

ROOTCLOUD Platform

White Paper

ROOTCLOUD Technology Co., Ltd.

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1. China's IIoT platform in the new era

1.1. Digital transformation is becoming the consensus among Chinese manufacturers

According to the Annual Report on China's IIoT Market Research for 2020-2021 released by CCID Consulting in June 2021, the global IIoT market size was \$843.58 billion in 2020, a decrease of 0.5% compared to the previous year, and the growth rate of the global IIoT market turned negative. However, the Asia-Pacific market maintained a high growth rate and its market share rose to 32.2%, surpassing Europe's 30.0% and North America's 31.9%, becoming the dominant IIoT market in the world for the first time.

The report shows that in 2020, the total size of China's IIoT market reached RMB 671.27 billion, a year-on-year increase of 10.4%. Despite the impact of the COVID-19 pandemic, investment in transformation and upgrading by Chinese manufacturing companies has maintained a steady growth. Undoubtedly, the Chinese market provides the strongest growth momentum for the entire Asia-Pacific region, and digital transformation based on IIoT has become a consensus among manufacturing companies.

1.2. What kind of IIoT platforms do Chinese manufacturers need

From the Guiding Opinions on Deepening the Development of "Internet Plus Advanced Manufacturing Industry" to Develop IIoT issued by the State Council in 2017, and a series of follow-up supporting policies, to the IIoT Innovation and Development Action Plan (2021-2023) issued by the Ministry of Industry and Information Technology in January 2021, it will jointly promote the upgrading of the IIoT platform system from three aspects: "building platforms, using platforms, and building ecosystems", accelerating the platform application service level. After exploring and validating in the real market, China's IIoT has ended its "barbaric development period" and entered a period of growth and development.

Manufacturing companies have also begun to truly consider digital transformation in this wave of IIoT. From "I want my data to go to the cloud" to "Why do I want my data to go to the cloud", from "putting data on the cloud" to "putting business value on the cloud", manufacturing companies' choice of IIoT is shifting from subsidy-oriented to demand-oriented market behavior. What they need now is a solution provider and partner that can quickly solve practical problems, not just an IIoT platform.

1. Connectivity is still the foundation and core of IIoT, including various devices, products that need to be monitored, and even industrial software. Based on the "Internet of Everything", it realizes process tracing, remote monitoring of equipment status, fault warning, etc., and then forms overall solutions such as smart factories and smart services.

2. The integration of IT and OT data is still an unchanging formula for creating value in IIoT. Simple IoT presentation cannot bring operational value to enterprises. Only by combining device IoT data with production, logistics, inventory know-how can we see how equipment parameter adjustments will affect revenue and gross profit, and truly help enterprises make money or save money.
3. Software is reshaping the physical world and socio-economic infrastructure. Industrial apps based on the advanced architectures of IIoT platforms and microservices can finally find a fit with customers, better and faster meet enterprises' business control needs based on IoT, and see explicit landing value.
4. Various deployment methods allow enterprises to make choices based on reality. By considering multiple factors such as cost, effectiveness, security, and energy consumption comprehensively, different-sized manufacturing companies can choose from local deployment, dedicated cloud, public cloud solutions or a combination of multiple solutions, and provide corresponding platform O&M services or tools. This is the answer given by market demands.

2. ROOTCLOUD: A new base for industrial digital transformation

2.1. Introduction

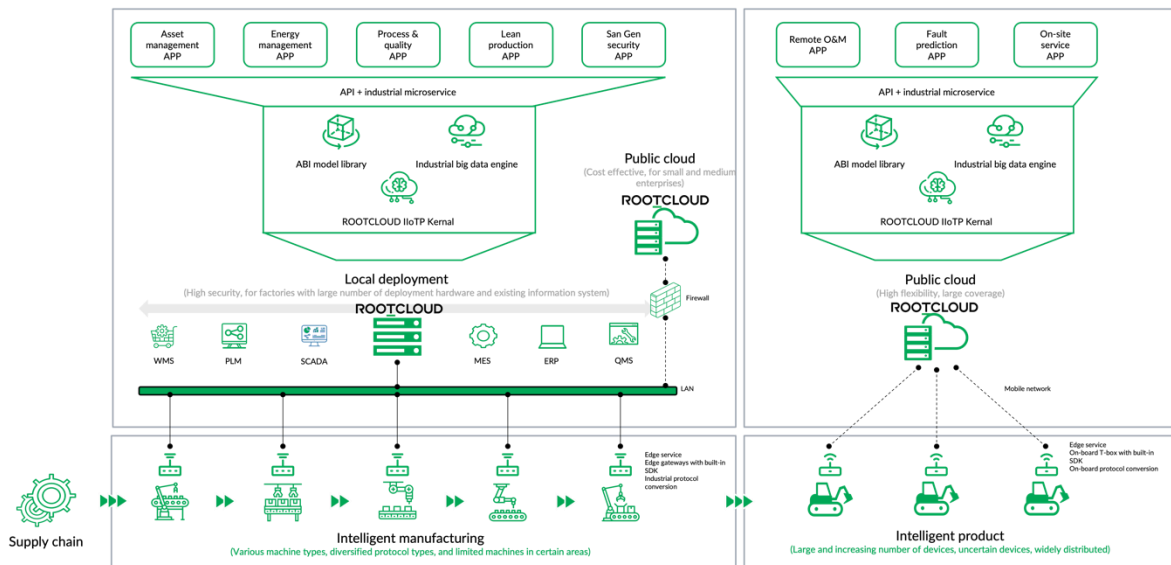
ROOTCLOUD is dedicated to strengthening the depth of the IIoT platform, and is an operational platform that helps industrial enterprises create end-to-end solutions from device connection, visualization to industrial applications. It provides end-to-end, low-cost, efficient, and reliable solutions for industrial enterprises to implement IIoT and focuses on building an IIoT operating system to provide a new base for industrial digital transformation.

