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Centralized Management and Control System of Offshore Engineering based on Dynamic Programming Algorithm

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Abstract: At present, from the situation and trend that the three major domestic oil giants have successively gone abroad to participate in project construction in overseas countries, the importance of the centralized control(CC) system of offshore engineering(OE) is increasingly prominent. It has become an inevitable trend for the CC and integration of offshore oil engineering to enter informatization and standardization. At the same time, it is also one of the important topics facing the offshore oil engineering industry. This paper designs and analyzes the centralized management and control system of OE based on dynamic programming algorithm(DPA). By analyzing the problems existing in the management of OE, this paper discusses the framework principles and processes of the development of the centralized management and control system of OE, analyzes the application of DPA in the centralized management and control of OE, and then designs the centralized management and control system, which greatly improves the development efficiency and security of OE.

1. Introduction

With the rapid development of China's economy, especially since the 12th Five Year Plan, such characteristics as difficult construction, complex technology, high risk, many participating units, large investment and complex information communication have gradually emerged in China's marine engineering projects, which makes China's marine engineering project management face severe tests and challenges. With the rapid development of various software and hardware technologies in China. With the popularization of the Internet and the advent of the era of knowledge economy, the design of CC system for OE has become an inevitable trend. Therefore, this paper proposes a DPA, and designs the centralized management and control system of OE based on this algorithm.

The quality of CC information data of OE is the cornerstone of digitalization of engineering facilities, and the quality control of engineering data of the project team is an important link for the smooth implementation of the whole project. During the construction and construction of offshore oil's oil and gas field project, the project information must be collected in real time as much as possible to facilitate the project manager to make decisions [1]. The data handover time at the completion stage is also very important. If the handover time is too long, the production and operation efficiency will be low. Scholars at home and abroad have carried out a series of studies on the system design of DPA in centralized management and control of OE [2].

Aiming at the design of CC system of OE, this paper proposes a DPA based on previous studies, and designs the CC system of OE based on this algorithm. The design and development of the CC system avoids the continuous use of offline document office processes to deal with a large number of engineering data information generated during the implementation of large-scale construction projects, greatly improves the efficiency of OE development, and unifies the operation platform. The documents, information, data and other related resources of the project are shared to the maximum extent, giving full play to the value and timeliness of these project information, So that the project can quickly and smoothly transition from construction to operation [3-4].

2. Design of CC System for OE

2.1. CC System for Problems in OE Management

Since the implementation of the 12th Five Year Plan, the construction of offshore oil and gas field development projects has reached a peak, which is a leap forward development stage of deep-water oil and gas field development. With the rapid advancement of large-scale construction projects, a large amount of engineering information and project documents will be generated. CNOOC's engineering project management is relatively mature. The owner and contractor are generally CNOOC enterprises, and under the leadership of the company, many sets of information management systems have been built, which has a good supporting effect on the improvement of engineering project management [5-6]. However, the basic information data of facilities are not fully collected, sorted out and stored, and there is no basic database prepared at the company level, which seriously affects the integrity management of facilities assets and increases the cost of oilfield operation and later development. Due to the parallel and tight cycle of many OE projects, the frequent flow of project management personnel, insufficient training, huge project investment, great reliance on the personal ability and experience of the project manager, and lack of standardization and effective control [7-8].

CNOOC's management of engineering management project documents is limited to offline management of paper documents. However, the construction sites of participating units are blooming everywhere, the number of personnel responsible for the collection and management of project information and documents is small, and the mobility of personnel is large, resulting in the omission of some documents and the loss of data. In addition, some projects do not pay attention to collecting relevant documents and materials in the early stage of the project, and only supplement them in the later stage of the project, resulting in the final collection of project information [9-10].

2.2. Development Process of CC System for OE

System planning stage: in the system planning stage, conduct preliminary communication with relevant staff, design the overall scheme of the new system according to the user's requirements for the system, conduct feasibility analysis, and complete the system development plan and feasibility study report [11].

System analysis stage: in the system analysis stage, according to the development scope determined in the planning stage, the system is investigated in detail, the business process is designed, the shortcomings are pointed out in combination with the needs of users, and the basic objectives and logical models of the new system are determined through timely communication with users, and the system analysis specification is completed [12-13].

