Construction of Big Data Monitoring Cloud Platform for New Energy Industry Chain

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Abstract: In order to solve the problems related to the lack of coordination of production process, production process safety, industrial management confusion, inefficient operation and promotion and safety of new energy industry chain, with the help of the artificial neural network algorithm of reinforcement learning, the bus transmission technology of the Internet of things, big data and cloud platform and other high and new technologies, the big data monitoring cloud platform of the new energy industry chain is constructed, to enhance the capacity of the new energy industry chain for safe production, operational control and sustainability based on technological innovation and promotion, thereby reducing costs and increasing productivity, and based on user demand, prediction and control of power and dual-carbon targets.

1 INTRODUCTION

New Energy sources such as wind energy and light energy are entering the production process and living environment of human beings with a large proportion and on a large scale. Except that the small industries with wind-solar hybrid can be used in densely populated areas, most of the wind, photovoltaic and other new energy power stations (including yard and grid) locate in sparsely populated area. Therefore, there are some problems, such as the lack of coordination of production process, the safety of production process, the confusion of industrial management, the low efficiency of operation and maintenance, and the related problems of promotion and safety. At the same time, there are many problems in new energy data, such as massive multi-source heterogeneity, isolated data island, hidden fault data, dominant fault, imbalance of energy dissipation and storage, low level of intelligent control, etc. (Wang, 2021)

In order to solve these problems, a series of new energy big data platforms have been developed by domestic and foreign new energy industry chain manufacturers. For example, the world's largest energy IoT platform EnOS, UP-WindEYE system platform integrating high-speed real-time communication and super-grid support, "wind-gathering control ABC distributed system platform" built by Shanghai Electric Company of China, they are all the best at what they do. The data collection strategy of new energy big data platform is an important part of cloud platform construction (Wang, 202; Yang, 2019). Reference (Shi, 2017) based on R, Python, H2o, Spark methods, data mining and full data model training and verification are realized, and a large data platform for new energy of wind power is constructed. Reference (Liu, 2021) based on massive data, a new method for large-scale access state estimation of new energy distribution network is proposed, and the constraints of new energy platform after grid-connected are established. Most of the new energy platforms use the cloud to acquire multi-source data, perform massive parallel computation in the distributed cluster, and feed back the information to the field and the client to realize the reasonable dispatch and allocation of resources (Sun, 2021). When it comes to cloud computing, reference (Zhang, 2022) presents a hybrid algorithm, a parallel residual convolutional neural network (HPR-CNN) model for RUL prediction, by fusing multi-period data, the hidden features are used to extract different depth information effectively through residual network, and the on-line cloud prediction is realized in practical application. Reference (Zhang, 2021) based on the basis of Personal Computer technology, using HADOOP big

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data management platform, a new distributed data cluster management system is adopted, and the basic design features and implementation of Hadoop big data platform are described in detail. In data optimization, dynamic prediction and scheduling, artificial intelligence algorithms have been applied more and more widely and mature.

In the aspect of data collection, this study adopts multi-source data fusion technology based on industrial company's Internet of things platform and cloud resource layer utilizing Siemens bus communication, and develops distributed file storage technology, with the functions of high compression ratio, real-time I/O, support vector operation and high scanning performance, it can realize multi-level index and instant retrieval of mass data. In cloud computing, data optimization and dynamic prediction, the cloud platform adopts an enhanced depth q network training algorithm (Huawei, 2022) to make full use of the advantages of the elastic cloud server, and Integration of multi-professional computing and performance analysis software to achieve dynamic optimization and scheduling adjustment.

