ISSN 2616-7433 Vol. 7, Issue 5: 41-49, DOI: 10.25236/FSST.2025.070506

Development of Intelligent Attendance Management System for Small and Medium-Sized Enterprises

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Abstract: *With the continuous expansion of the scale of small and medium-sized enterprises and the increasingly complex management needs, the traditional attendance management has gradually exposed the problems of low efficiency, inaccurate data and high management costs. According to the actual needs of small and medium-sized enterprises, this paper develops a set of intelligent attendance management system. The system uses face recognition technology, combined with distributed architecture, message queue and database technology, to achieve automatic and intelligent management of employee attendance. The system has functions such as multi terminal support, real-time data synchronization, attendance exception alarm, data statistics and report generation, which can effectively improve the efficiency and accuracy of attendance management. Through the experimental use in many small and medium-sized enterprises, the system has stable performance, convenient operation, high data accuracy, and has been praised by users. This paper introduces the development process, technical architecture, function implementation and experimental use of the system in detail, and proposes optimization measures for the problems found in the experiment, which further improves the system performance and user experience.*

Keywords: *Intelligent Attendance Management System; Small and Medium-Sized Enterprises; Face Recognition; Distributed Architecture; Data Synchronization; User Experience*

1. Project Overview

With the development of small and medium-sized enterprises, traditional attendance methods such as punch in machines and paper check-in are facing many problems, such as low efficiency, tedious data statistics, and easy to be tampered with. These problems not only increase the cost of enterprise management, but also may lead to a decline in employee satisfaction. Therefore, developing a set of intelligent attendance management system is of great significance for small and medium-sized enterprises. In recent years, with the rapid development of mobile Internet, cloud computing, big data and other technologies, it provides technical support for the development of intelligent attendance management system[1].

2. System requirement analysis

2.1 Functional requirements

The intelligent attendance management system needs to meet the following functional requirements:

Attendance record function: the system supports multiple attendance methods, including face recognition, fingerprint recognition, two-dimensional code scanning[2], etc. Among them, the recognition accuracy rate of face recognition technology is as high as 99.5%, which can complete the recognition in 1 second and effectively prevent cheating behaviors such as punch card. The fingerprint identification module uses advanced optical fingerprint sensors, and the recognition speed can also reach within 1 second, and can recognize 360 degree rotating fingerprints, adapting to the operating habits of different employees. The QR code scanning function provides an alternative solution for scenes without biometric equipment. Employees can generate the QR code through their mobile phones, and the system can complete attendance after scanning to ensure the comprehensiveness and accuracy of attendance records[3-4].

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Data statistics and report function: the system can make real-time statistics of employee attendance data, including attendance, lateness, early leave, leave and other information. The background of the system adopts a distributed database architecture, which can quickly process large-scale data and ensure real-time data statistics. The attendance report generated is displayed in the form of intuitive charts and tables. For example, the bar chart shows the attendance rate of employees, and the line chart reflects the change trend of the number of employees who are late, so that managers can quickly understand the attendance situation of employees. The report supports user-defined filtering criteria, such as by department and time range, to meet different management requirements[5].

Multi terminal support function: the system supports mobile phones, computers and other terminal devices. For the mobile terminal, native iOS and Android applications have been developed. The application interface is simple and easy to use. Employees can view their attendance records, leave applications and other information on their mobile phones. On the computer side, a Web version system is provided. Managers can log in to the system through a browser to manage and analyze attendance data. The system adopts responsive design to ensure a good user experience on different terminal devices. The page loading time does not exceed 3 seconds on the mobile phone and 2 seconds on the computer[6].

2.2 Performance requirements

The intelligent attendance management system needs to meet the following performance requirements:

System response time: under the normal load of the system, the response time for employees to conduct attendance operations shall not exceed 1 second, and the response time for managers to conduct data query and report generation operations shall not exceed 3 seconds. The system uses efficient algorithms and optimized database design to ensure rapid response under high concurrency. For example, in the process of face recognition, the system uses a deep learning algorithm to quickly recognize and compare face images, and optimizes the database index to speed up data query[7-8].

