Architecture Design and Key Technologies Study of Omnichannel Business Platform for Electric Power Marketing

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Abstract. Building the omnichannel business platform for the electric power marketing and integrating all online service resources, with the features of customer aggregation, business integration and data sharing, are an inevitable pathway for the power grid enterprise to establish the customer-centric modern service system and realize its digital transformation strategy. The overall architecture of the omnichannel business platform is proposed and the detailed design for the eight shared service centres are given respectively for user centre, ticket centre, electronic bill centre, payment centre, order centre, points centre, online customer service centre, and messaging centre. Some typical application scenarios are described to illustrate the internal working mechanism of the shared service centres and the cooperation mechanism among them, such as management of comprehensive energy business, online interaction service for the electric power customer, and instant messaging delivery. The key technology applications and practices are discussed for the implementation of the business platform, such as improving data processing capabilities, building integrated services with fast response, and developing digital operational capabilities. The development prospects of the business platform are concluded finally, whose service centres would be gradually be evolved into an important component of the strategic business platform for the power grid enterprise by continuously precipitating the business capabilities and establishing the competent service centres.

1. Introduction
With the energy revolution, power system reform, and innovative technology development, etc., the changes of the business environment and profit model for the power grid enterprise are taking place, and the demands from the electric power customers in the new era have the features of convenience, diversification, and interaction. The focus of the power supply services provided by the power grid enterprise has been transferred into the balance between the growing demand for high quality services from the electric power customers and the uneven, inadequate development of the business approaches. It is necessary for the power grid enterprise to integrate innovative technologies into the business development, optimize and upgrade the power supply service system, reengineer the business flows, and innovate the service models, to realize the cross-border integration of the traditional power services with the new energy services, such as the ones of e-commerce energy, electric vehicles, comprehensive energy, etc., to continuously expand the products of the electric power services to meet the increasingly diversified quality service needs of the electric power customers [1][2][3].

There are the internal channels, the 3rd party cooperative channels and the external channels in the power grid enterprise, where the internal ones include the business halls, self-service terminals, 95598
call services, mobile applications, electric vehicle networking, etc.; the corporative ones include banks, WeChat, Alipay, etc.; the external ones include those of government, telecom operators, public utilities, etc. However, there are some issues in the channel management as follows: (1) The customers have to register separately in each channel, which makes the customers difficult to choose and use the channels, leading to the user experience and low efficiency of service collaboration; (2) The public service resources such as points, payment and online customer service are not effectively integrated, and the service resources are not fully utilized; (3) The online customer requests are accepted separately and the online demands cannot be managed in a unified way, which affects customer service satisfaction; (4) The online channel operation management is carried out independently and the service data of each channel is isolated, which is not convenient to carry out data statistical analysis and business operation monitoring, for fully exploiting customer value and providing accurate marketing services.

To solve the above issues, the omnichannel business platform for the electric power marketing with the features of customer aggregation, business integration and data sharing can be built to integrate all of the online service resources and channels, establish the unified online service platform, take customer demand as guide, provide the customers with more convenient, intelligent and intimate energy experience, which could become the main entrance of the power supply services for the electric power marketing business, and is an inevitable pathway for the power grid enterprise to establish the customer-centric modern service system and realize its digital transformation strategy.

2. Detailed Design of Omnichannel Business Platform
The omnichannel business platform is based on the shared service centres, where the core service capabilities are highly abstracted and summarized from the core businesses of the power grid enterprise [4][5][6]. The shared service centre is designed according to the internet product model, adopting the design method of microservices and microapplications, that is, taking the business scenario as the minimum design unit, focusing on the functional implementation and user experience, and organizing the enterprise resources in the form of business capabilities encapsulated with certain technical architecture as the services which can easily be consumed. Thereby the reuse, assembly, maintenance and management of the services can be realized to flexibly and rapidly develop the enterprise applications for the specific business purposes [7][8][9][10].