2 CONSTRUCTION OF BIG DATA MONITORING CENTER PLATFORM FOR NEW ENERGY INDUSTRY CHAIN

The platform of big data center is based on the elastic cloud platform of deep learning ANN Technology and multi-source data fusion, communicating decision-making layer, big data institute, and Industrial Company chain. Through the Operation Management Center management and achieve efficiency analysis, data management, sales management, energy dissipation, scheduling coordination and other multi-channel coordination. Through the supporting business center to achieve fault diagnosis, disaster forecasting, weather environment, solve the hidden danger, supporting industries and other supporting industrial chain

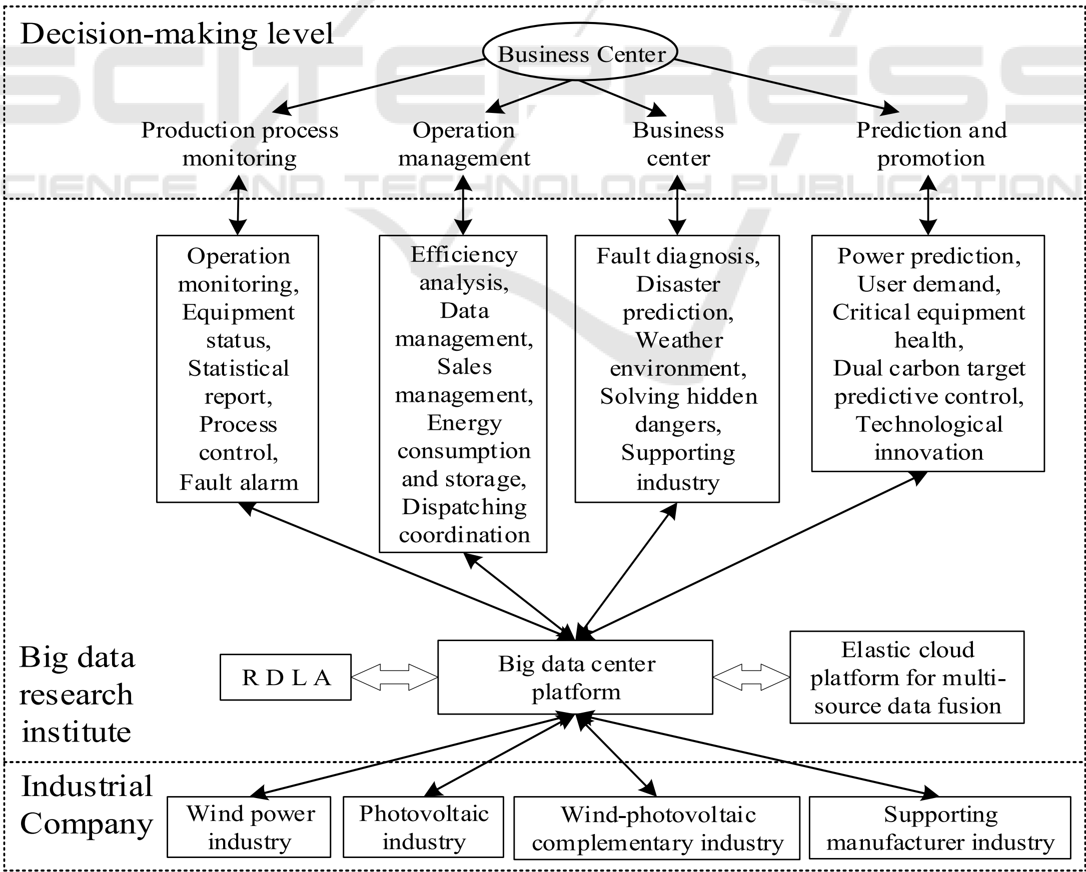

Figure 1: Big data business architecture.

operations. The forecast and control of the future target is realized through the forecast and extension center, including power forecast, user demand forecast, key equipment health condition assessment, double carbon target forecast control, and technology innovation and so on. Big Data Centers Exchange data with the IoT platform of industrial companies through the elastic cloud platform of multi-source data fusion. The industrial companies not only include the conventional wind power and photovoltaic industries, but also in this design, in particular, include the small-scale industries with complementary scenery and the relevant supporting manufacturers, because the supporting industries, especially the industries with supporting key components, it is of great significance to the sustainable operation of the new energy system. New Energy Industry Chain Big Data Monitoring Center platform functional structure and data flow, as shown in Figure 1.