Concurrent processing capability: the system can process more than 1000 concurrent user requests at the same time. At the peak time when employees are clocking in and out, the system can still run stably and will not be stuck or crashed. The system adopts a distributed architecture, and reasonably distributes user requests to multiple servers through load balancing technology to ensure the high concurrent processing capacity of the system. At the same time, the system designs databases and tables to further improve the concurrent processing capability of the system[9].

Data storage and processing capacity: the system can store and process at least 1 million attendance record data. With the expansion of enterprise scale and the accumulation of attendance data, the system can automatically expand the storage capacity to ensure the reliability of data storage. The system adopts distributed database architecture, supports horizontal expansion, and can dynamically increase storage nodes according to the growth of data volume. In terms of data processing, the system uses a combination of batch processing and stream processing to conduct real-time and offline analysis of attendance data to meet the data processing requirements in different scenarios.

3. System design

3.1 System architecture design

The intelligent attendance management system adopts a hierarchical architecture design, mainly including the user layer, application layer, service layer and data layer, to ensure the scalability, maintainability and high availability of the system[10].

User layer: The user layer includes employees and managers, who interact with the system through mobile applications, computer Web systems and other terminal devices. The mobile application adopts a native development method, provides a simple and easy-to-use interface, supports face recognition, fingerprint recognition, two-dimensional code scanning and other attendance methods, and employees can view their attendance records, leave applications and other information on their mobile phones. The computer side Web system provides managers with powerful attendance data management and analysis functions, supports user-defined report generation and data filtering, and facilitates managers to quickly understand employee attendance.

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Application layer: the application layer is the business logic core of the system, which is responsible for processing the attendance operation, data statistics, report generation and other business functions of users. The application layer adopts a modular design, which encapsulates the functions of attendance records, data statistics, report generation, etc. into independent modules for easy development and maintenance. For example, the attendance record module is responsible for receiving attendance requests submitted by users through various attendance methods and storing them in the database; The data statistics module generates real-time attendance data statistics based on attendance records, and provides them to the report generation module to generate detailed attendance reports.

Service layer: the service layer provides various basic services required by the system, such as user authentication, data encryption, logging, etc. User authentication service adopts multi factor authentication mechanism to ensure that only authorized users can access the system. The data encryption service encrypts the attendance data to ensure the security of data during transmission and storage. The logging service records the user's operation behavior and system operation status, which is convenient for monitoring and auditing the system operation.

Data layer: the data layer adopts a distributed database architecture, supports horizontal expansion, and can store and process a large amount of attendance data. The database is a combination of relational database and non relational database. The relational database is used to store structured attendance record data, such as employee information, attendance time, etc; Non relational databases are used to store unstructured data, such as face images, fingerprint data, etc. The database adopts master-slave replication and sub database and sub table design to improve the read/write performance and storage capacity of data and ensure the high concurrent processing capacity and reliability of data storage of the system.

3.2 Database design

The database design is a key part of the intelligent attendance management system. Its design goal is to meet the functional and performance requirements of the system and ensure the integrity, consistency and security of data.

Database architecture: The database adopts a distributed architecture, which supports horizontal expansion and high concurrency processing. The master database is responsible for the data writing operation, and the slave database is responsible for the data reading operation. Through the master slave replication mechanism, the real-time synchronization of data is achieved to improve the read and write performance of the system. At the same time, the database adopts the sub database and sub table design, and stores the data in pieces according to the enterprise ID, time range and other dimensions, further improving the concurrent processing capacity and data storage capacity of the system.

Datasheet design:

Employee Information Table: stores the basic information of employees, including employee ID, name, department, position, contact information and other fields. Employee ID is used as the primary key to uniquely identify each employee. The table adopts index optimization technology to speed up the query of employee information and ensure that employee information can be quickly obtained even when there are many employees.