System implementation stage: in the system implementation stage, the purchase, installation and commissioning of computers, switches and other equipment, the preparation and commissioning of application programs, and the training of relevant application personnel should be carried out. The work in each stage should be carried out as planned and the implementation progress report should be completed [14-15].

2.3. Framework Principle of CC System for OE

The hierarchy division of the system follows the following principles: separation of business logic and interface implementation; Function modularization; Atomization and objectification of business logic; The system architecture of the system platform big data CC center is mainly divided into three layers, and the data center architecture is mainly divided into five layers, as shown in Figure 1:

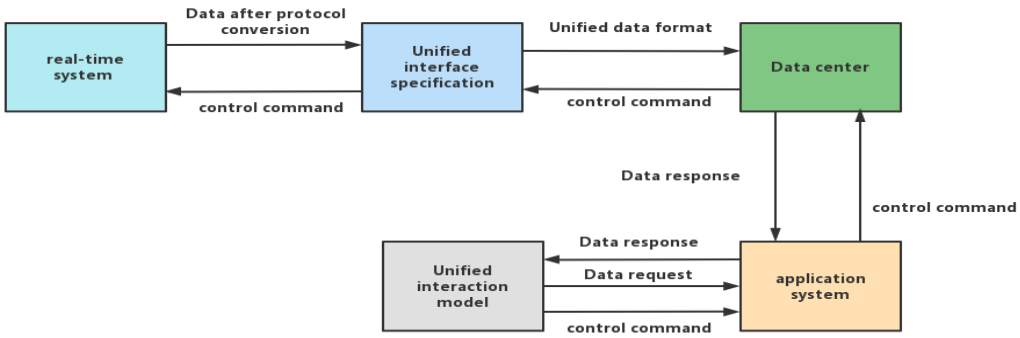

Figure 1. Data center architecture

2.3.1. System Interface

According to the design of the data integration technology of the data centralized supervision system, the technologies used for the data integration between the business application system and the data center include ESB and data access. The selection principles of the technical route are shown in Table 1:

Table 1. Selection principle of technical route

technology roadmap	Single data volume is less than 2m	The single data volume is more than 2m, and the real-time requirement is not high	The single data volume is more than 2m, and the real-time requirement is high
ESB mode	√		√
Data access method		√	√

For the CC system with a single transmission data volume larger than 2m of the CC system and low requirements for real-time data, the data access method is adopted to achieve data access For those with large amount of data and high real-time performance, it is recommended to use the mode of combining CC system ESB CC system and data access mode for data access [16].

2.3.2. Data Access Mode

Data access means that after the centralized data supervision system provides the intermediate database table and grants certain access rights, each business system pushes the data to the intermediate database table to achieve data access. As shown in Figure 2, the specific implementation steps are as follows:

