Research on the quality Data Service Platform architecture of Intelligent electricity Meters

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Abstract. This paper introduces the basic situation of the quality data of intelligent electricity meters, and designs the overall architecture of the quality data service platform of intelligent electricity meters in view of the informationization demand of the quality data of the whole chain of intelligent electricity meters. The technical framework of the platform is further studied, and combined with the technical framework, the equipment quality data trusted acquisition system, digital factory service system, measurement equipment quality data service system, operation management system and quality data edge acquisition terminal are respectively introduced. Finally, the further development of the platform and its application in practical business are prospected.

1. Introduction

Smart electricity meter is an important data acquisition tool for energy Internet and strong smart grid perception layer. It is also a crucial equipment for power grid enterprises to provide quality services to customers. The quality of its products is closely related to the vital interests of the government, power companies and people. Under the background of made in China 2025, intelligent manufacturing and power system reform, the quality of intelligent electricity meters has been greatly improved. However, the intelligent electricity meters produced in China are in low price competition, with low added value and low market share in the international high-end market. Therefore, the product quality still needs to be improved to a higher level. [1-2].

After the comprehensive promotion of intelligent electricity meters, the number of detuning and failure data are increasing day by day. At present, the content of the fault database is not complete, and it has not been included in the fault data of electric energy meter verification and detection business and on-site investigation. At the same time, the reliability and robustness of the software are not considered in the compilation of the energy meter software, and the data is not shared between the electricity meter manufacturer and the power company, and there is a lack of comprehensive control of the quality control points in the whole life cycle of the design, manufacture and operation of smart meters. There are many accidental failures in the operation of smart meters, and the company is facing greater operational risks, operation and maintenance costs and public opinion pressure[3].

In view of the problems existing in the quality improvement of intelligent watt hour meter, such as weak systematicness, insufficient coordination and insufficient overall technical solution ability, it is necessary to combine the company's development strategy of improving quality and efficiency and
strengthening the network with quality. Starting from strengthening the quality foundation ability, focusing on the overall quality improvement, taking the quality coordination of upstream and downstream enterprises in the smart energy meter supply chain as the idea, the quality control is "moved forward" to the supplier manufacturing end. To carry out the research and application of quality analysis and evaluation technology of smart energy meter based on the whole chain data, so as to promote the overall improvement of the quality level of smart energy meter[4].

2. Overall architecture of quality data service platform for intelligent electricity meters
The intelligent electricity meter quality data service platform is mainly deployed in China Electricity Research Institute without other site requirements, including private cloud platform and public cloud platform. This study mainly introduces the public cloud platform. Public cloud deployment quality data trusted acquisition system, digital factory service system, measurement equipment quality data service system, operation management system, storage production enterprise side quality data and power company side desensitization calculation results data. The private cloud platform and the public cloud platform ensure the security of data interaction through the security gate. Quality data edge acquisition terminals are deployed in production enterprises. The overall architecture of the platform is shown in Figure 1[5-6].

![Figure 1. Overall architecture of quality data Service platform for intelligent electricity meters](image)

3. Technical architecture of quality data Service Platform for intelligent electricity meters

3.1. Quality data trusted acquisition system
The quality data trusted acquisition system of intelligent electricity meters provides the equipment with safe and reliable connection and communication capability, connects the massive equipment downward, and supports the equipment data acquisition to the cloud. The cloud API is provided upward, and the instruction data is sent to the device side through API calls to realize remote control. In addition, the trusted collection platform for quality data also provides other value-added capabilities, such as edge computing function, platform security function, trusted data collection function, application hosting function, etc. The basic functions of the system are shown in Figure 2.
3.2. Digital factory service system

Digital factory is based on Internet of things, cloud computing and big data technology platform, for electric meter production enterprises implement business operations are supported by reliable digital information, constructs a set of digital control and manage resources, collect and analyze historical information, based on the data analysis results, business decisions and optimization techniques and methods. The digital factory connects the equipment in the manufacturing enterprise to the cloud through the Internet of Things technology, represents the operation business objects through the digital model, and then integrates the industrial applications needed in the whole process of product research and development, production, sales, logistics and after-sales service value chain through the digital model to achieve business collaborative processing. The business data generated by industrial intelligent applications and the operational data of intelligent devices collected by the Internet of Things are correlated and traced, the events and indicators in manufacturing enterprises are comprehensively monitored and visually displayed, and the efficient and intelligent decision making and feedback are realized through multi-dimensional analysis and data mining. The architecture of the digital factory service system is shown in Figure 3.

