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TIMS: A Secure Testing-Machine Information Management System

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Abstract

The testing information refers to the data obtained by the quality inspection center after testing steel, cement and other materials through testing machines and other instruments. The quality inspection center issues a report according to the testing result, which serves as the basis for the batch of materials to be put into the market. At present, the information level of testing-machine information management is relatively low, and there is no safe and effective management mechanism. In order to solve this problem, this paper proposes TIMS, a secure testing-machine information management system, which adopts the separation-of-three-rights management mode and a secure identity-binding interface to improve the management efficiency as well as ensure the security of data and workflow. At the same time, we combine the watermark QR code technology aiming at report anti-counterfeiting. We implement the prototype of TIMS, which realizes the above functions and provides a user-friendly interface for management and statistics.

Keywords: Tesing-machine information; Management system; Security

1. Main text

The constitution and establishment of modern city cannot be separated from steel, cement, concrete and other basic building materials, whose quality determines the use and safety performance of high-rise buildings, roads, bridges and many products. Therefore, the detection and test of materials becomes very crucial before it is put into

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the market. Not only the enterprises, but also users in the industry care about how to judge the load-bearing capacity of a steel bar, or how to know the service life of a batch of concrete. Under this circumstance, the testing machine came into being. Those machines can be used to simulate the use and consumption of materials in order to calculate the performance indicators of materials according to the national standards, so as to determine whether a batch of materials can be sent to the market for further processing and production. The data obtained by the testing machine is the decision basis for new product development, daily quality supervision and continuous improvement of product performance. In the traditional manufacturing industry which represented by steel, construction materials, road traffic, mechanical equipment, vehicles and military equipment, the central (or sub-center) laboratory is an essential and important department in its organizational structure. According to the actual needs of each enterprise, those laboratories are equipped with various types of testing machines and necessary conventional physical and chemical inspection facilities. Today, with the wave of information technology sweeping the world, the pace of network construction in manufacturing industry is speeding up. Therefore, it is common for the industry to utilize the information network in order to manage the testing machine and testing data. Unfortunately, there are several issues that have to be solved in this area:

(1) **Difficulty in Determining the Authenticity of the Report Sheets.** In fact, the quality inspection report of steel issued by the quality supervision stations or research institutes has national effect, so the authenticity of the report is very important. At present, the reports issued by quality supervision stations are paper printed or electronic reports, thus the contents and official seals of the reports can be forged easily. Tampering with the content of the reports has greatly damaged the credibility of the quality inspection stations or research institutes, which will cause immeasurable losses to the users of steel building materials. Therefore, a scientific and information-based scheme is needed for the identification of report sheets.

(2) **Complex Traditional Mode with Great Influence of Human Factors.** Taking the construction quality inspection station as an example, although the current quality supervision station has introduced information equipment to a certain extent, most of the work still depends on the paper form transmission. In this way, the traditional mode of work is inefficient, complex management and human factors can not be completely solved. In the process of work, it is inevitable that there will be omissions of paper forms, not to mention it is difficult to manage the work efficiently. Once there is any accident, the process of returning to the superior is not only complex but easy to disrupt the existing arrangement system.

(3) **Difficulty in Controlling the Interface Security.** There are many complex and diverse test equipment in this region, which are manufactured by different manufacturers in different countries, leading to various identity authentication methods. As a result, it is impossible for the tester entity to bind with the operation ID of the testing software safely, which brings about potential security crisis.

At present, there are many management processes and corresponding software for the industry, yet they all contain one or more of the above issues. Based on our analysis, we propose testing-machine information management system (TIMS). The problem of report anti-counterfeiting is effectively solved by watermarking two-bar code technology. Because of the concealment of the watermark, the existence of it can not be distinguished, which effectively reduces the possibility of malicious copying and tampering of the QR code. By using information network technology, the quality inspection process can be independent from paper-form. Moreover, we introduce the "Separation-of-Three-Rights (STR)" as our manage methods, which completes the segregation of different departments and their duties in both geography and information. At the same time, we implement a prototype of TIMS, which bases on MySQL database and accomplishes the bounding between the tester entity with their testing ID. TIMS takes the network operating system as the working platform and the database server as the core which provides the comprehensive management functions of safe management of the laboratory.