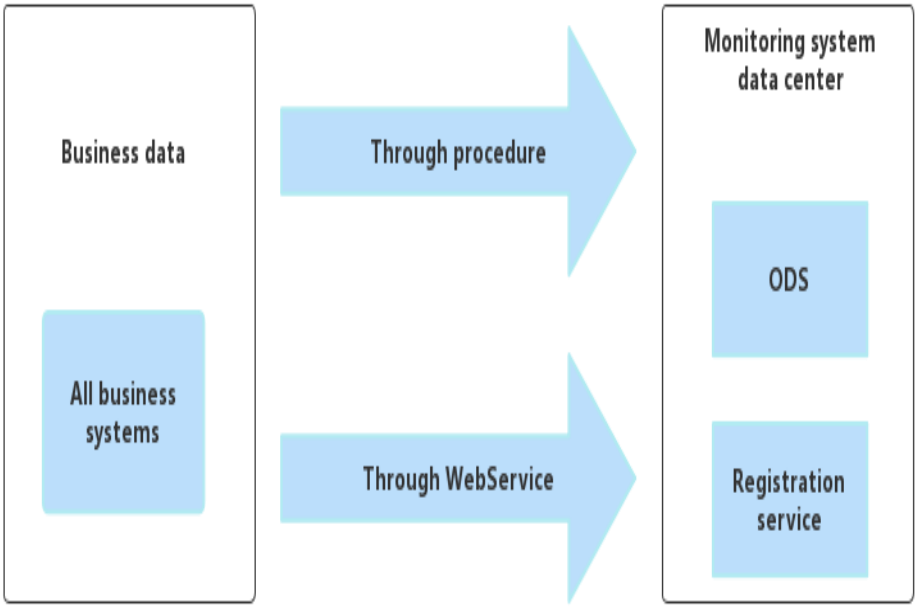

Figure 2. Data access method

The data center provides CC system ODS users and data storage models with select / insert / delete permissions of the CC system, and provides CC system Web Service CC system services of data resource access logs; Each business application system is coded according to the data center; After the business data is pushed, the business application system calls the CC system service of the supervision system access log CC system Web service to record the data access log. The recorded information includes the table CC system ID, the table primary key, the number of records and other information [17-18].

3. DPA

DPA is a mathematical optimization method proposed by Behrman, which is often used to solve multi-stage decision optimization problems. This algorithm is based on the bellman optimality principle, and seeks the best solution of the problem by solving all possible decision-making quantities at each moment. Moreover, this method has high programming properties and is very

suitable for solving by computer. Therefore, this algorithm is widely used in the system design of CC of OE.

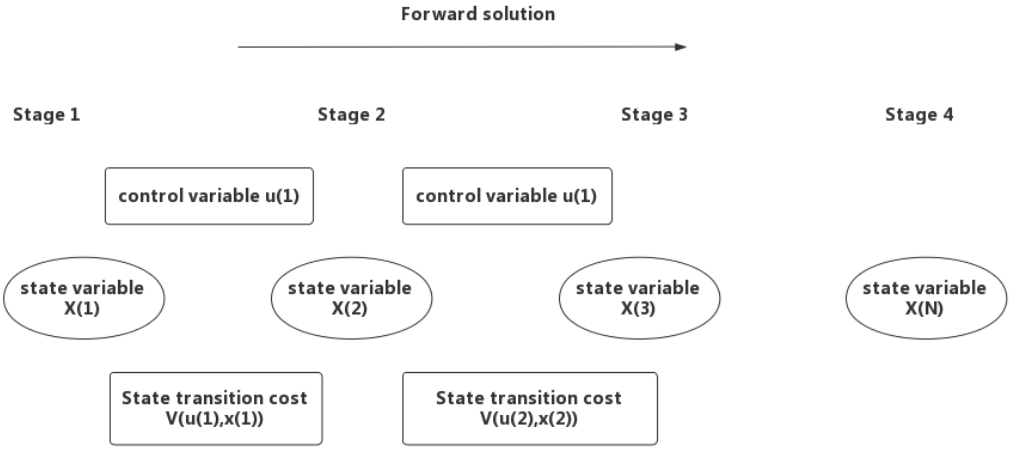

Figure 3. Schematic diagram of DPA

The basic principle of the DPA is shown in Fig. 3. Its main idea is to convert the multi-stage problem into a single stage problem, solve each sub problem in sequence according to the preset stage order, and then obtain the optimal decision sequence until all the sub problems are solved.

In general, if you want to use dynamic programming to solve the problem, the problem to be solved must conform to the following three characteristics: no aftereffect: previous states and decisions will not have any impact on the evolution of the subsequent process; Optimization principle: for the decisions already made, the decisions made in the rest of the process must form an optimal decision; Overlap of subproblems: there are overlapping parts between subproblems, and the solution of the current stage subproblem may be used in the solution of subsequent subproblems.

Based on the above principles, the global optimization problem of the centralized management and control system of OE can be decomposed into two-stage decision-making problems of the centralized management and control system n. The back-to-front calculation method can be adopted, which can reduce repeated calculation and improve the solution speed. After discretization in the time domain, the state transition equation of the system is:

$$a(h+1) = g[a(h), u(h)] \tag{1}$$

Where, a (H + 1) and a (H) are the time states of the system's first CC system H + 1 and H CC system respectively; U (H) is the control amount of the CC system of the first CC system h at the time.