Figure 3. Architecture diagram of digital factory service system

Digital factory Operations center provides manufacturing enterprises with digital factory infrastructure platform services on the proprietary cloud. Digital factory operations center based on the quality of credible data acquisition platform of Internet of things, cloud technology and industrial technology of big data and business operations for electric meter manufacturing enterprise real reliable
digital support, provides a set of digital building and management resources, gathering and trace the production information for business decisions, based on the data analysis results and optimization techniques and methods. The digital factory operation and Management Center represents the objects in the factory through the digital model, and integrates all the applications needed by the manufacturing enterprise in the whole process of product development, production, sales, logistics and after-sales value chain through the unified system platform, unified portal entrance, unified authority management and unified data model. Digital factory operation center mainly includes digital factory portal, data center service, business center service and platform management service module.

3.3. Measuring equipment quality data service system
Measurement equipment quality data service system, to achieve the production enterprise, power company data fusion sharing, business integration. With the open sharing idea of "micro service, micro application", it provides the management ability of diversified data service, application service and developer service for regulators, power companies, production enterprises, the public, so as to improve the development efficiency of application scenarios and ensure the reliable and stable operation of application scenarios. It includes quality data fusion and analysis management and quality application service management. The specific architecture of the system is shown in Figure 4.

![Figure 4. Architecture diagram of quality data Service system of metering equipment](image-url)

3.3.1. Quality data fusion and analysis management
The convergence data center provides basic data support at the source end for public data by accessing and storing data at the production enterprise side, the power company side, the collection and control platform, the state grid information platform and so on. The public data center processes and integrates the source data accessed by the data center to provide support for data extraction and open detailed data query scenarios, etc. The extraction data center integrates the data based on the standard provided by the public data center, refines the analysis model, processes the data into the data with the meaning of business association, and stores the data as needed, which can also support the open details query to the public.

3.3.2. Quality application service management
As an application request gateway, API gateway provides client load balancing, fault fuse, service routing, service current limiting, data encryption and decryption capabilities to ensure high availability of services. Provide protocol adaptation ability, at the same time support HTTP/HTTPS/websocket MQTT/ssal agreement. The authentication center provides functions of identity authentication, device
authentication, key issuance, authority acquisition and system operation parameter acquisition, providing security guarantee for device security access, data transmission, micro-application authority management and micro-service interaction. The configuration center can be used for publishing and pushing distributed configuration, reducing online downtime and improving stable operation capacity. As the core service of microservice distributed architecture, registry provides service registration and discovery capability, ACL capability, cluster service anomaly monitoring capability, and guarantee service extensibility, high availability and service access security. Application center provides visual rights configuration ability, unified management of business microapplications, equipment management ability and announcement publishing function. Internet of Things Bridge service is implemented based on MQTT protocol and aims to provide reliable network services for IoT devices in low bandwidth and unstable network environment. Support real-time message, offline message, support message persistence capability, device access security mechanism. Application monitoring provides application health monitoring, health check capability for key services and components, and warning when abnormalities are found to ensure the normal operation of services. Service management provides microservice visualization deployment capability and microservice grayscale release management function.

3.4. Operation management system

Operation management system for digital factory and the unification of the measurement equipment quality data service system operation management, portal management, news center, service management, application center, business center, operation center, information center and configuration, and other functions, to support the intelligent measurement upstream and downstream industry chain measuring equipment manufacturing enterprises, electric power company (using the enterprise), public (customers), regulators operating service work, build new ecological win-win, good, healthy and continuous measuring equipment quality of ecosystem services. The platform architecture is shown in Figure 5.

![Figure 5. Operation management system architecture diagram](image)

Portal management realizes the unified access entry function for all participants of the platform, and provides external publicity, product promotion, operation management and other functions of the platform, including registration/login, personal center, homepage, service list, subscription ranking, service subscription, my desktop, help and support and other functional modules.

The news center provides the unified management function of news information in the system, including the functions of adding, modifying, deleting, publishing and putting the news at the top. The news information includes the title, content, publisher and update date. Service management includes several modules of merchant management, organization management, role management and audit management.

The application center provides application scenario services and digital factory application service publishing functions, including commodity management and service management. Service management mainly realizes the management function of service image, including the publication, deployment, upgrade, destruction and other functions of service image, and supports the unified
docking interface function managed by the application in the digital factory service system. Commodity management realizes the commodity unified management function of application service and digital factory service, including commodity attribute definition, commodity pricing and other functions.