ROOTCLOUD aims to solve the two core pain points in the digital transformation process of the industrial manufacturing industry: the high cost and low speed of data collection from the devices due to the disability, inaccuracy, and instability; as well as the high cost, long cycle, difficult iteration and maintenance of applications. It focuses on solving the problems from data collection to application development to:

- Realize device connection with the strongest compatibility, the highest reliability during data uploading/issuance, the lowest cost, and the fastest speed;
- Build component libraries for general purposes, specific industries, and certain features to provide an end-to-end application development ability.

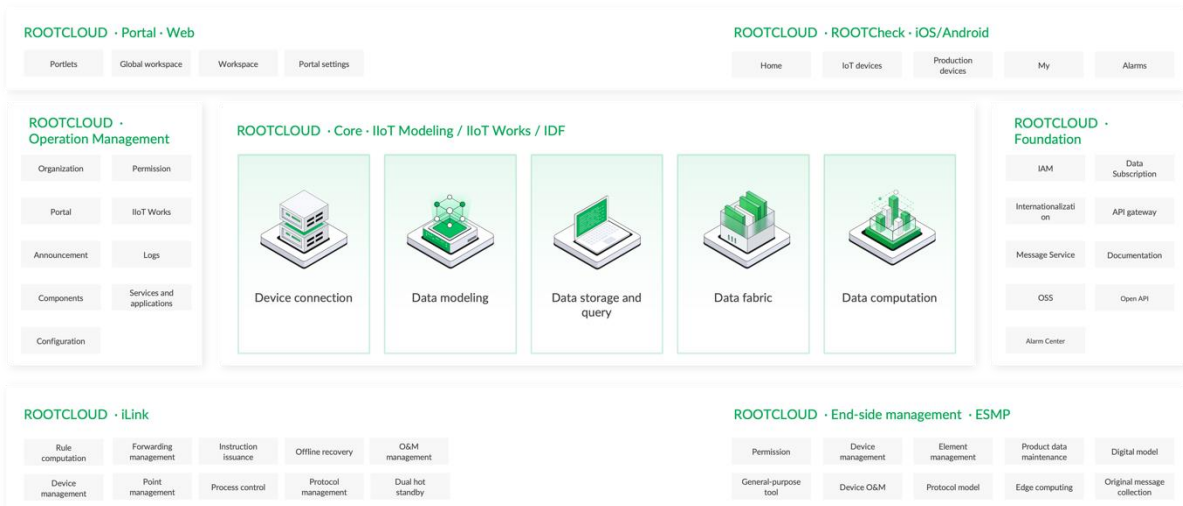
How does ROOTCLOUD platform solves problems?

As a basic platform for IIoT products and services, ROOTCLOUD platform focuses on three key technologies: IIoT operating systems, integrated IT/OT edge services, and component-based industrial APP development. It also supports homogeneous and polymorphic deployment, unified portal, and end-to-end security protection system. It creates a low-cost, cross-platform, cloud-native, multi-terminal, and highly secure IIoT operating system for the intelligent manufacturing era with seamless updates, system-level security, long-term connections, multi-level interactions, fragmented applications, and industrial mechanism AI capabilities.



- **Industrial Big Data:** Based on three major modules including industrial device connection and instruction issuance, industrial data storage and query, and industrial data modeling and computation, this service provides one-stop connection management and services for basic data required by IIoT applications through abilities such as rapid device connection, data collection, modeling, data computation, and data storage. It realizes the comprehensive management and intelligent control of devices by users.
- **Industrial Data Management:** Based on the capabilities of Industrial Big Data, this service provides the ability to manage IoT devices and business master data, helping users effectively manage data stored in other business systems (including device ledger, production process, yield, organization, and personnel), realizing integrated data management that combines IT and OT to support operation metric calculation or data subscription.
- **Industrial Model Management:** It includes the creation, precipitation, and reuse of industrial mechanism models such as industrial metric models, industrial algorithm models, and industrial device health models to realize the inheritance of industrial experience and knowledge. It can also support statistical analysis and visualization of business data, ultimately providing effective basis for production and operation decision-making.
- **Application Enablement:** This service provides application developers with the ability to quickly build business applications based on the ROOTCLOUD platform, including general-purpose and industrial components accumulated during project delivery, intuitive and simple low-code development tools, unified containers and development frameworks. This allows developers to focus more on the implementation of business logic, reduce R&D and O&M costs, and shorten application development cycles.