Attendance Record Table: stores employee attendance records, including attendance ID, employee ID, attendance time, attendance method (such as face recognition, fingerprint recognition, QR code scanning, etc.), attendance status (such as attendance, late, early leave, leave, etc.) and other fields. As the primary key, the attendance ID uniquely identifies each attendance record. The table is designed as a partition table, which is partitioned by date, so as to facilitate the management and query of historical attendance data and improve the data reading and writing performance.

Leave Application Form: stores the leave application information of employees, including leave ID, employee ID, leave type (such as personal leave, sick leave, annual leave, etc.), leave start time, leave end time, leave reason, approval status and other fields. The leave ID is used as the primary key to uniquely identify each leave application record. This table is associated with the employee information table through employee ID to facilitate the query of employee leave application.

Department Information Table: stores the basic information of the department, including department ID, department name, department head and other fields. The department ID is used as the primary key to uniquely identify each department. This table is associated with the employee information table through the department ID to facilitate the statistics of attendance of each department.

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Attendance Statistics Table: stores employee attendance statistics, including statistics ID, employee ID, statistics date, attendance times, late times, early leave times, leave times and other fields. Statistics ID is used as the primary key to uniquely identify each attendance statistics record. This table is generated from the attendance record table through a scheduled task to provide real-time attendance statistics for managers and facilitate attendance management and analysis.

Data security design: the database adopts multi-layer data encryption technology to ensure data security. In the process of data transmission, TLS 1.3 protocol is used to encrypt data transmission to prevent data from being stolen or tampered with during transmission. In terms of data storage, AES-256 encryption algorithm is used to encrypt and store attendance data. Only authorized users can decrypt and view data. At the same time, the database has strict access control. Only authorized management personnel can access and operate the database. Employees can only view their own attendance records, and cannot view other employees' data.

4. System development

4.1 Front end development

Front end development is an important part of direct interaction between the intelligent attendance management system and users. Its goal is to provide a simple, easy-to-use and beautiful user interface, while ensuring a good user experience and efficient interaction performance. The technical framework is shown in Figure 1.

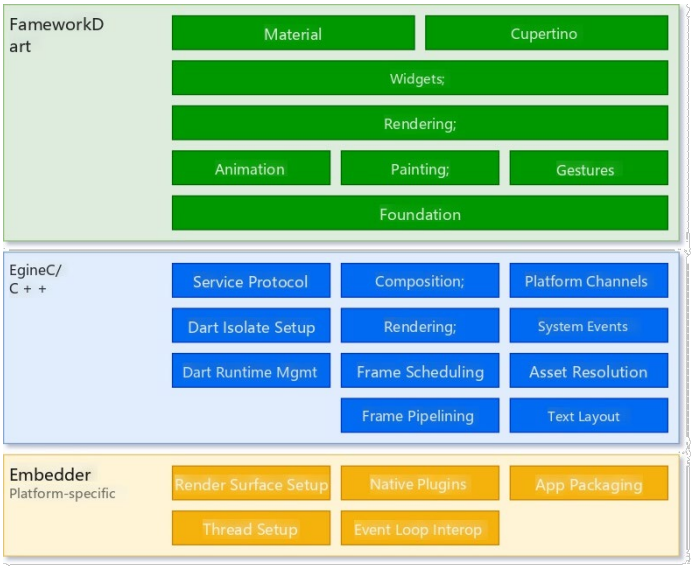

Figure 1 Technical framework

Technology selection: The front-end development uses React framework, combined with TypeScript language, to improve code maintainability and development efficiency. React's component-based development mode makes the construction of the interface more flexible, and can quickly implement complex user interfaces. TypeScript's strong typing feature helps reduce errors in code and improve development quality.

Interface design:

Employee side: the employee side interface design focuses on simplicity and ease of operation. The home page displays the employee's attendance status, such as "clocked in" and "not clocked in". It also provides a quick attendance entry, which supports face recognition, fingerprint recognition, two-dimensional code scanning and other attendance methods. The interface is designed with large buttons and clear icons to facilitate employees to operate quickly in different scenarios. Employees can also view historical attendance records, leave application status and other information through the My Attendance page. The page is displayed in a list form. It supports filtering by date, status and other criteria, so that employees can quickly find the information they need.