2.1 Cloud Management Interface Between Big Data Center Platform and Multi-Source Data Fusion

Elastic cloud platform API service and cloud resource layer are the technical elements and physical carriers of cloud management interface between big data center platform and multi-source data fusion respectively. Elastic cloud server has rich specification types, rich mirror types and disk types, reliable data security and efficient operation and maintenance, real-time cloud monitoring and load balancing functions.

The platform of Internet of things based on data collection of Industrial Company realizes data interchange with data source through Siemens bus. The Siemens bus, which is the basis of Industry 4.0, seamlessly integrates with the ECS and OpenStack native interfaces provided by the elastic cloud server, allowing it to adjust the specifications of the elastic cloud server as needed, build a reliable, safe, flexible and efficient computing environment. Flexible cloud platform API services allow for interface switching and debugging in the API Explorer. The core of the “Remote management” module of the IoT platform is the construction of the network transport layer (Li, 2020). In this design, the network transport layer is constructed by using Intel Virtualization Technology, using Intel Virtualization Technology to build a part of virtual machine in Lan, Internet, fiber ring network and so on, to improve the network transmission speed, provide a smooth network environment for data transmission. It also takes advantage of the Intel Virtualization Technology’s flexible deployment capabilities to receive and process data from the bus based perceptual control layer, and to convert the data into structured data that can be distributed to a nearby virtual machine. As an important part of the transition between the sensing control layer and the elastic cloud computing service layer, the network transport layer uses Intel Virtualization Technology to receive the data first, then process the data, finally, the processed data is transferred to the cloud

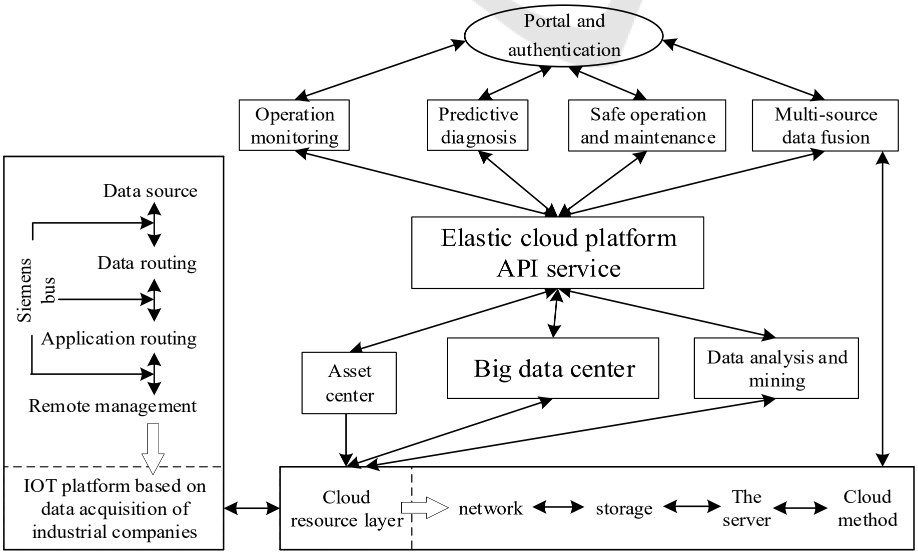

Figure 2: Cloud management interface between big data center platform and multi-source data fusion.

resource layer, which can greatly reduce the data computation of the cloud computing service layer, and make the cloud computing service layer concentrate the computing power resources on the big data analysis, data mining and so on.

A cloud management interface for large data center platforms and multi-source data fusion, as shown in Figure 2.