- Unified O&M Platform: This service provides monitoring capabilities for various levels including infrastructure, middleware, application services, and business for customers and O&M personnel. By providing features such as log management, metrics visualization, alarm notification and processing, it ultimately forms a visual and intelligent O&M management system that integrates "monitoring, management, control, operation, and service".



Currently, ROOTCLOUD Platform supports homogeneous and polymorphic deployment such as public cloud, dedicated cloud, and local deployment. Among them, dedicated cloud supports the deployment of VPC exclusive/private environments of mainstream cloud service providers (AWS, Alibaba Cloud, Tencent Cloud, and Huawei Cloud).

ROOTCLOUD Platform's dedicated cloud and local deployment are designed for large-scale enterprises' exclusive environments or local. Derived from ROOTCLOUD Platform's public cloud, it is based on the public cloud's powerful underlying capabilities and can provide customers with various standard specifications of enterprise-exclusive basic services, platform services, and O&M services, allowing enterprises' digital transformation to enjoy higher privacy, exclusivity, and security.

In addition, ROOTCLOUD Platform's dedicated cloud supports a federated architecture, providing solutions for multinational group companies facing problems such as how to deploy across the entire group across regions and parks, how to manage tenants in different regions and business units, how to ensure the security of data flow across parks, and how to achieve centralized management of business and isolation among business units so that assets and personnel in multiple parks will be managed centrally.

2.2. Values and advantages

- The platform provides group control and collaboration capabilities across multiple parks, catering to the needs of large multinational and cross-regional groups for unified control of master data

and machine data in various locations. Federated architecture on dedicated cloud and cross-regional collaboration plan are at your choice.

- The platform offers a convenient and easy-to-use industrial data connection and modeling of industrial mechanisms. It integrates the industrial expertise, supports zero-code component-based metric configuration and analysis, and realizes a closed-loop process of metric analysis from data connection, logic editing, to visualization.
- The platform supports over 1100 industrial protocols, enabling the connection of millions of industrial devices and millisecond-level real-time data collection.
- It also provides powerful industrial device management capabilities, from independent device modeling to multi-level nested production line and workshop modeling, to the modeling of facets that abstract commonalities for applications. This simplifies the digital twin process of industrial devices and industrial sites.
- The platform implements access control at property level. As a native account permission system, it realizes data control over integrated IT/OT data and property-level data from the source, and supports cross-tenant role authorization based on business needs.
- The platform boasts reliable data security qualifications, being the first IIoT platform to pass the Ministry of Public Security's security level protection (level 3), with ISO27001 security certification.
- The platform is developed with sophisticated technology, having passed the CMMI5 evaluation certification of software capability maturity. This lays a solid technical foundation for the continuous innovation and upgrading of company products.

3. Core capabilities of ROOTCLOUD Platform

3.1. Industrial device management and on-site data collection

3.1.1. Multiple-device connection capabilities

Three types of configurations are available to connect devices to the platform: direct connection, via gateway, and auto-networking. Devices and gateways can be connected to the platform via various network methods, including wired, 4G module, WiFi, Lora, and dynamic networking. The devices connected to the platform include meters with modules, PLCs, machine tools, robots, SCADA, MES, HMI, databases, mobile AGV vehicles, and charging vehicles.

3.1.2. Powerful device modeling capabilities

ROOTCLOUD Platform provides five types of device modeling: connection models, abstract models, models, compound models, and facets. The connection model solves the problem of many-to-many mapping between devices or systems and models on the platform. For large enterprises, abstract models enable model control and standardization. Multi-level compound models meet the needs to build models based on the hierarchical structure. The facets perfectly standardizes the business logic from IoT device models to applications.

3.1.3. Alarm and fault code management

The configuration of alarm rules include three types: rules based on single properties, multiple properties, and groovy expressions, which cover over 95% of all scenarios. Delayed alarm triggering and clearing effectively resolve false alarms caused by data jitter. The alarm messages are pushed to multiple relevant personnel through the Message Service in numerous ways, such as email, SMS, DingTalk, WeChat, etc. With fault code management, users can receive, store, and analyze abnormal status information of devices.