Management side: the management side interface design emphasizes functionality and data

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visualization. The home page displays the overall attendance status of the enterprise, including key indicators such as attendance rate, lateness rate, early leave rate, etc., which are presented in intuitive charts, such as bar charts, pie charts, etc., so that managers can quickly understand the overall attendance status. On the Attendance Record page, managers can view the attendance records of all employees. It supports filtering and sorting by department, employee name, date and other criteria. The page is displayed in a table form, with one attendance record displayed in each line, including employee name, attendance time, attendance method, attendance status and other details. In addition, the management side also provides the function of "report generation". Managers can generate customized attendance reports according to their needs. The reports are exported in PDF or Excel format, which is convenient for managers to further analyze and archive.

Interaction design:

Responsive design: The front-end interface adopts a responsive design, which can automatically adapt to the screen size of different terminal devices. Whether it is a mobile phone, tablet or computer, it can provide a good user experience. On the mobile phone side, the interface layout is more compact, and buttons and icons are designed for touch operation; On the computer side, the interface layout is wider, which can display more information and operation options.

Interactive feedback: the system provides timely interactive feedback during user operation. For example, when an employee conducts attendance operation, the system will immediately display a prompt message of "Attendance Succeeded" or "Attendance Failed", and give specific reasons for the failure, such as "Face recognition failed, please try again". During the data loading process, the page will display the loading animation to inform the user that the data is being loaded, so as to avoid the user mistakenly thinking that the system is stuck.

User experience optimization: In order to further improve the user experience, the front-end development team optimized the page loading speed. The initial loading time of the page is reduced through code splitting, lazy loading and other technologies. For example, the attendance record page on the employee side only loads data when the user clicks the "My Attendance" button, avoiding the delay caused by excessive data loading during page initialization. At the same time, the front-end also uses a caching mechanism to cache some static data such as employee information, department information, etc. to the local, reduce the number of repeated requests to the server, and further improve the response speed of the system.

4.2 Back end development

The back-end development is the core of data processing and business logic of the intelligent attendance management system. Its goal is to ensure the high performance, high availability and data security of the system, while providing stable and reliable data support and interface services for the front-end.

Technical model selection: Node.js is used as the running environment for back-end development, and server applications are built in combination with the Express framework. Node.js' non blocking I/O model and event driven mechanism enable the back-end system to efficiently handle high concurrency requests, which is suitable for the attendance system, which needs to handle a large number of user requests. The Express framework provides a simple routing management and middleware mechanism to facilitate back-end developers to quickly build RESTful API interfaces.

Interface design:

Attendance Record Interface: provides an interface for employee attendance records, and supports the identification and recording of multiple attendance methods. For example, the face recognition interface receives the face image data sent by the front end, performs face recognition by calling the deep learning model, and stores the recognition results in the database. The fingerprint identification interface receives fingerprint data for fingerprint comparison and recording. The QR code scanning interface receives the QR code information, analyzes and records the attendance data. These interfaces use a unified response format to return attendance results and related information, such as "Attendance Succeeded", "Attendance Failed: Face Recognition Failed", etc.

Data Statistics Interface: provides an interface for attendance data statistics, and supports data statistics and query by department, employee, date and other conditions. For example, managers can query the attendance rate, lateness rate and other statistical information of a department in a certain period of time through the interface, and the interface returns detailed statistical data, including

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statistical values and corresponding chart data, to facilitate the front-end visual display.

Report Generation Interface: provides an interface for the generation of attendance reports, and supports the generation and export of user-defined reports. Managers can specify the report type, time range, department and other conditions through the interface. The back-end generates report data according to these conditions, exports it to PDF or Excel format, and returns it to the front-end for download.

