, patch distribution and other functions; and big data operation and management system, which has provided functions such as monitoring data analysis, log analysis, and reporting and statistics.

Introduction to China Railway

China Railway is a solely state-owned enterprise under the management of the central government, set up by the approval of the State Council according to the Law of the People's Republic of China on Industrial Enterprises, and is owned by the Whole People, with a registration capital of RMB 1,036 billion.

According to the Scheme of Institutional Reform and Function Transformation of the State Council approved on the first session of the 12th National People's Congress (NPC), the commercial arm of the railway sector shall be separated from the administrative arm to form China Railway. On March 14, 2013, China Railway was officially set up with more than 2.05 million employees, consisting of 20 internal organizations, 18 railway bureaus, 3 specialized transport companies, and other enterprises. As of the end of 2016, China's railway mileage in service has reached 124,000 km, ranking first in the world, with total assets of over 7.251 trillion yuan.

China Railway focuses on railway passenger and freight transport services while also running a diversified business operation. Its responsibilities include: unified control and command of railway transport; operation and management of passenger and freight transport by national railways; public welfare transport specified by national regulations; key transport related to the national economy and the peoples' livelihood, as well as special transport; dedicated transport and transport tasks for rescue and disaster relief; draft of railway investment and construction plans and suggestions on national railway network construction and financing schemes; preliminary work and management of construction projects; and guarantee of national railway transport safety by undertaking the principal responsibilities for railway safe production.

Commercial value

China Railway is a large-scale and wide-reaching backbone enterprise for the national economy, and it is targeted to transform into a first-class modern logistics company.

The IT infrastructure of China Railway has involved from the mainframe era to the minicomputer era, and then into the cloud computing era. The information systems have been gradually upgraded with new ones, adopting the most appropriate IT technology to support major business systems. This time, the project is based on the OpenStack architecture to build a cloud platform for railway industry, which means China Railway has stepped into the cloud computing era. This is the first time China Railway has worked with an OpenStack service vendor to build up a joint development team, and it marks the beginning of fully and open-mindedly embracing open source technology.

Cloud projects based on the information system construction mode of big platforms, micro services, and light integration delivers great value to China Railway. From now on, they are able to support operations flexibly, enhance equipment utilization rates, reduce overall costs, and further optimize operation and maintenance management.

The application of China Railway Cloud promotes transforming the construction model of China railway information system from the traditional project-driven to platform-driven while better supporting business transformation, booming development, and the extended business with the railway information infrastructure based on the cloud platform. The passenger services of China Railway have extended to train catering, hotel bookings, tourist supermarkets, vehicle reservations, concierge service, and other related services. Freight transportation services have extended to electronic tickets, block trades, logistics services, warehousing services, multi-modal transportation, etc. The diverse business services also cover on-board commercial services, land development, insurance, financial planning, material procurement, and other areas.

The trends for the informatization of traditional giant enterprises are decoupling basic hardware and software, flexible and sharing resources, agile application development, continuous application integration, rapid application deployment, and automated operation and maintenance.

The trendsetting China Railway Cloud is a classic case. Not only does its successful deployment mark the only gateway for China Railway to build a more efficient, more convenient, and environmentally friendly IT infrastructure, but it also provides useful references for other enterprises and industries.

Take action

If a suitable solution for your company is needed, please contact your Intel representative or go to the **Intel Business Channel.**