From formula (1), it can be seen that the problem required to be solved is to solve the optimal system sequence of centralized management and control of OE to minimize the objective function. The form of the objective function is shown in formula (2).

$$W = \sum_{h=1}^{N} V[a(h), u(h)] \tag{2}$$

Where, h is the current stage; V is the instantaneous transfer cost; N the CC system is the total number of stages after the centralized OE isolation cycle time domain; W is the accumulated cost

function value during the iteration.

4. System Design of Centralized Management and Control of OE based on DPA

4.1. Overall Architecture of Marine Engineering CC System based on DPA

The overall architecture design of the system is divided according to the business functions of the system. The overall architecture of the marine engineering CC system is divided into system layer, business platform layer and application layer according to the business functions. The application layer includes application function modules such as salary management, attendance management and to-do management. The platform layer, as the support of the upper application layer, provides basic functional modules such as workflow engine, search engine and online processing engine for OE based on DPA. It is not necessary to integrate all engines in the process of system development, Instead, secondary development is carried out according to specific business needs through DPA in the development process. The system layer is the software and hardware support environment of the platform layer, providing system resource scheduling, management, operation monitoring, etc. for the operation of the platform layer. The overall architecture of the system is shown in Figure 4.

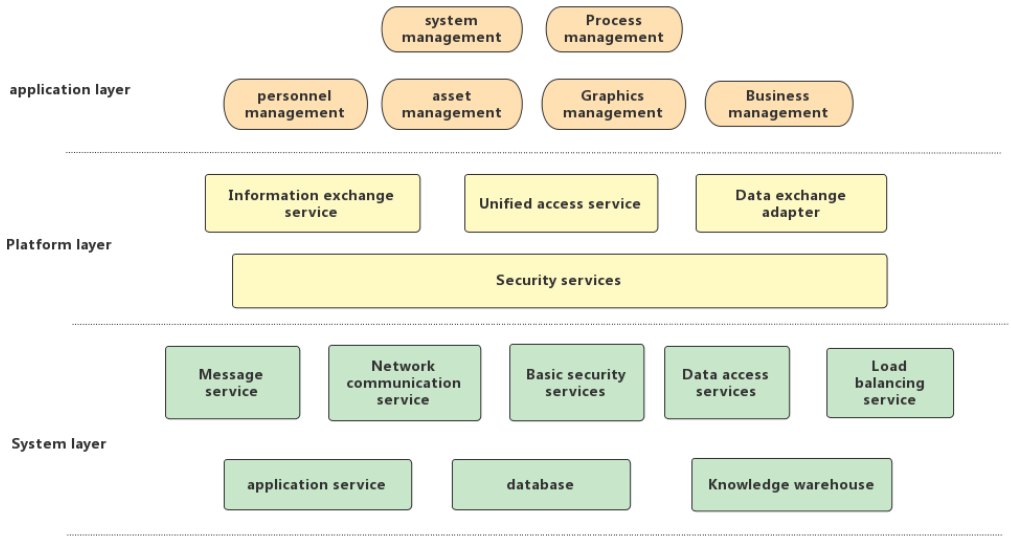

Figure 4. Overall system architecture

As shown in the overall system architecture in Fig. 4, according to the architecture design mode and theory, the system architecture is divided into system layer, platform layer and application layer from bottom to top. In the layered architecture design idea, each layer contains corresponding functional modules. The modules of the same layer provide a unified calling interface for the upper layer services in a relatively independent loose coupling manner. The lower layer functional modules provide services for the upper layer service modules in a transparent manner. The upper layer functional modules complete business processes and data transmission through the lower layer functional modules.

The system layer provides software and hardware environment, system operation resource management, control and operation status monitoring for the whole system. The advanced architecture design mode must consider the forward compatibility of existing hardware resources. Therefore, in the architecture design process, it is necessary to fully consider the software and

hardware collocation of the DPA system layer to prevent unreasonable resource requirements in the process of calling the upper layer to the lower layer. The data format, message transmission mode, call mode and function connection of all modules in the three layers need to formulate interfaces that meet the specifications and standards, and finally generate system documents to facilitate enterprises to complete secondary development by themselves.