To summary, the contributions of our work are as below:

- We propose a trusted authentication mechanism based on watermark QR code for reports.
- We propose the "Separation-of-Three-Rights (STR)" as our manage mode.
- We propose an identity authentication interface based on MySQL.
- We implement a prototype of the testing information management system (TIMS).

The rest of our paper is organized as follow: Section 2 introduces the previous work and related background which are closely related to this paper. Section 3 will analyze the design and workflow of TIMS in detail. Section 4 introduces the prototype of TIMS, and finally Section 5 summarizes and prospect.

2. Related Work

2.1. Report Anticounterfeiting

The anticounterfeiting of the report can be divided into physical anti-counterfeiting and technical anti-counterfeiting. Physical anti-counterfeiting includes using special paper [2], ink [1], special materials to make anti-counterfeiting labels (such as currency) [3] [4], or through the report font, size, color, line spacing and other subtle differences and cross stitch seal for anti-counterfeiting, so as to prevent private printing, copying, tampering, etc. These methods can increase the difficulty of copying and reduce the possibility of tampering to a certain extent, but the cost of special materials is high which is not realistic to use in batch. On the other hand, the anti-counterfeiting ability of fine typesetting or cross stitch seal is relatively low, but is easy to copy and can not meet the needs of modernization and informatization. According to the difference of process, technical anti-counterfeiting can be divided into interactive anti-counterfeiting and non-interactive anti-counterfeiting. The most representative interactive anti-counterfeiting method is the query method, which provides users with a query platform through a specific application or web system. Users only need to input specific information to obtain the authenticity judgment, such as the drug anti-counterfeiting system based on the Internet of things proposed by M. wazid[5] and others, and the encryption anti-counterfeiting system based on two-dimensional code proposed by Liu et al[6]. However, the interactive anti-counterfeiting method requires enterprises to provide open query platform and data storage server, which is expensive and may cause security vulnerabilities. The non-interactive anti-counterfeiting method needs no communication between users and enterprises, and users can judge the authenticity of reports locally, leading to higher efficiency. These researchers [7] [8] add watermark to the two-dimensional code, which effectively prevents the QR code from being tampered and copied maliciously, thus realizing the anti-counterfeiting effect of physical entities.

2.2. Information Management System

At present, there are many information management systems for various scenarios, such as schools and catering [10]. In view of the less design of test information management system in quality inspection center, Chen et al. [11] summarized the difficulties in the combination of tension machine and information management system. In this paper, a testing-machine information management system based on STR is designed for the testing-machine technology platform, and a security interface based on MySQL is proposed, which effectively improves the test efficiency and information level in the field of testing machine.

3. Our Approach

In this section, we introduce the workflow and core technology of TIMS system. The workflow of TIMS is described in Figure 1.

The left side of the Figure 1 shows the main workflow. The sample collecting department inputs the user's requests for entrustment where the sample number and test content are arranged. After sample collecting, samples are allocated to different laboratories and are assigned to different testers for quality inspection test. A report is generated and printed according to the test situation once the testing period is finished, and the report is finally handed over to the entrusted user.

In the following, we introduce the key functions in the workflow.

3.1. Trusted Authentication Mechanism of Report Based on Watermark QR code

As mentioned in Section 1, since the reports are of great importance, the anti-counterfeiting work of the report is crucial. In this paper, a trusted mechanism of report based on watermark QR code is proposed, which can effectively enhance the anti-counterfeiting ability of the report.