2.2 Dynamic Optimization Strategy of Cloud Computing and Data

With the rise of deep learning, the combination of deep learning and reinforcement learning has received a lot of attention. Deep reinforcement learning integrates the powerful perceptive ability of deep learning into the traditional reinforcement learning algorithm, which forms a new research hotspot in the field of artificial intelligence. In this design, an intelligent algorithm based on reinforce deep learning ANN (RDLA) is used in cloud computing, data optimization and dynamic prediction, which can not only be used in the related business of the big data center platform, and it can be directly used in the process of multi-source data fusion. The principles of fast transmission, high speed calculation, high-cost performance and reliability, and meeting double carbon targets are emphasized in the calculation and implementation. The depth q network learning method in reinforcement learning is the foundation of the Algorithm. It uses the idea of "Value function" approximation to fit the long-term value of each "Action" under the current state through a strategy value network, in the decision-making directly using the highest value of the "Action", the use of neural network strong nonlinear processing capacity, to achieve the state dimension reduction. At the same time, the "small step" reinforcement learning method is adopted in the rigid system processing link to improve quality and control accuracy, while the "Large step" artificial neural network simplified learning method is adopted in the non-rigid system processing link (Liu, 2020), to get better cost performance.

The core process of cloud computing and data dynamic optimization strategy RDLA, are described and illustrated in Figure 3.

3 APPLICATION CASE: STABILIZE THE POWER GENERATION THROUGH THE PREDICTION AND PROCESSING OF EXTREME WORKING CONDITION DATA

Taking the real-time monitoring of large-scale wind turbine blades in the wind power field of a wind power company as an example, the power generation

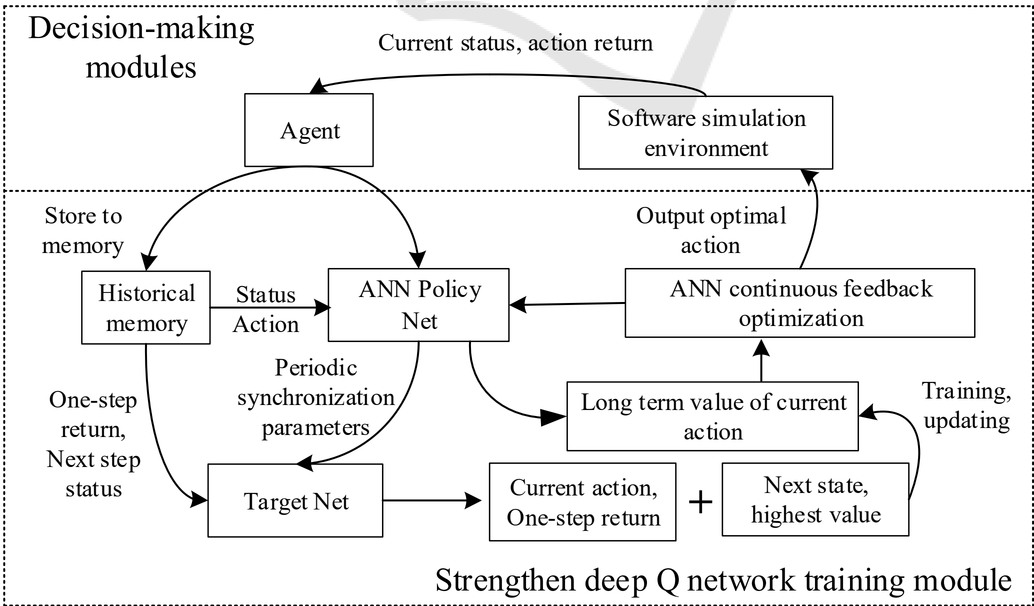

Figure 3: The core process of cloud computing and data dynamic optimization strategy RDLA.

is stabilized by predicting and processing the data of extreme working conditions. The company's large wind turbine blades adopt flap structure and hydraulic pitch system to jointly deal with the aerodynamic instability excitation under extreme working conditions. Under normal working conditions, the flap is in the initial and non-excitation state, and the maximum power is obtained only by pitch driving. Under extreme operating conditions, such as the blade is in stall state, the power is attenuated, and the blade is in a pneumatically excited hazardous state with potential damage. In mild and moderate stall states, the power will be attenuated, and with the continuation of stall state, the blade may produce potential invisible faults and affect the blade life. In the severe stall state, if the stall state continues to extend, not only the power will be extremely attenuated, but also the blade may produce an instantaneous dominant fault-fracture failure.

