Design And Implementation of Construction Project Management System Based on Web Technology

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Abstract. This article addresses the issue of inefficient information transmission and coordination in construction project management and designs and implements a web-based construction project management system. The system employs a B/S architecture and utilizes JavaScript and PHP for front-end and back-end development, respectively. It encompasses multiple functionalities, including project progress management, resource management, quality management, and communication collaboration. By dynamically generating project task network diagrams, the system provides a visual representation of project plans. Additionally, it facilitates centralized management of project documentation and team collaboration through online discussion forums and document sharing. The system enhances the digitization of construction projects, effectively promoting standardization and collaboration in project management.

Keywords: construction engineering, project management system, web technology.

1. Introduction

In traditional construction project management, the outdated management approach leads to poor information exchange and suboptimal resource allocation. Therefore, establishing a project management information system is imperative. This system can facilitate the collection, transmission, sharing, and collaboration of information throughout the entire project process, thereby improving work efficiency. Compared to traditional paper document management, information systems offer advantages such as timely document updates, quick data statistics, and precise resource scheduling. Additionally, the system can generate various statistical reports and planning charts, enabling project managers to monitor and control project progress more intuitively. This article designs and implements a construction project management system using web technology. The system includes functions for project progress management, resource management, and communication and collaboration, addressing issues such as information isolation, difficult resource allocation, and ineffective team collaboration, ultimately achieving comprehensive information-based project management.

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2. Overall System Design

2.1 System Architecture

Before constructing any complex system, it is crucial to understand its architecture and components. This article will introduce a system based on the B/S architecture (Browser/Server model)[1], where the main components of the system run on the server, providing users with robust functionality and stable performance, as shown in the table below.

Table 1 System Architecture

System architecture	B/S architecture (Browser/Server mode)
client	Browser
Server side	Linux server
Front-end technology	HTML, CSS, JavaScript
Back-end technology	PHP language
Archive	MySQL
Server-side operation	Business logic processing, data access, data dynamic generation, etc
User access mode	Access the Web server through a browser

As shown in Table 1, the B/S architecture enhances system stability and efficiency, while keeping low hardware and software requirements for clients. It also offers easy deployment and maintenance, allowing multiple clients to share a single server, thereby reducing overall costs[2]. Additionally, this architecture facilitates application maintenance and updates as upgrades can be performed on the server side without requiring modifications on the client side, greatly simplifying version management.

2.2 Functional Design

The system's primary functions include project progress management, resource management, communication and collaboration, quality management, document management, and system administration. The project progress management module provides a visual representation of project schedules, dynamically generates Gantt charts, and provides real-time updates on project milestone progress while issuing warnings for delayed tasks. The resource management module collects, stores, queries, and performs statistical analysis on project resource information[3]. The communication and collaboration module offers online discussions and instant messaging capabilities. Quality management ensures comprehensive quality monitoring throughout the project lifecycle, including incident management and quality assessments[4]. The formula for quality assessment is as follows:

$$UCL = \bar{X} + Z \cdot \sigma \quad (1)$$

$$LCL = \bar{X} - Z \cdot \sigma \quad (2)$$

In this context, $\bar{X}$ represents the sample mean, Z is the standard score (commonly seen as 3), and σ is the standard deviation of the process.

The document management component enables centralized management and version control of project documents. The system management component implements permission control and system log querying. These functional modules complement each other, collectively

enhancing transparency and collaboration in the project process. Project progress management allows all participating parties to track plan advancements. Resource management ensures optimized resource allocation [5]. Communication and collaboration strengthen information exchange. Quality management drives comprehensive quality improvement. Document management establishes a project knowledge repository. System management guarantees the secure and stable operation of the system. The system comprehensively elevates the level of project informatization and fine-grained management.

3. System Detailed Design and Implementation

3.1 Project Progress Management Module

The core functionality of the Project Progress Management Module is the dynamic generation of Gantt charts. This module reads structured project data from the backend database, including project work breakdown structures, estimated durations for each work package, dependency logic relationships, and other data. Following the drawing rules of Gantt charts, after processes such as sorting, determination of hierarchical relationships, and calculation of time coordinates, it dynamically generates interactive Gantt charts for the client and displays critical project path nodes [6]. Building upon the Gantt chart, in conjunction with a more detailed project network plan, it can monitor the actual progress and variance from the planned progress for each work package. For work packages that are already delayed, the system can intelligently assess their impact on subsequent nodes, provide progress delay risk warnings, enabling the project team to take early measures for time compression to ensure that critical nodes are completed on time. The logic for generating Gantt charts is handled on the server-side, with JavaScript used for client-side interaction rendering, facilitating dynamic visualization monitoring of the planned progress [7]. Project team members can intuitively grasp project plans and actual progress within a client browser, thereby enhancing the precision of project management [8].