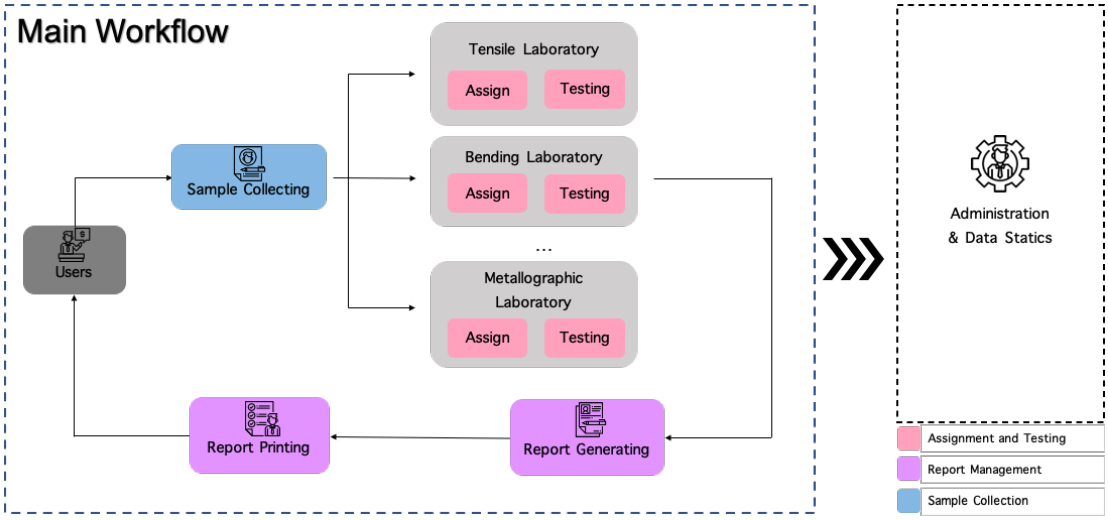

Fig. 1. The workflow of TIMS.

According to the workflow of TIMS, multiple reports will be generated for one users' order, and different reports reflect the characteristics of different aspects of the product. The core content of the report includes basic information such as "commission order number", "entrusting unit", "project name" and "entrusted time", as well as test information related to various tests. Only when all types of tests meet the requirements, the item "inspection conclusion" in the front page of the report will be judged as "qualified". In addition, the report also contains the information and signature of the verification and issuing personnel. Based on the composition of TIMS report, we propose to use {client number, client, commission time, [inspection conclusion,] signature of verifier} as the report information verification key IK, and generate a QR code to attach to the report. However, the QR code can be easily copied or tampered with, and can not be used as the security identification of information. To address this issue, we first apply RSA to IK, and then add watermark to the QR code.

3.2. System Construction Mode of Separation of Three Rights

In this paper, we put forward the system construction mode of separation of three rights, which effectively reduces the influence of human factors in the process of experimental information management. Without losing generality, the inspection process of the quality inspection centre can be divided into three functional modules (corresponding to the three different colour blocks in Fig. 1), in which the sample collection will input the basic information of the entrusting unit and the corresponding multiple entrusted samples. In the allocating and testing stage, multiple samples will be allocated to each laboratory, including but not limited to tensile, bending, and test so on. Finally, according to the test data and the corresponding national standards, the inspection conclusion is generated. In practice, because the commission order number is the unique identification ID in the management process, it is inevitable to expose the relevant information of the commissioning unit to the testing-related personnel in the allocation and testing stages. Based on it, we propose a double-identification strategy, and make use of the unique advantages of computer network technology to realize the efficient conversion between double identification IDs and an effective atomic rollback mechanism.

3.2.1. STR Model Based on Double-Identification Strategy and Network Authority Division

In this paper, in order to realize the effective separation of rights and responsibilities, we introduce the double identification mechanism. In the back-end database, the report-ID is used as the primary key for sample collecting and report generating and printing, while the sample-ID is selected as the primary key in the allocation and test stages. In order to meet the needs of transmitting the value of primary key and user visualization through web server, each ID contains two data types: integer and string. In practical application, when the receiving personnel completes

the test arrangement, each sample will enter multiple laboratories according to its assigned testing type. At this time, in addition to the super administrator, the distribution personnel and test personnel can not check the specific source of each sample, especially the information of the commission sheet and the commissioning unit, so as to ensure the fairness and rationality of the test process as well as reduce the possibility of human intervention.