In the "on-site real-time monitoring" link of production process monitoring of the big data platform, the fully distributed optical fiber sensing differential pressure feedback measurement system installed in the blade finds that the blade is in stall state, and directly transmits the on-site wind condition data and stall state to the cloud resource layer through Siemen's bus and remote managed virtual machine system. The elastic cloud APP pulls out the NA63215 airfoil structure data chord length c and density ρ_b stored in the big data center, and uses the Xfoil software and AirfoilPrep software in the built-in software environment to obtain the lift and drag aerodynamic coefficients C_L and C_D, for angle of attack α in the range of -90º~90º , and likewise fits them to the sixth-order Taylor series curve. Combined with the continuous integration of multi-source data, the elastic cloud server invokes the RDLA system for the optimization process. The sixth-order Taylor series expression of the invoked original data and the optimized aerodynamic coefficient is as follows:

$$f(w)=\sum_{i=1}^{6} a_i \sin\left(b_i w + c_i\right) \tag{1}$$

where w is the ratio of airfoil position vector to blade span, when $f(w)$ represents c and ρ_b; w is the instantaneous angle of attack of the airfoil, when $f(w)$ represents C_L and C_D.

Table 1: Parameters of aerodynamic Coefficients in six-order Taylor series.

Items	c	ρ_b	C_L	C_D
a_1	5.5609	21.659	0.8687	3.3091
b_1	3.9432	4.6555	2.0731	0.3508
c_1	-0.3823	0.2601	0.0412	1.4879
a_2	141.88	25.485	0.3071	0.7147
b_2	8.5757	8.5638	4.0132	2.0368
c_2	-0.3955	-0.2688	-0.0581	-1.5801
a_3	139.09	12.477	0.1990	2.6581
b_3	8.6264	12.522	5.8919	0.4023
c_3	2.7111	0.7951	-0.0509	-1.6633
a_4	0.3314	4.0963	0.1711	-0.0180
b_4	18.433	21.243	0.7129	2.9866
c_4	-0.4111	-1.8908	0.8469	-1.5277
a_5	0.2577	2.2964	0.1375	0.0201
b_5	24.511	25.077	7.6131	3.9489
c_5	-1.3026	-1.4001	-0.1191	1.5861
a_6	0.1405	0.3705	0.0856	0.0003
b_6	30.595	36.386	9.2975	4.8155