3.1.4. Industrial device management and instruction issuance

Within permission, users are able to write property values; issue custom instructions and files; and conduct multi-layer lock/unlock, configuration update and OTA upgrade. The overall instructions of control include issuing instructions to different devices in batch, asynchronous schedule through instructions, and offline instruction buffer. In addition, retry after disconnection is available to manage devices remotely in

different business scenarios.

3.2. Industrial mechanism modeling and analysis

3.2.1. Native IT&OT data fabric

In the purpose of eliminating data silos and enabling digital transformation for enterprises, ROOTCLOUD Platform develops a native Industrial Data Fabric (IDF), which, through Data Link, connects to external business systems including HRS, MES, and MOM. It weaves IT and OT data through dynamic data models to simplify and integrate the management of various kinds of data. Therefore, data stored in different business systems can be managed efficiently at each layer and permissions to data can be granted, which is the basis of metric computing and application development. Besides, data are accessible at different locations and applications to ensure continuity of business and enhance efficiency of operation and management.

Scenarios:

- Act as a managing tool of IT and OT data integration to eliminate the data silo among IT systems for enterprises. Also, it is extensible to deal with increasing data volume.
- Act as a storing and managing tool of data assets to build reliable and strong data channels for use case operation and analysis with the ability of visualization.
- Act as a dynamic modeling and configuration tool of data to build a basis for application development with flexible data structure configuration (including field/data type/whether to display in list/whether it is queriable).

3.2.2. One-stop visualized data computation

ROOTCLOUD Platform provides high-performance real-time and offline data development services based on Apache Flink for developers and technical personnel with data analysis backgrounds. Real-time data development supports streaming data development through standard SQL and low-code drag-and-drop. Offline data development integrates multiple data development scenarios such as data processing, scheduling dependencies, and task O&M, providing a one-stop solution to data development problems to respond more quickly and accurately to changing data requirements.

Additionally, IIoT Works provides "one-click access" O&M, monitoring, and log query capabilities to solve the difficulties of big data development and help users mine the value of IoT data.

Scenarios:

- As a low-code tool for data processing, the ROOTCLOUD Platform builds a back-end data computing logic for SaaS applications;
- As a visualized data processing tool, it provides a POC (proof of concept) verification project to help partners quickly build data computing capabilities;
- As a real-time data dump tool, it supports dumping real-time data from the ROOTCLOUD Platform to specified external relational databases or message middleware Kafka.

3.3. Industrial application development and integration

3.3.1. Cross-platform mobile application development framework

Based on the ROOTCLOUD Platform's APIs and the experience of building apps with the ReactNative hybrid framework, the environment for the front-end presentation of business is abstracted, and the capabilities are standardized. A unified container and development framework are provided to shield the differences between platforms and ends through the container. This allows business developers to focus only on implementing business logic within the container, maximizing the reuse of existing capabilities and enabling rapid development of IIoT mobile apps.

Scenarios:

- The front-end developers of mobile apps can quickly embed H5 pages into the development framework and implement the app's basic functions through JS-SDK without worrying about the underlying differences of the mobile apps. This dramatically improves the efficiency of app development.

3.3.2. Out-of-the-box native applications

Based on the service capabilities of the ROOTCLOUD Platform, we build "out-of-the-box" native applications for users to help them achieve digital performance management (DPM) and digital sustainable development (DES), assisting enterprises in building lighthouse factories.

Scenarios:

- Enterprise managers who intend to gain insights into their company's energy usage can access the DES system to review various energy consumption reports and carbon emission data. By analyzing energy consumption from different dimensions and product consumption trends, managers can identify energy usage issues and continuously reduce energy consumption and carbon emissions through management measures, thereby achieving green and sustainable development for the

enterprise.

- Enterprise managers who seek to understand the operating efficiency of their devices can access the DPM system to view device operating efficiency indicators. By analyzing real-time startup rates and operation rate data, they can promptly identify abnormal device operation, adjust production through on-site intervention and analysis of abnormal events, reducing non-operational standby time of devices, and improving device OEE and other performance data.

3.3.3. Detailed and clear development documentation

Development documentation of ROOTCLOUD Platform is dedicated to helping developers start quickly and delve into ROOTCLOUD's ability of application development and integration. In the purpose of integrating developers of various programming backgrounds into the ecosphere of application development, Documentation of the Platform introduces the capabilities and steps to develop applications with detailed explanation for new concepts and examples for hard parts.

Scenarios:

- Beginners: Beginners get to know and learn to use the Platform by reading the detailed product description including the structure, features, and use steps.
- Intermediates: Delivery personnel and new users locate problems by reading the process of operation, development, and FAQs to cut training costs.
- Seniors: Application developers tests connection through MQTT and API online test tools, examples of native applications, and source code to lift efficiency.

3.3.4. Top ability of OpenAPI

400 industrial APIs are open to the tenants to build large-scale industrial applications. OpenAPI of ROOTCLOUD Platform solves problems involving connection and data like various industrial communication protocols, complex device connection, high-cost data storage, diversified heterogeneous data, etc. With the help of OpenAPI, the application developers are spared from the above troubles to focus on their business advantages.

