China Earthquake Disaster Loss Investigation and Evaluation: Design and Development of Online Examination Application

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Abstract

After a destructive earthquake, it is of great significance for the country to effectively carry out emergency rescue, post-disaster reconstruction, and investment planning for earthquake prevention and disaster reduction with quickly, accurately, and comprehensively grasping the loss of the earthquake-stricken area. To effectively improve the timeliness, scientificity and accuracy of the investigation and assessment of disaster losses in China after the earthquake, a high-quality earthquake disaster assessment team has been established. Moreover, considering the current popularization and application of smart phones and mobile networks, an online examination app is designed and developed in this paper for China's earthquake disaster loss investigation and evaluation training based on the Android system. What is more, based on the mobile Internet, this APP provides functions such as online exams and self-tests for the majority of earthquake disaster assessment team members through mobile terminals such as mobile phones and tablet, which is not only a new set of learning, training, and assessment methods, but also effectively strengthens the professional level of members in disaster assessment team, making each team member more smoothly complete the investigation and assessment of disaster losses at the earthquake site in the future, and comprehensively improving the overall quality of the disaster assessment team.

Keywords- earthquake; disaster loss; investigation and evaluation; online examination; APP

1. INTRODUCTION

Earthquake disaster loss investigation and assessment plays an important role in earthquake emergency response work, providing an objective and scientific basis for decision-making on emergency rescue, resettlement of victims, material allocation and other response measures. After the earthquake, it requires a professional team with a high level of professionalism to complete the work that investigate and assess disaster loss quickly, efficiently and orderly. [1-3] In recent years, earthquakes in China have mostly been concentrated in Yunnan, Sichuan, Xinjiang, Tibet, Qinghai and other places. In many provinces, even less destructive earthquakes are difficult to occur, and emergency team members in provinces with few earthquakes and weak earthquakes have few opportunities to practice and experience disaster rescue on-site, whose knowledge and understanding of earthquake disaster loss investigation and assessment work is mostly limited to theoretical knowledge in books. Therefore, to strengthen the construction of earthquake disaster loss investigation and assessment team, comprehensively improve the on-site work ability of emergency team members, and promote their comprehensive quality, it is necessary to strengthen this aspect of training and assessment in daily work. [4-8] Since 2012, with the funding of the China Earthquake Administration, a training system has been researched and developed for the earthquake disaster loss investigation evaluation in China in this paper. The online examination subsystem and the simulation exercise subsystem have been applied in the earthquake disaster loss investigation and evaluation training courses on a national scale and in various provinces and cities. Moreover, based on the Internet, the system provides training services such as online examinations and simulation drills for the national earthquake disaster assessment team members. However, with the widespread application of smart phones and the rapid

development of mobile 5G networks, it is particularly necessary to carry out earthquake disaster assessment examinations and training services on the mobile terminal.

To effectively improve the professional capabilities of earthquake disaster assessment personnel so that disaster loss investigation and assessment on earthquake site can be carried out more effectively, a high-quality earthquake disaster assessment team is established. Meanwhile, conforming to the current development and popularization of mobile internet networks, a set of online examination apps for earthquake disaster loss investigating, evaluating and training in China is designed and developed in this paper based on the Android system, which can train and test personnel of national earthquake disaster assessment on line through mobile devices such as mobile phones.

2. DESIGN PURPOSES AND FUNCTIONAL REQUIREMENTS OF SYSTEM

With the rapid development of current technology, Internet applications are becoming more and more popular, and the proportion of mobile Internet applications on mobile phones is increasing day by day. According to the "the 47th Statistical Report on Internet Development in China", up to December 2020, the number of Internet users in China has reached 989 million, with an increase of 85.4 million compared to that on March 2020; the Internet penetration rate reached 70.4%, with an increase of 5.9 percentage points compared to that on March 2020; the number of mobile Internet users reached 986 million, with an increase of 88.85 million compared to that on March 2020; the proportion of Internet users using mobile phones to access the Internet reached 99.7%, with an increase of 0.4 percentage points compared to that on March 2020. Besides, the proportions of surfing the Internet using TV, desktop computers, laptop computers, and tablet computers are 24.0%, 32.8%, 28.2% and 22.9%, respectively, which are all lower than those in March 2020.[9]
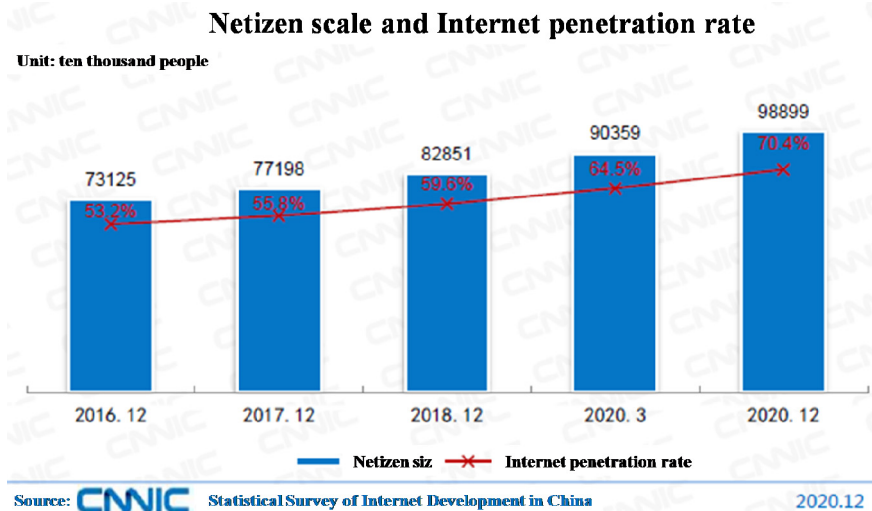