In the TIMS management system, the personnel identity is strictly set. The leader of quality inspection center has super administrator authority, which has three core departments including sample collecting, laboratory and report generation center that those departments cannot visit each other. The internal of core departments is organized and planned by the department leaders. The authority of the superior is allowed to be compatible downward, but the lower level cannot access the authority of the superior, and the personnel at the same level have the same authority. TIMS uses decoBean of Django framework to define the permission function, which strictly implements the access control of staff.

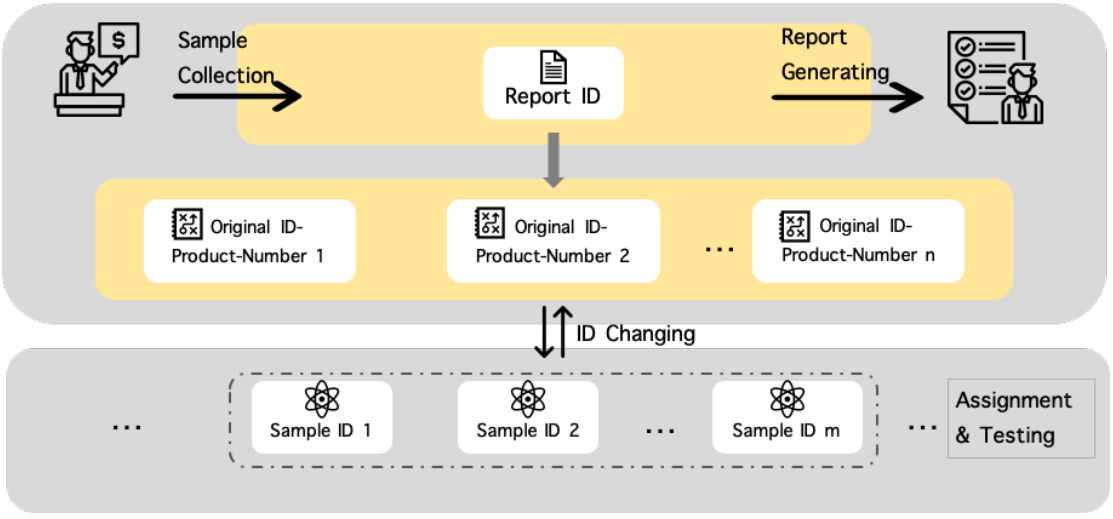

Fig. 2. ID conversion in Workflow of TIMS. After the user places an order, the order is stored with the report-ID as the primary key. Each report-ID contains multiple original-IDs and the corresponding product-number, and each original-ID corresponds to multiple sample-IDs. Once it is in the allocating and testing stage, the system will take the sample-ID as the primary key. Finally, when the experiment is completed and the report is printed, the report-ID is used as the primary key again for retrieval.

3.2.2. Atomic Rollback Mechanism

In the process of allocating and testing, we designed the atomic rollback mechanism to facilitate the tester to turn down some of the allocation without affecting the work of other stuff or their work considering the possible misclassification in practical application. In order to ensure the atomic operability, the flag bit is used as the status basis of the sample in the database, and the system will read the database and display it at the front end when the user clicks refresh, so as to realize the rollback operation of sample allocation status.

To sum up, TIMS based on computer network technology not only separates the above-mentioned "three rights" in geographical space, but also reduces the risk of human factors by setting double identification mechanism and network authority. At the same time, using the characteristics of computer network, the atomic operation rollback mechanism is realized on the basis of optimizing the quality inspection process, which greatly improves the system security and management efficiency.

3.3. Authentication Interface Based on MySQL

This section describes the identity authentication interface of TIMS based on MySQL. For the quality inspection centre, the test software and equipment used are mostly produced by different manufacturers in different countries through bidding, resulting in numerous and complicated interfaces. In the application of the general management system, it is inevitable for the tester to manually open the testing program and input the test information by hands.