Scenarios:

- To acquire IoT, permission, metric, alarm data from the Platform with the help of the latest OpenAPI, development guide, and code examples, etc. for application development.

3.3.5. Autonomous subscription to open real-time data

Real-time data can be subscribed from the Platform as it is open to industrial applications. It covers data of online/offline, machine data, and alarms due to device exceptions. With Data Subscription, the applications will receive the data from the platform in real time with less delay due to polling. Therefore, rich industrial applications are available to integrate well with the Platform.

Scenarios:

- The application displays real-time overview of device machine data, including the voltage and energy consumption of each machine data.
- Once the configuration of the devices changes, the information need to be updated timely to avoid wrong data matching. Any information of the device monitored by the application will be reported and updated to all modules of the application.

3.3.6. Flexibly configured alarms and notices

Alarm notices and message collaboration are available due to the flexibly configured alarms and notices. Messages of metric monitoring, device status, and service notices, etc. will be sent to business personnel through email, SMS, or office IMs regardless of the location.

Scenarios:

- As offline devices may result in production suspension, it is necessary to notify owner of the production line to trace the problem.
- When a device is in fault, a maintenance worksheet will be created in O&M system and a notice will be sent to O&M personnel to follow up.
- An email of monthly report on running condition of devices will be sent to O&M personnel with a piece of message from the application notifying them.

4. User cases

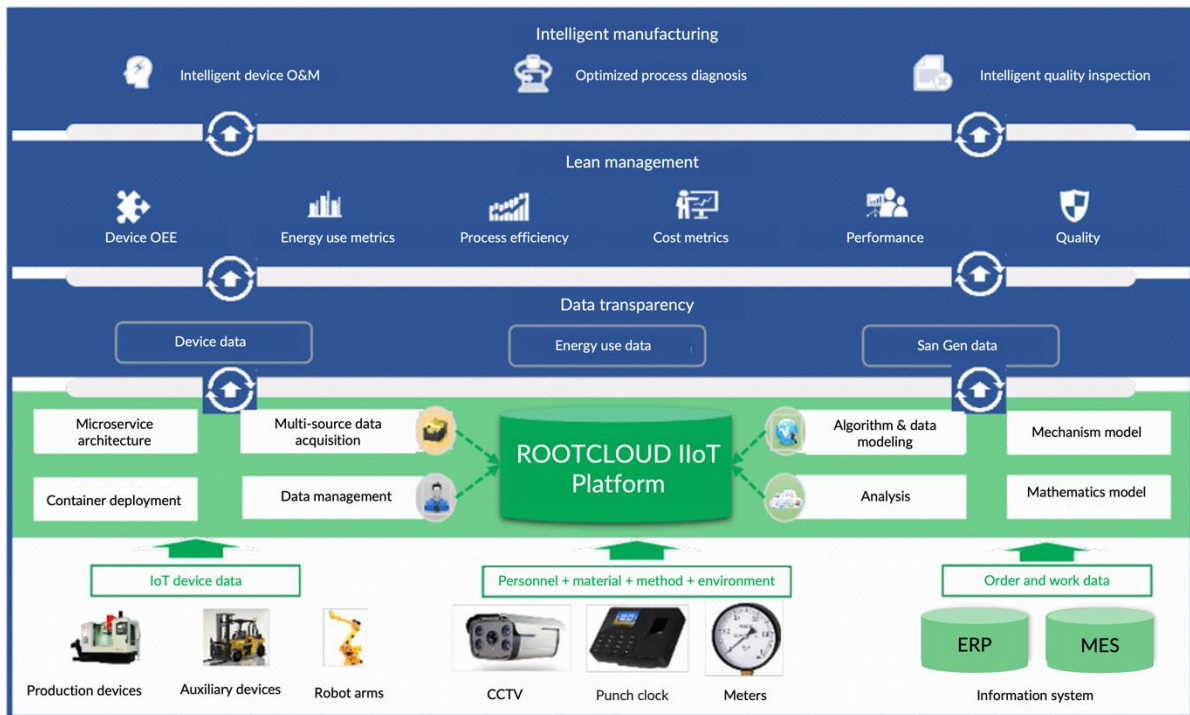
User case 1: Lean digital management leads to transparent factory of vehicles

In an environment of micro-growth globally and negative growth in China, vehicle manufacturers are faced with fierce competition, diversified and personalized terminal users. Therefore, many of the top ones hope to meet requirements of energy saving and green development through deep digital transformation and continuous technology step-up. Meanwhile, they hope to enable existing IT systems and devices in the purpose of being competitive and influential over the globe, thus achieving continuous success.

Digitalization construction has always been a critical support for a Chinese leading vehicle brand which produces globally-known SUVs and trucks in its internal operation and factory building.