The core of the shared service centres in the business platform is to abstract and logically divide the shared services between the frontend applications and the core backend systems such as the electric power marketing business application system [11][12], and to build an independent, public capabilities for single purpose. After the analysis of the service scenarios and business domains, the eight shared service centres are designed: User Centre, Ticket Centre, Electronic Bill Centre, Payment Centre, Order Centre, Points Centre, Online Customer Service Centre and Messaging Centre. The shared service centres can be implemented with the distributed microservice architecture by applying some mature internet technologies and components, such as distributed service governance, distributed database, message queue, global transaction management, full-link monitoring, etc., which can ensure the rapid development and stable operation of the shared service centres, and provide the frontend applications with the core business capabilities deposited by the shared service centres for the electric power customers [13][14].

2.1. Overall Architecture
The overall architecture is shown in Figure 1. The business platform enables to develop flexibly and quickly the enterprise applications for specific business purpose, reduce the cost and risk of implementing the new business applications from the business and technical viewpoints, and also facilitate the continuous precipitation and iterative upgrading of the business platform. For instance, the tickets are generated and managed in Ticket Centre when the electric power customer submits the self-serviced ticket or inquires the processing progress of the submitted ticket. The generation, status change and inquiry of the orders from the electric power customers are completed uniformly in Order Centre, and the timeliness is guaranteed and the customer experience is perfect. The payment for the order is completed in Payment Centre which will invoke the payment channel to complete the
payment request; when the payment channel returns to Payment Centre with the successful payment, Payment Centre can send the frontend application with the message which would be prompted in real time to the customer that it is successfully paid, where the message delivery is supported by the capabilities of Messaging Centre.

2.2. User Centre
User Centre is acted as the unified user information hub which can include the Internet account information, the basic profile information and the characteristics of the electric power customers. User Centre includes the functions of registration management, login management, account management, identity authentication, etc., and the supported microservices of unified account service, user label service, etc.

2.3. Ticket Centre
Ticket Centre creates the centralized ticket pool to aggregate the tickets about the complaints, power supply, electric repairs, electric vehicle, photovoltaics, etc. from the electric power customers, realizing the unified generation, aggregation, division, distribution, processing, inquiry, dispatch of the tickets in the whole process for the all channels. Ticket Centre includes the functions of ticket management of electricity business expansion, comprehensive energy services, customer services, etc., and the supported microservices of ticket management, ticket pool management, etc.

2.4. Electronic Bill Centre
Electronic Bill Centre is the one of gathering the energy consumption information, generating and managing the electronic bills for the electric power customers to meet their requirements of the online inquiry, downloading, pushing, subscription and printing of the electricity bills, business fees, photovoltaic electricity bills and subsidies, electric vehicle charging fees, etc. Electronic Bill Centre includes the functions of personal electronic bill management, corporate electronic bill management, electronic bill management for photovoltaic access, electronic bill management for electric vehicle
charging, electronic invoice management, etc., and the supported microservices of electronic bill service, electronic invoice service, etc.

2.5. Payment Centre
By building the unified payment gateway, Payment Centre realizes the management of its own payment channel and the third-party payment channels to provide various payment approaches to the customers, such as bank cards, Alipay, WeChat Pay, mobile banking, online banking, etc. Payment Centre includes the functions of order payment, refund management, electricity fee management, my assets, etc., and the supported microservices of payment gateway service, payment service, etc.

2.6. Order Centre
Order Centre supports the unified ordering and inquiry management of various orders, such as commodity orders, electricity bill orders, business fee orders, electric vehicle charging orders, etc., focusing on the centralized access and management of these orders. Order Centre includes the functions of commodity management, order management, logistics management, etc., and the supported microservices of order interface, etc.

2.7. Points Centre
Points Centre aggregates the point information from the online channels, to establish the integrated exchange rules, and to provide the customers with the unified points access, inquiry and exchange. Points Centre includes the functions of point acquisition, points redeem, etc., and the supported microservices of points inquiry service, etc.