c_6	-1.1844	-5.5199	-0.1929	-1.5748

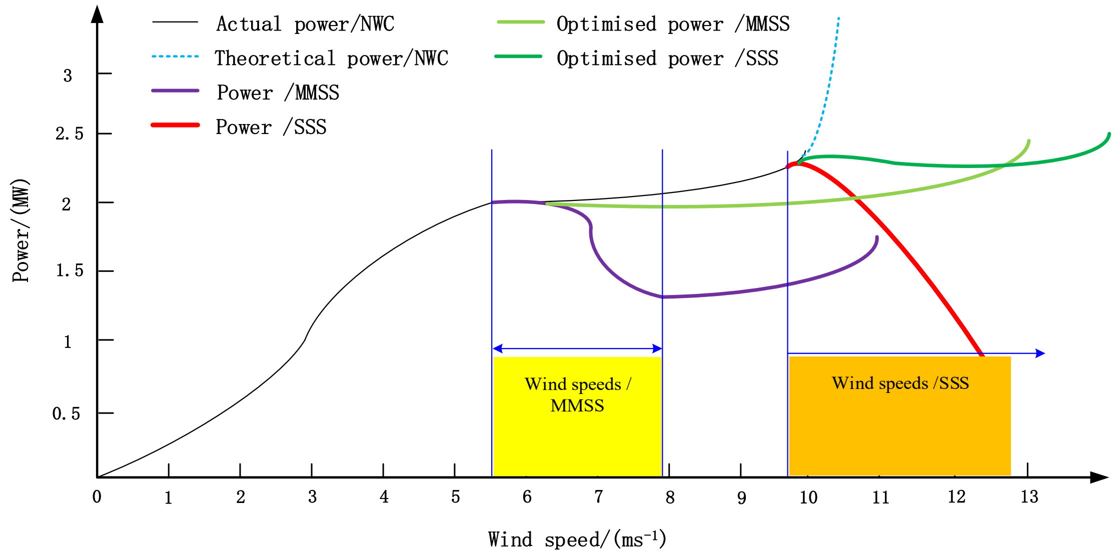

Figure 4: Power comparisons between normal working condition, stall state and that after optimized control.

Figure 4 shows the comparison between the power under normal working conditions, the power under stall state and the power after optimized control. The black line represents the actual power (Actual power/NWC) under normal operating conditions, because the wind speed under normal operating conditions on land generally does not exceed 10ms^{-1}, so at the end of the normal operating curve, when the wind speed exceeds 10ms^{-1}, is the Theoretical power/ NWC, which is the blue dotted line of the theoretical derivation. The wind speed corresponding to the light-yellow area in the figure is the wind speed fluctuation area with mild and moderate stall state, and the approximate range is between 5.5-7.9ms^{-1}. The purple curve represents the power fluctuation (Power / MMSS) in the state of mild and moderate stall without control. The light green curve is the power (Optimised power / MMSS) after the dynamic optimization control is turned on when the blade has mild and moderate stall, its numerical fluctuation is between the normal working condition and the stall state, and the fluctuation is stable, which reflects the effectiveness of the dynamic optimization control algorithm. Although it cannot reach the maximum power under the normal working condition, it is higher than the power under the stall state. More importantly, it avoids the harm of mild and moderate stall to the blade and the generation of blade hidden faults. At this time, the active control from the big data monitoring platform only drives the flap action to avoid mild and moderate stall. When the wind speed is greater than 9.6 ms^{-1}, the blade is in a severe stall condition. The red curve represents the power generation (Power /SSS) under the heavy stall state. The dark green curve represents the power (Optimised power /SSS) after the dynamic optimization control is turned on in case of severe stall of the blade.

After the stall state is controlled, the power is lost, at this time the big data monitoring platform simultaneously adjusts the matching of energy consumption and storage, completes the scheduling of relevant supporting links, so as to make the power grid in a stable output power supply state.

4 CONCLUSION

The design is based on reinforced deep learning to build a big data monitoring cloud platform for the new energy industry chain. Its big data business architecture communicates with the decision-making level, the big data research institute and the front-line industry companies, including production process monitoring, operation management, operation of relevant supporting business centers, prediction and promotion of sustainable business, to the wind power industry, photovoltaic industry, and all aspects of operation and maintenance management of relevant front-line supporting industries. Its advantages are reflected in the following aspects:

1) The big data center platform is based on RDLA and the elastic cloud platform of multi-source data fusion. It fully combines the cutting-edge RDLA optimization technology, the characteristics of multi-source transmission of industrial 4.0 Internet of things and the advantages of elastic cloud platform, so that the real-time transmission, elastic optimization storage, synchronous processing and dynamic optimization of massive data can be realized.

2) RDLA technology makes the comprehensive combination of reinforcement technology, deep learning and ANN, which is no longer limited to a single data mining process, but also successfully applied in cloud platform computing, dynamic optimization and active control.

3) The elastic cloud platform is no longer limited to a single cloud storage and cloud computing function. It can be seamlessly integrated with the industrial 4.0 platform of the Internet of things. At the same time, it has built-in rich engineering application software interfaces, making it possible to realize the real-time dynamic control and remote field regulation.

4) The specific case implementation of this paper only reflects a strategy of big data monitoring cloud platform to deal with extreme working conditions, and the function of big data monitoring cloud platform is not limited to this. It can also be used in consumption and energy storage optimization, fault prediction and diagnosis, power optimization and double carbon target control, coordination of real-time production and supporting industrial chain, sales management and scheduling coordination, and many other optimization processes.

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