After the test is completed, it is also necessary to manually fill the complicated test data into the system for saving. This process is tedious and complex, and human error is inevitable. More seriously, due to the disconnection between the management system and the testing program, the process can not guarantee that the login-entity (who has passed the system identity verification) and the tester (who uses the testing program without identity verification) are the same person, which brings potential problems to the follow-up performance evaluation, work management and even the responsibility traceability of test results. In order to solve the above problems, this paper proposes an identity authentication interface based on MySQL. TIMS and test program (taking tensile test program as an example) are implemented according to the following protocols:

Protocol 1: TIMS-Tensile Interface

Setup: TIMS builds the middle table share based on MySQL database, and gives the access rights of MySQL to the testing program. In addition to all data fields of tensile test, the share table also records the login ID, sample ID and status of samples;

Testing Prepare: When the user selects the specific samples for testing, TIMS performs the following steps:

```
for i in range(n):
    insert into share (id, sample_id, status) values ({id}, {sample_id[i]}, 0) ;
Write the test program to the registry:
    Build Hkey_classes_root/…/shell/open/command/URL_Protocol
    Wirte the value: Hkey_classes_root/…/Defaultation = “path of test program”“%id”
```

Testing: The testing program extracts ID value from $args$ parameter and performs database query:

```
select sample_id from share where id={id} and status = 0;
According to the extracted sample_ id, test;
When testing is completed, write it into the share table:
insert into share { test field } values { the test result corresponds to the test field } where id = {id};
update share set status=1 where id={id}
```

Update Database: After the test, the user returns to the TIMS management interface, click "get data" and execute:

```
select {test field} from share where status=1 and id = {id};
After confirming that the data is correct, the user can click "save" to execute the following operation:
delete from share where status=1 and id = {id};
```

Protocol 1 realizes the security interface between TIMS and testing program through MySQL middle table and system registry. Users don not need to manually input and export testing information. Meanwhile, the identity verification of TIMS ensures that the identities of the login and the tester are bound uniformly, eliminating the possibility of malicious attack or accidentally operation.

4. Prototype

Based on the above analysis, we have completed the prototype of TIMS, which can run completely, and implemented all the functions mentioned in Section 3. We test the interface with the tensile testing machine and its equipment management software, and implemented the data sharing and transmission. This section will introduce the prototype we built.

Figure 3 shows part of the front-end interface of the TIMS prototype. The user can log in to the corresponding functional module according to his identity recorded in the system to complete the functions described above. In addition to basic functions, TIMS prototype also provides users with search, data management and statistics functions. The TIMS prototype back-end is based on the Django framework, using C/S (Client/Server) which represents the client and server software system architecture, and the database access interface uses ODBC (Open Database Connectivity). ODBC itself also provides support for the SQL language, and users can directly transmit SQL statements to ODBC. ODBC-based applications do not rely on any DBMS for database operations, and do not directly deal with DBMS. All database operations are completed by the corresponding DBMS ODBC driver, making the prototype program has good portability and operability.

5. Conclusions

This paper proposes a testing-machine information management system (TIMS) based on the characteristics of testing data and management process. The watermarking QR code technology is used to increase the difficulty of report counterfeiting and reduce the risk of tampering. At the same time, a management model of STR is proposed, which implements the separation of responsibilities in both geography and information. The MySQL-based secure identity authentication interface realizes the binding of the tester entity and the login ID, which further improves the

Fig. 3. TIMS prototype. (a) the home page of sample collection, which shows all received orders in the database, and provide search function;(b)the home page of distribution, which shows all the sample information that are ready to do of the laboratory;(c)the home page of testing; (d) the home page of print report

security of the TIMS. Based on the above analysis, we have implemented the prototype of TIMS to provide users with a friendly and visual interface. In the future, we will further enhance the functions of TIMS and advance the process of information management of testing information.

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