The system layer provides basic functions and services, mainly including data warehousing tools and application servers. It includes network communication service, data access service and security mechanism. Load balancing refers to the deployment of application servers through load balancing software to meet multi-user and high concurrent access.

The platform layer provides modular functional components for the application layer based on the software and hardware resources and management resources of the system layer. On the one hand, the platform layer provides unified data access format and message transfer format for the application layer while ensuring the system operation, application access security and data security. Workflow engine and other functional modules serve as libraries to provide services to the upper layer.

The application layer mainly includes process management, system management, personnel management, graphic icons, asset management and business management. The process management is responsible for the processing of the system's business processes, and its sub functions include new processes, process delegation, to-do matters and settlement matters. The personnel management function module provides management functions for enterprise personnel information and other contents, including personal attendance query, attendance management, salary management, etc. The graphical report function provides system users with powerful graphical report functions, including report import, export, generation, review, submission and other functions.

4.2. Detailed Structure Design of CC System for OE

The detailed design of the system adopts the DPA (described. According to the software engineering idea, the detailed design process of the system and the detailed design process and work of the system are shown in Fig. 5).

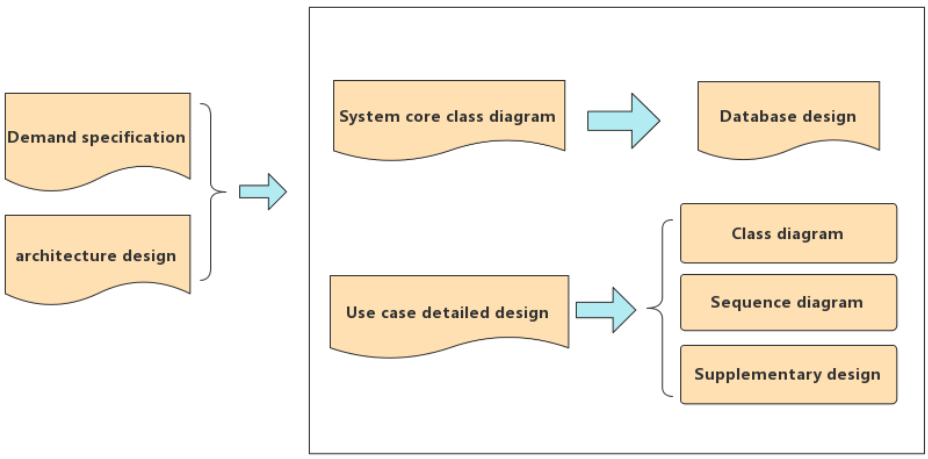

Figure 5. System detailed design

As shown in Figure 5, in the software life cycle, the detailed design of the system is to complete the detailed design of the core classes and use cases of the system entities on the basis of the

specification analysis of the DPA and the system architecture. In the detailed design process, according to the system business requirements, module division and call relationship, the class diagram, sequence diagram, database logic design and database table structure design are completed. In the detailed design process, we need to make full use of the design idea of DPA, including object-oriented demand analysis, design, testing, maintenance, etc. This chapter completes the detailed structure design of the system on the basis of the forward, and completes the design of the system database.

5. Conclusion

With the continuous improvement of the information level in the field of offshore oil engineering in China, more and more work needs to rely on network assistance, and higher and higher requirements will be put forward for the standard and standardization of engineering data. The centralized management and control system of OE is only the initial stage of information development in the field of offshore oil engineering construction, and there are still many problems that need to be continuously supplemented and improved in the future. The main problems are that in this system, the storage space of physical files is small, and there is a maximum limit of disk space. With the passage of time or more projects using the system, a large amount of data in this system will accumulate. The next step is to consider deploying connected storage. In order to meet the increasing new demands, the CC system can explore new, advanced and relevant data mining technologies in the next step, and apply these technologies to the system, so that the system can better analyze and manage the data systematically and provide auxiliary key data for the leadership when making decisions.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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