The exchange center provides the unified management function of the service transaction provided in the quality data service platform of digital factory and measurement equipment, including online transaction, transaction audit and other functions. The operation center provides unified operation management functions of the platform, including daily live statistics, monthly live statistics, promotion activity management, operation strategy management, operation situation statistics and other functions.

The message center provides messaging functions on the platform between users and users, between users and merchants, and between users and operators, and supports instant messaging to meet the needs of communication. The configuration center provides the unified management function of configuration information in the operation management platform, including system configuration parameters, business rule configuration, system display rule configuration and so on.

3.5. **Quality data edge acquisition terminal**

Linkedge is an edge gateway data processing platform, its functions mainly include: data acquisition, data flow, data processing, data on the cloud, cloud application delivery and edge deployment. Its architecture is shown in Figure 6.

![Architecture diagram of quality data edge acquisition terminal](image)

Figure 6. Architecture diagram of quality data edge acquisition terminal

General access protocol, industry standard access protocol and private access protocol belong to the data acquisition part. General access mainly includes WebSocket protocol, and industry standard access mainly includes MODBus protocol and OpCUa protocol. Meanwhile, SDK of C and Python versions are provided, and users can customize access protocol. The content of access protocol is distributed in the cloud to deploy the program to the edge gateway for data collection. The message center is part of the data flow. The user can choreograph the path of the data flow. The rules engine mainly implements the scenario rules of simple logic. Streaming computing processes data quickly and in real time through streaming data. Edge applications implement user customizations that are deployed to the edge gateway through the cloud platform. In the external interface, the cloud channel is used to synchronize data on the cloud in the edge gateway. OpenAPI is used to provide a functional
interface to the edge gateway. Other supporting modules provide edge gateway related monitoring and maintenance functions.

Terminal application is to collect the data of the equipment (or system) of the production enterprise and upload the data of the production enterprise to the trusted collection platform. Terminal application is divided into two modules: acquisition module and upload module. The acquisition module collects the data of production enterprises through three modes (one or more modes are adopted in actual use): direct acquisition mode of equipment, active reporting mode of equipment, and third-party uploading mode. The terminal application transmits the data to the trusted collection platform through the interface through the upload module.

4. Conclusion
The construction of the platform can provide typical demonstration applications such as measuring equipment precision supervision service for government agencies, electricity meters full life cycle information service for the public, electricity meters fault analysis and early warning service for power companies, and industry positioning analysis service for production enterprises.

In the context of the energy Internet, it is increasingly common to use advanced information technologies such as cloud computing, big data and artificial intelligence to solve business problems. By studying the architecture of quality data service platform for smart electricity meters, the quality data service platform for smart electricity meters is built, following the principle of "openness, sharing, cooperation and win-win", the main line of business is to improve the product quality of service manufacturers, strengthen the quality network of service power companies, quality supervision of service regulatory agencies, and quality information concern of service public, so as to gather the data of the whole chain of intelligent electricity meters. We build an application service scenario with global coverage, data fusion and multi win-win situation, enable the continuous value of all parties, and help the high-quality development and industrial transformation and upgrading of the whole industrial chain of measurement equipment.

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References
[1] WANG Sitong, ZHOU Hui, YUAN Ruiming,et al.Concept and Application of Smart Meter[J].Power System Technology,2010,34(4):17–23.
[2] WEN Kehuan, HUANG Huaidong, LI Weihua,et al. The typical design and application of intelligent measurement system based on cloud platform[J]. Electrical Measurement And Instrumentation,2016,53(5):118–123.
[3] CAO Junwei, YUAN Zhongda, MING Yangyang,et al. Survey of Big Data Analysis Technology for Energy Interne [J]. Southern Power System Technology, 2015, 9(11):1–12.
[4] WU Kaifeng, LIU Wantao, LI Yanhu,et al. Cloud-Computing Based Power Big Data Analysis Technology and Its Application [J]. Electric Power,2015,48(2):111–116.
[5] WANG Jiye, CHENG Zhihua, PENG Lin,et al. Summary on Cloud Computing and Its Application Prospect in Power Sector[J]. Electric Power,2014,47(7):108–112.
[6] LIU Zhengwei, WEN Zhongling, ZHANG Haitao. Cloud computing and cloud data management technology[J]. Journal of Computer Research and Development, 2012, 49(S1):26-31.