2.8. Online Customer Service Centre
In Online Customer Service Centre, there are the customer service representative and the intelligent robot to provide the functions of online customer service conversation, online business consultation, ticket acceptance, customer satisfaction survey, etc. to achieve the rapid collection and authoritative response to the online customer appeals [15]. Online Customer Service Centre includes the functions of online customer service, etc., and the supported microservices of online service access, online self-service, etc.

2.9. Messaging Centre
Messaging Centre supports various types of message formats such as text, voice, and rich media; provides various message transmission channels, such as text, email, app message, WeChat; and supports various message transmission modes, such as peer-to-peer, group, broadcasting, instant transmission, and timing transmission. Messaging Centre includes the functions of message subscription, message inquiry, etc., and the supported microservices of message pushing service, message service, messaging queue management, etc.

3. Cooperative Mechanism Between Shared Service Centres
The typical application scenarios, such as the management of the comprehensive energy business, the online interaction service for the electric power customer, and the instant message delivery, are described to illustrate the internal working mechanism of each shared service centre and the cooperative mechanism between the shared service centres [16][17][18].

3.1. Management of Comprehensive Energy Business
As shown in Figure 2, the electric power customer submits the online request for the comprehensive energy business, such as new photovoltaic installation and electric charging station installation. Ticket Centre generates the ticket for the request, splits the ticket and distributes the tickets to the corresponding business unit. Ticket Centre updates the processing progress of the tickets in real time according to the feedback from the business units.

The specific processes are described as follows: (1) The request is routed to Ticket Centre from the front application, which could be via Online Customer Service Centre, or not; (2) The ticket is
automatically split and retrieved at Ticket Centre; (3) The ticket of the electricity business expansion is automatically dispatched to the corresponding business unit (for instance, the province subsidiary of the power grid enterprise); (4) The ticket of the new photovoltaic installation or electric charging station installation is automatically dispatched to the corresponding business unit (for instance, the ecommerce or electric vehicle subsidiaries of the power grid enterprise); (5) The processing progress is updated for the ticket of the electricity business expansion; (6) The processing progress is updated for the ticket of the new photovoltaic installation or electric charging station installation.

**Figure 2.** Management of comprehensive energy business

### 3.2. Online Interaction Service for Electric Power Customer
As shown in Figure 3, the electric power customer clicks on the online customer service via the frontend application to initiate a conversation with the intelligent robot. The robot can respond quickly to the customer needs via various forms such as text, graphic, video, etc. If the robot cannot meet the needs, the request can be transferred to the customer service representative. The specific processes are described as follows: (1) The customer has conversation with the intelligent robot; (2) The customer chooses to transfer to the customer service representative; (3) The electricity, electronic bill, customer profile could be provided to assist the conversation of the online customer service.

**Figure 3.** Online interaction service for electric power customer

### 3.3. Instant Messaging Delivery
As shown in Figure 4, when the ticket status is changed, Ticket Centre submits the request of the message delivery to Messaging Centre, which will create the message content according to the
message template, and send the message via the specified channel. The specific processes are described as follows: (1) When the ticket status is changed, Ticket Centre invokes the service of Messaging Centre to generate a message; (2) Messaging Centre receives the request of the message delivery and writes the request to the message delivery queue; (3) The app message request is retrieved by the service of the app message pushing, which triggers to push the message to the mobile application; (4) The email message request is retrieved by the service of the email sending, which triggers to send the email to the customer; (5) The short message request is retrieved by the service of the short message sending, which triggers to send the short message to the customer.

![Diagram of Instant Messaging Delivery](image)

**Figure 4.** Instant messaging delivery

4. Key Technologies Study on Omnichannel Business Platform Implementation
Since each service capability provided by the omnichannel business platform will bring the most professional ones for the electric power marketing business, the higher requirements are brought to the business platform: the provided services should be more stable, the service capability should be scalable, and the response should be faster. Some key technology applications and practices should be broken through during the implementation of the omnichannel business platform.