The extension of global business and innovation of technology result in harder O&M and management due to large-scale production and various product categories. As the programmed O&M lacks the ability of real-time monitoring, the rate of device faults and cost of maintenance stay high and expensive.

The enterprise builds a system to monitor device faults and on-site running status based on ROOTCLOUD Platform and services. Physical devices are modeled on the Platform, with their real-time status and machine data being integrated with the BOM, forming a super BOM for devices to reduce times of unplanned stopping and have data of device status and business systems transparent. The system provides for the enterprise with a whole-process auto-loop digital O&M system and a management model of device health. It helps shorten the stopping hours of thousands of devices from 23.45 minutes to 13.95 minutes, improving the capability of O&M and responding efficiency. Additionally, the management and maintenance costs have been cut by 30% and warehousing costs dropped by 20.4%.



User case 2: Enable steel industry by digging value of big data

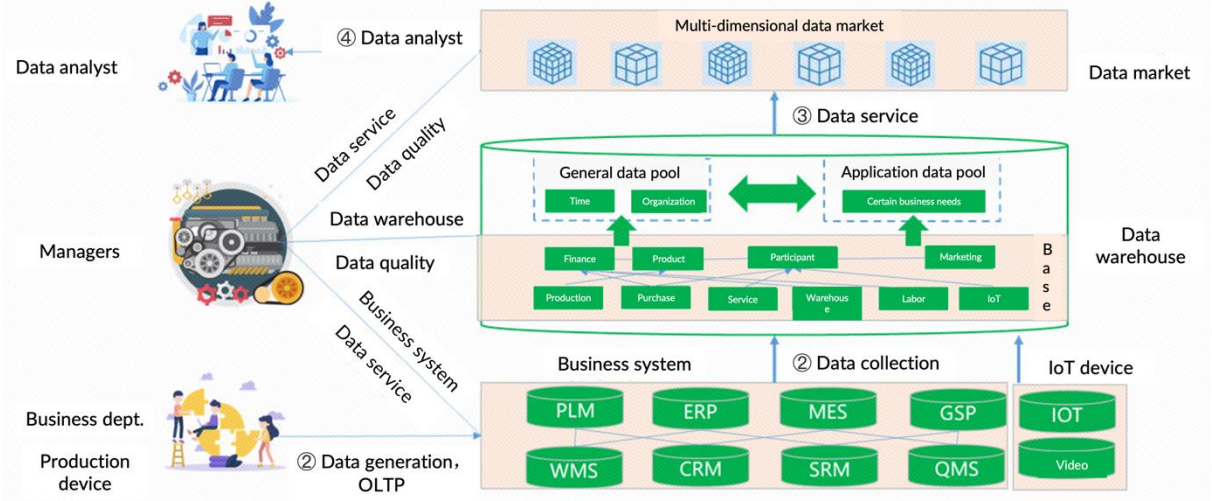
As the pillar industry of national economy, steel industry plays an important role in economy, society, finance, national defense, and employment, etc. However, due to the long-lasting extensive development, problems like lack of high-end products, overcapacity, pollution are notable, which restricts the further development of China. In the background of “Carbon Neutrality” and “Emission Peak”, China made an industry revolution at demand side where enterprises have to upgrade productivity and focus on technologies like high-precision, high-efficiency milling, and heat treatment. Meanwhile, the research on process control technology become the direction that the steel industry should pay more attention to.

A cold-rolled sheet company, the subsidiary of a China’s integrated large-scale mixed ownership steel company, has been a critical producer of metal plates in North China.

In traditional steel enterprises, common pain points include large but diversified data, high risk of data security, weak visualized monitoring, and high personnel cost. As a common forging method, cold rolling requires more precise and unique process and rules due to the high requirements of raw material quality and unified operation of multiple machine sets. That, therefore, means a cold-rolling enterprise requires more urgently data integration and report analyzing among all production systems and along the whole production process.

To transform the enterprise in an easier and quicker way, a set of complete data system and all-dimensional metric system is built on ROOTCLOUD Platform based on the business and data characteristics,

trend of steel industry, forming a solution of data interconnection and integration from material, order, production to delivery, logistics, and security protection. The efficiency to collect data and form reports improved by 30%; the efficiency to develop operational metrics up by over 50%, data utilization rate up by over 80%; energy utilization rate up by 15%, which lowers cost for the enterprise effectively.