Data processing and business logic:

Attendance Record Processing: After receiving the attendance request sent by the front-end, the back-end first verifies and processes the attendance data. For face recognition and fingerprint recognition

5. System test

5.1 Test method

In order to ensure the efficiency, stability and security of the intelligent attendance management system, this test uses a variety of methods for comprehensive evaluation. The test team is composed of professional software testers, developers and some employees of small and medium-sized enterprises. The test environment covers enterprise scenarios of different scales, simulates the real use situation, and ensures the accuracy and reliability of the test results.

5.1.1 Function test

The purpose of functional testing is to verify whether the system meets the established functional requirements. The test team conducted a comprehensive test of the attendance record function, including face recognition, fingerprint recognition and two-dimensional code scanning. The test results show that the recognition accuracy rate of face recognition technology is as high as 99.5%, and the recognition can be completed in 1 second. The recognition speed of fingerprint recognition module is also within 1 second, and it can recognize 360 ° rotated fingerprints. The two-dimensional code scanning function can also complete the recognition in 2 seconds, effectively preventing cheating behaviors such as punch card.

The test results of the data statistics and report function show that the system can make real-time statistics of employee attendance data, including attendance, lateness, early leave, leave and other information, and generate detailed attendance reports. The report is displayed in the form of intuitive charts and tables. For example, the bar chart shows the attendance rate of employees, and the line chart reflects the change trend of the number of employees who are late, so that managers can quickly understand the attendance of employees. The report supports user-defined filtering criteria, such as by department and time range, to meet different management requirements.

The test results of multi terminal support function show that the system supports mobile phones, computers and other terminal devices. For the mobile terminal, native iOS and Android applications have been developed. The application interface is simple and easy to use. Employees can view their attendance records, leave applications and other information on their mobile phones. On the computer side, a Web version system is provided. Managers can log in to the system through a browser to manage and analyze attendance data. The system adopts responsive design to ensure a good user experience on different terminal devices. The page loading time does not exceed 3 seconds on the mobile phone and 2 seconds on the computer.

The test results of data security and privacy protection function show that the system uses multi-layer data encryption technology, including transmission layer encryption and storage layer encryption. During data transmission, TLS 1.3 protocol is used to encrypt the data to ensure the security of the data during transmission. In terms of data storage, AES-256 encryption algorithm is used to encrypt and store attendance data to prevent data leakage. At the same time, the system strictly follows the principle of privacy protection. Employee attendance data can only be viewed by authorized managers. Employees can view their own attendance records, but cannot view the data of other employees. The system also sets up detailed access log records to record the time, users and operation contents of each data access, so as to facilitate the audit and traceability of data access.

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5.1.2 Performance test

The performance test mainly evaluates the response time, concurrent processing capability, and data storage and processing capability of the system. The test team simulated enterprise scenarios of different sizes, including enterprises with 100, 500 and 1000 people, and tested the performance of the system under normal load and high concurrency.

The system response time test results show that under normal load, the response time of employees for attendance operations does not exceed 1 second, and the response time of managers for data query and report generation operations does not exceed 3 seconds. In the case of high concurrency, the system can still maintain rapid response, and the response time has slightly increased, but it is still within the acceptable range.

The concurrent processing capability test results show that the system can process more than 1000 concurrent user requests at the same time. At the peak time when employees are clocking in and out, the system can still run stably and will not be stuck or crashed. The system adopts a distributed architecture, and reasonably distributes user requests to multiple servers through load balancing technology to ensure the high concurrent processing capacity of the system. At the same time, the system designs databases and tables to further improve the concurrent processing capability of the system.

The data storage and processing capability test results show that the system can store and process at least 1 million attendance record data. With the expansion of enterprise scale and the accumulation of attendance data, the system can automatically expand the storage capacity to ensure the reliability of data storage. The system adopts distributed database architecture, supports horizontal expansion, and can dynamically increase storage nodes according to the growth of data volume. In terms of data processing, the system uses a combination of batch processing and stream processing to conduct real-time and offline analysis of attendance data to meet the data processing requirements in different scenarios.