The limitations of data processing capabilities can be broken through by practicing the technologies of database partitioning, distributed database with sub-database/sub-table and column storage, to solve the I/O performance bottleneck that the traditional centralized database cannot surpass, and to have the ability of the linear performance expansion of the database. The integrated services with fast response can be achieved by the means of the asynchronous implementation of the business processes and the database transactions, the performance improvement of the strong consistency transaction, and the reasonable exploitation of the caching technology, all of which can provide the support to solve the issue of the poor performance of invoking service calls between the shared service centres, to guarantee the final consistency of the message transaction and the data synchronization in the complex network environment, and to reduce the time of the service response and improve user experience. The digital operational capabilities can be achieved by establishing the capabilities of the event tracking and log collection, the distributed processing of massive logs, and the real-time flow computing; then the full link monitoring solution in the complex environment can be obtained to build the abilities of the real-time monitoring of the service status, the tracking analysis of the service invoking chains, and the real-time monitoring of the business processes.

4.1. Improve Data Processing Capabilities
In the process of building the shared service centre, each service centre has its own independent database, that is, the business data is vertically partitioned, which greatly alleviates the performance issue caused by the limitation of the database connection resources, and too many tables and data in the database. However, with increasing the population of the electric power customers and the development of the electric power marketing business, the data access to the single service centre will
inevitably reach the upper limit of the database, especially for User Centre, Oder Centre with much heavier load than the other shared service centres. Therefore, some data processing technologies should be taken to improve the capabilities [19][20].

First of all, the read-write separation of the database can be implemented, i.e., let the master database handles the transactional operations of insertion, update and deletion while the slave database is specifically responsible for processing the query operations. The database will synchronize in background the data modification in the master database caused by transactional operations to the slave database in the cluster, which expands the capability of the database to process data reading, and the overall capabilities can be greatly improved of the data reading and writing in database.

When there is a large amount of data in a single table, the database can be sharded by horizontal partitioning, i.e., the different data in the same table is split into different databases. The distributed database framework can be used to provide support of database sharding in the various business scenarios. Adding SQL parsing can support more accurate routing control, cross-database merging, statistics and other calculations. In the case of high concurrent requests, it is necessary to consider heterogeneous indexing means to circumvent, in order to expand the overall capacity of the database, and to use asynchronous mechanism for saving each complete creation or update in the original table to another dimension to save a complete data table or index table. The essence of the table or index table is the solution of "taking space for time" always used by Internet companies.

For SQL requests that require large data volume aggregation operations and calculations in memory, the platform itself will not have much performance impact if such SQL is not heavily concurrent or frequent. Other platforms should be taken into consideration to meet the requirements of this type of scenario, such as Hadoop for offline data analysis of large data volume, if such SQL requests have concurrent or frequent access requirements. If the application requires high real-time requirements, the technologies can be used, such as in-memory database, Hbase, etc. Taking User Centre as an instance, the user data can be distributed at even in several databases by hash code of user ID, which ensures that the data stored in a single database with good read-write performance. The technical component of the distributed database could be adopted in some shared service centres, such as User Centre, Order Centre, etc.

4.2. Build Integrated Services with Fast Response

In the distributed system architecture, the performance of the platform can be improved by the means of the call invoking asynchronization, transactions asynchronization, and real-time data synchronization [21][22], which can solve issue that the response time to the request processing is too long caused by a large number of remote service linear calls and the overall processing throughput is too low. The transaction processing can be used to achieve the balance between transaction consistency and database processing performance when the data is being asynchronously operated. The technologies of caching and database synchronization also play an important role in shortening response time.

In the shared service centre, the service request initiated on the front page needs to be combined with different services of the backend systems to process the service request. The sequential calling mode will take the system longer to process the frontend request, bringing long-term resource consumption in the session processing thread of the service and having impact on the overall system throughput of the server. For the time-consuming synchronous calls, the services that the invocation sequence should be strictly kept in order, are processed synchronously; the services that can be processed simultaneously are handled in asynchronous manner. The shared service centre can exploit the message component to realize the asynchronous operations and improve concurrent processing as much as possible, which greatly reduces the time of processing the entire service request.