User case 3: Central management and control over data through federal architecture

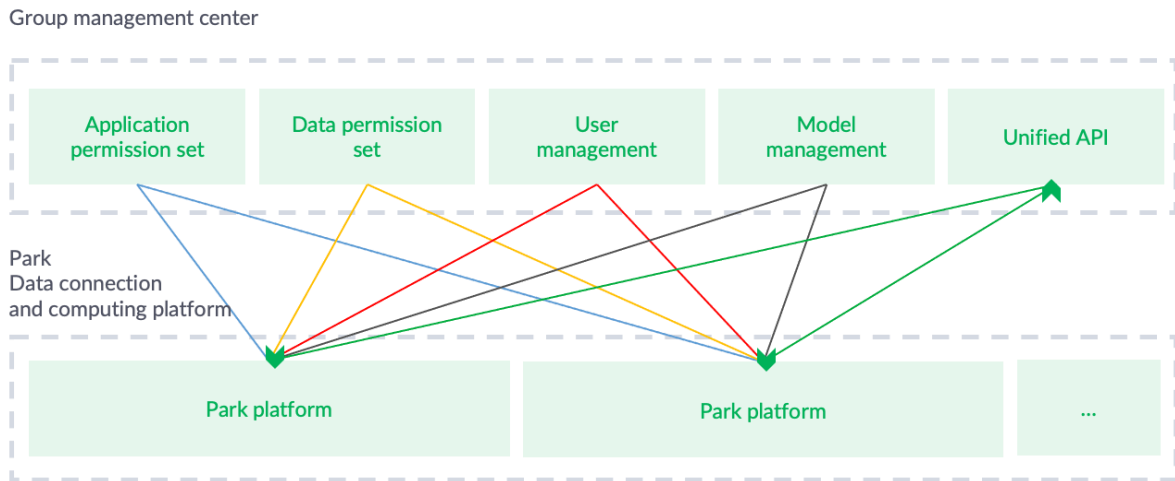
The business extension and technology development of manufacturers nurture them into group or international enterprises. While the difference of management systems and use of business systems among their branches results in information silos within the group and further harder management from headquarters. The increasingly weaker management and control over the parks, branches, and subsidiaries leads to progressively more violent contradiction. However, real-time, transparent, and remote management and control that comes with IIoT is a solution to the dilemma.

Sany, the leading enterprise of engineering machinery, needs central management and control during its digital transformation based on IIoT to deploy the Platform distributedly in different parks; to realize unified management and configuration of IoT platform, permission, organization, and assets; to query data from different parks; and to collaborate business across business units and regions.

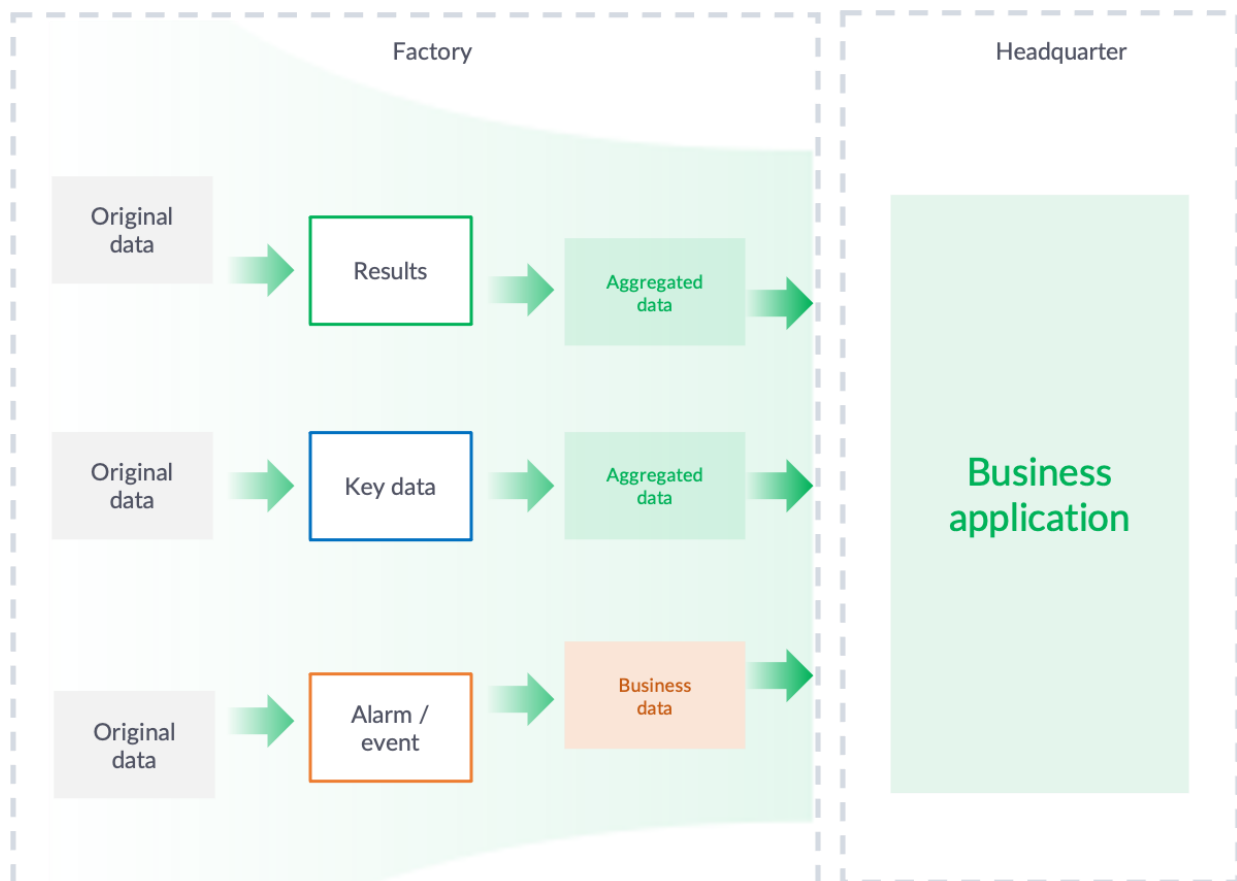
Based on the dedicated deployment and federal architecture, ROOTCLOUD builds a federal IIoT platform that connects data of the headquarter and cross-region parks for Sany.