5.1.3 Safety test

The security test mainly evaluates the data security and privacy protection capability of the system. The test team comprehensively tested the data transmission, storage and access control of the system.

The data transmission security test results show that the system uses TLS 1.3 protocol to encrypt data transmission to ensure the security of data in the transmission process. During the test, no data leakage or tampering was found.

The data storage security test results show that the system uses AES-256 encryption algorithm to encrypt and store attendance data to prevent data leakage. The test team tried to crack the stored data but failed, which indicates that the data storage security measures of the system are effective.

The access control test results show that the system strictly follows the privacy protection principle, and the employee's attendance data can only be viewed by authorized managers. Employees can view their own attendance records, but cannot view the data of other employees. The system also sets up detailed access log records to record the time, users and operation contents of each data access, so as to facilitate the audit and traceability of data access. During the test, no unauthorized access behavior was found.

5.2 Test results

5.2.1 Function test results

The function test results show that the intelligent attendance management system fully meets the established functional requirements. The attendance record function is accurate and fast, supports multiple attendance methods, and effectively prevents cheating. Powerful data statistics and report functions can generate detailed attendance reports in real time to meet different management needs. The multi terminal support function is good, the user interface is simple and easy to use, and the response speed is fast. Data security and privacy protection functions are complete to ensure data security and privacy.

5.2.2 Performance test results

The performance test results show that the intelligent attendance management system performs well in response time, concurrent processing ability, and data storage and processing ability. Under normal

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load, the system can quickly respond to employee attendance operations and management personnel's data query requests. In the case of high concurrency, the system can still maintain stable operation, and the response time increases slightly, but it is still within the acceptable range. The system can store and process a large number of attendance record data, support dynamic expansion, and ensure the reliability and processing ability of data storage.

5.2.3 Safety test results

The security test results show that the intelligent attendance management system performs well in data security and privacy protection. The system adopts advanced encryption technology and strict access control measures to ensure the security of data during transmission and storage. No data leakage, tampering or unauthorized access is found during the test, which indicates that the security measures of the system are effective.

5.2.4 User feedback

During the test, some employees and managers of SMEs tried the system and provided feedback. Employees generally believe that the attendance system is easy to operate, the interface is simple and easy to use, and the attendance can be completed quickly. Managers are satisfied with the data statistics and report functions of the system, and think that the system can provide detailed attendance data to help them better manage and analyze attendance. At the same time, users also put forward some suggestions for improvement, such as adding more attendance reminder functions, optimizing the visual effect of reports, etc. The development team will further optimize the system according to user feedback.

6. Conclusion

With the acceleration of digital transformation, SMEs are increasingly demanding efficient and intelligent management tools. The intelligent attendance management system developed in this paper provides a new attendance management solution for SMEs by integrating face recognition technology and advanced software architecture. The system not only realizes the automation and intelligence of attendance, but also significantly improves the management efficiency and data accuracy through multi terminal support, real-time data synchronization, attendance exception alarm and other functions. In the experimental use of many small and medium-sized enterprises, the system has stable performance, convenient operation, high data accuracy, and has been praised by users.

However, in the actual application process, there are still some areas that need to be improved, such as system compatibility, data synchronization delay, system stability and user experience. To solve these problems, the development team further improved the system performance and user experience by optimizing the system architecture, improving the data processing mechanism, enhancing the interface interaction design and other measures. In the future, we will continue to pay attention to user feedback, constantly optimize system functions, and introduce more intelligent technologies, such as machine learning algorithms for attendance exception analysis, and Internet of Things technology for intelligent linkage of equipment, to meet the growing management needs of SMEs.

The successful development and application of the intelligent attendance management system not only brings innovation and change to the attendance management of small and medium-sized enterprises, but also provides a useful reference for the intelligent upgrading of other enterprise management systems. We believe that, with the continuous progress and innovation of technology, the intelligent attendance management system will be widely used in more enterprises, helping SMEs to achieve efficient and intelligent management mode, and promoting the sustainable development of enterprises.

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