In the scenario of order management in Order Centre, for instance, it is necessary for the services of the data update operations, such as order generation, payment record generation, to ensure that these services succeed or fail simultaneously in an order request. The solution for solving the issue of the distributed transaction scenario is based on distributed message transactions, and the final consistency of distributed transactions is achieved by the transaction message function of message queues. By means of the asynchronous transaction with messages, it should ensure the success or failure of the
two database transactions at the same time, maintain the consistency of the transaction, and avoid the long-term resource locking of the data by the traditional two-stage commit transaction mode, so the overall throughput of the database and the performance can greatly exceed the traditional distributed transaction mode. In the case of using a message service to implement distributed transactions if there is an exception, the method of forward compensation is generally adopted, i.e., the rollback will not be performed in turn when the abnormality occurs in the traditional transaction mode, the message will be continuously retried or manually interfered, and the transaction operation continues to move forward, avoiding transaction rollbacks.

4.3. Develop Digital Operational Capabilities
When the distributed shared service centre system is becoming a complex service interactive link network, some issues have to be faced, such as how to get rapid positioning when there are millions of service calls occurred daily, how to monitor the current status of the services in real time, and how to present the focused business indicators to the operation team for their real-time precision marketing. Taking Order Centre as an example, the order creation operation of the user in the frontend applications will trigger the interactions among dozens of servers in the business platform and the backend systems, where there are not only many direct calls between the services invoked in the synchronous or asynchronous manner, but massive interactions to the databases, data caches and distributed file systems [23]. The design of the full-link monitoring service can quickly and conveniently build the business monitoring capability of the second-level response based on the dimensions of the frontend, application, and business customization. The full-link monitoring function realizes the monitoring of the calling link by means of the mature Internet components, which can perform the complete link monitoring and diagnosis on the call request and response initiated by the frontend applications, perform the delved analysis on the call request of each stage, and implement business diagnosis.

The function of the service call chain tracking is a real-time presentation of the service running state and the calling relationships, and to a certain extent, meets the developer's demands for service monitoring. However, it is not much help for the dependencies between the services that the business architect cares about, and the continuous stability and optimization of the service operations. Therefore, it is necessary to have the functions of the calling chain analysis for the business architects. Based on the tracking data of the service calling chain, the statistics and analysis on the data are provided according to a certain time zone, such as month, quarter, half year, etc., so that the business architect can get more rational service chain, and optimized fact data for the supported business decisions. The function of service calling chain analysis is a statistical analysis function tailored for business architects, allowing them to have an intuitive understanding of the operational status of their designed business links in actual production, using the analysed data to target at the optimization of business link processes or improve quality of certain services, which will bring the electric power customers with better user experience.

5. Conclusion
The omnichannel business platform provides the stable, mature data models and shared services which support the power grid enterprise to have quick response to market and minimize system duplication and the cost of operation and maintenance. The mobile application supported by the omnichannel business platform has been officially put on the shelves in major application stores, serving to all electric power customers and gradually becoming the first choice to all customers for paying electricity fees, receiving customer services, etc. Besides the omnichannel business platform, the whole system has been bearing the important mission of connecting electric power customers, gathering various resources, linking supply and demand, innovating business models and fostering ecology, which is an important foundation and support for the development of the electric power marketing business.

In order to meet the requirements for the stable growth of traditional power business, the extended services such as comprehensive energy, and the future innovation and digital operation business, the business capability of the electric power marketing should gradually and continuously be precipitated
in the omnichannel business platform, upgraded and iterated to increase the scope of business and the thickness of the services, providing common shared services to the business application layer, supporting rapid innovation, iterative development, and reducing the cost of the internal development and operation. The platform will continuously strengthen the capacity of data sharing with government platforms to explore the data sharing mechanism for the public services, improve the marketing services by exploring big data and artificial intelligence technologies to mine and analyse the customer behaviour data to ensure the accuracy, quality and efficiency of the marketing services. The basic service capability provided by the existing service centres and the service capability based on the service combination should be evolved into more powerful shared service centres, which could gradually be integrated to become an essential component of the whole enterprise-level business platform for the power grid enterprise.

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