3.2 Resource Management Module

The Resource Management Module primarily encompasses the collection, storage, query, and statistical analysis of project resource information. Resource information includes various types such as human resources, equipment resources, and material resources. The system provides resource information templates, enabling project managers to conveniently create new resource records. These templates encompass various attributes of resources, such as personnel names, specialties, responsibilities, equipment model parameters, and more [9]. Resource information is stored in a relational database with multiple indexes established for rapid queries. The Resource Management Module offers comprehensive query capabilities, allowing for combination queries based on resource type, project, time, and other criteria. It also allows for the saving of commonly used queries for future convenience. The statistical analysis function can consolidate project resource utilization, generating various resource statistics and charts. Centralized resource management allows project managers to gain a comprehensive understanding of project resource situations, enabling comparison, contrast, analysis, and the formulation of optimized resource scheduling plans. Resource scheduling

commands can also be issued through the system, guiding the rational planning, allocation, and utilization of project resources, thus preventing resource wastage or shortages [10].

3.3 Quality Management Module

The Quality Management Module facilitates end-to-end quality monitoring, encompassing functions such as quality planning, quality assessment, and quality improvement. The source code for this module is as follows:

```
from graphviz import Digraph

# Initialize a flowchart object

dot = Digraph()

# Add nodes representing various stages of quality management

dot.node('A', 'Establish Quality Policy')

dot.node('B', 'Quality Self-Check')

dot.node('C', 'Statistical Analysis')

dot.node('D', 'Incident Management')

dot.node('E', 'Generate Assessment Report')

# Add edges between nodes

dot.edges(['AB', 'BC', 'CD', 'DE'])

# Generate and display the flowchart

dot.render('Quality Management Process Chart', format='png', cleanup=True, view=True)
```

In the early stages of the project, it is possible to establish a quality policy and quality standards, develop quality checklists, and link them to corresponding activity nodes to guide project quality management. During project execution, participants involved in specific nodes are required to conduct self-inspections, complete checklists, and submit them for review. The project manager organizes quality spot checks and assessments. The system utilizes the information from the quality checklists to statistically analyze quality issues, assign quality responsibilities, and manage quality incidents, proposing corrective measures. In the project closure phase, the system automatically generates a quality assessment report, summarizes lessons learned from quality management, and continuously refines and improves the quality management process to achieve ongoing quality enhancement. The application of quality management functions encourages all parties to prioritize quality, improve work methods, and minimize the occurrence of quality incidents.

4. System Application Testing

We conducted detailed functional testing on various modules by selecting typical user scenarios. Testing included basic functionalities such as user login, project creation, resource allocation, document uploading and downloading, and project discussions. Additionally, it

encompassed professional features like plan development, progress monitoring, resource management, and quality assessment. The test results indicated that all test cases were executed successfully, and all functionalities met the design requirements. We also performed load testing and stress testing on the system using automated testing tools.

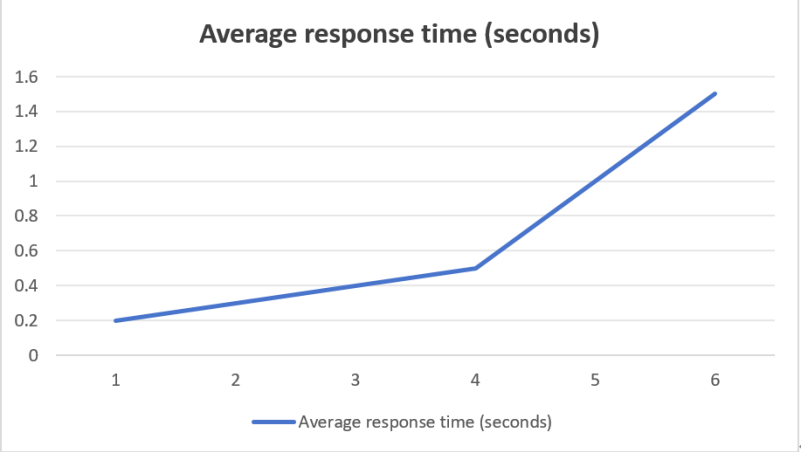

Figure 1 Average response time

Based on Figure 1, it can be observed that when simulating 20 concurrent users, the system response time is less than 0.5 seconds, and all functions execute correctly. When simulating 100 concurrent users, the system's average response time is approximately 1.5 seconds. CPU and memory usage are relatively high but within acceptable limits, and there have been no crashes or data losses. The test results indicate that the system can support applications for larger-scale projects. Penetration testing and vulnerability scanning were conducted to assess the system's security, including various common threats such as SQL injection and XSS attacks. The test results demonstrate that the system effectively filters various inputs and requests, and there are no apparent security vulnerabilities. Compatibility testing was performed on various mainstream browsers and operating systems. The system operates normally on browsers such as IE, Chrome, and Firefox, and it performs well on operating systems such as Windows, Linux, and Android.

5. Conclusions

This paper addresses the issue of insufficient informatization in construction project management and designs and implements a web-based project management system. The system encompasses functions such as project planning, resource management, communication collaboration, quality management, and document management. It employs a B/S architecture and is developed using JavaScript and PHP. The system enhances the transparency and collaboration of project processes, strengthens fine-grained project management, and effectively improves project management efficiency. Through testing and application, the system has been validated as functionally complete, performance-efficient, secure, and stable, capable of meeting the requirements of projects of various scales. This

system provides an effective platform for construction enterprises to achieve informatized project management processes and is worthy of widespread application. The next steps will involve further optimizing and refining the system in practical projects to enhance the user experience and better serve construction project management.

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