- Unified management and control from headquarter: The headquarter manages the organization structure, applications, permissions, and device model. Any change from the headquarter will be passed to all parks, which ensures consistency on the Platform. Meanwhile, the unified interface addresses are gathered in the management center of the group. Therefore, no repeated operation

is required to meet needs of business change, lowering cost for these change.



- Closed loop of local data for stable real-time data report: Besides connecting IoT data to the Platform, parks are also responsible for the computing of basic data and triggering of events. The real-time data and information will be transmitted to local systems like MES, MOM, etc. If, unfortunately, the parks lose network connection to the group, the data cached will be imputed by time to avoid data loss and computation disorder.
- Local use of parks' real-time data and computing results: The data reported to the headquarter can be those that have been aggregated in a lower frequency to reduce bandwidth occupancy and cost of data transmission.



User case 4: Platform services for international enterprises

Driven by Industrial 4.0, industrial globalization has been speeding up. As the product and also catalyzer of globalization, international enterprises have grown with new traits and traces. One example is that manufacturers are growing from primary production, manufacturing, mining to high-end manufacturing and service industry, which is the same as the development of global industrial structure and also the trend of transforming from manufacturing to service industry.

Putzmeister, a German leading enterprise in concrete machinery in Stuttgart is founded in 1958. Its main business is to develop, produce, and sell transmission pumps of various kinds of concrete, industrial pumps, and auxiliary equipment. What are spreading all over the world include not only its products, but also its services from training to technical support and from device selection to project consultation.

As an international supplier, its products are distributed all over the globe, and, generally, work in complex outdoors. Therefore, once there is fault in the machine, it is hard for the maintenance personnel to be on site timely, while hard for remote after-sale service person to know details. In addition, the lack of maintenance data record results in difficult fault analysis of products and limited transformation of the enterprise.

A global intelligent operation plan is developed based on ROOTCLOUD Platform. Based on core technologies of digital twins, big data, and machine learning and the ROOTCLOUD-developed data collection terminal, the machines are connected to the global IoT platform of ROOTCLOUD. Besides, applications to manage and operate global devices are tailored for the enterprise to build a closed loop of data collection and analysis. Core services like remote analysis of device status, oil consumption, and performance based on market standards enhance the efficiency of manufacturing and after-market services.

- Real-time data collection and report: Collect, store, and analyze at real time data of various kinds of running devices like location, oil consumption, and running status.
- Remote asset management, electric fence: Monitor and manage devices at anytime and anywhere through real-time data collection. Count the device workload (total running time, oil consumption, engine speed, etc.) for better work plans and maintenance. In addition, the electric fence protects machines from being stolen by reminding timely for the machines at wrong places.
- Remote fault diagnosis: Remote fault troubleshooting to shorten time of machine halt by analyzing machine data, parameters of use, and degree of wear, etc. with the help of parts replacement data and fault history.

Performances with the help of ROOTCLOUD solution:

- a) Higher device management efficiency: With the end-to-end service provided by ROOTCLOUD Platform, Putzmeister has its machine data stored, analyzed, and used to monitor and optimize running machine data as well as path of devices. Besides, remote fault troubleshooting is available. The oil consumption is 20% lower and machine halt is 60% shorter, not to mention the higher security of machine running.
- b) High-quality after-market service: Intelligent scheduling of external and internal service resources through real-time data of the machine facilitates terminal users and raises degree of satisfaction.

About ROOTCLOUD

ROOTCLOUD is a national cross-industry and cross-field IIoT platform company and the only Chinese IIoT platform enterprise that has been selected for three consecutive years in Magic Quadrant for Industrial IoT Platforms.

ROOTCLOUD platform provides digital transformation services in intelligent manufacturing, transparent factory management, online management of machines (services, intelligent manufacturing, R&D, energy), industrial chain platforms, industrial AI, equipment financing, and other areas for machine manufacturers, equipment users, government regulatory departments, and other organizations.

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