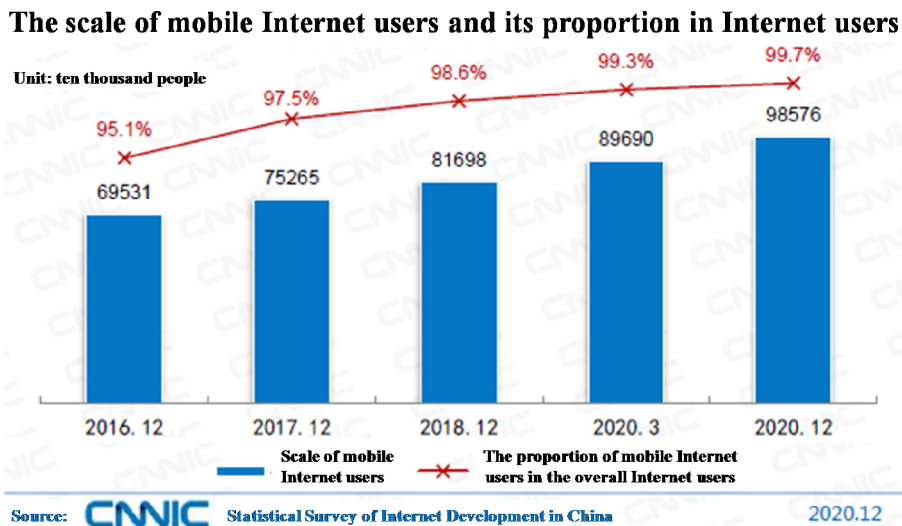**Figure 1** Scale of Internet users and Internet penetration rate

Figure 2 The scale of mobile Internet users and their proportion in Internet users
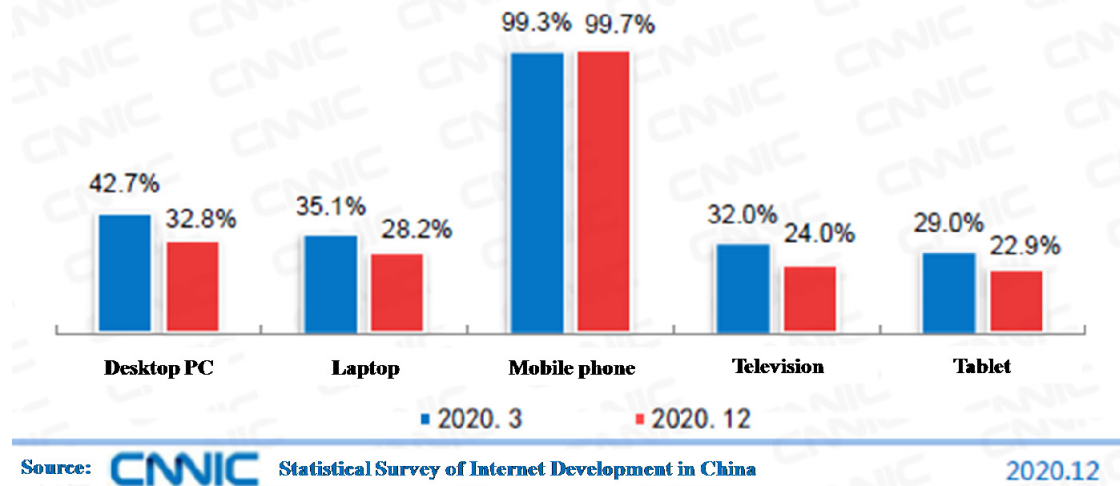
Figure 3 Usage of Internet access equipment

As is shown in Figure 1-3, smart mobile terminal devices represented by mobile phones are occupying and changing people's lifestyles. As the key entrance and main innovation platform for Internet services, more and more services and applications develop with the help of mobile terminals, and the mobile APP business is also developing and growing. [10] Therefore, to conform to the development of the era of science and technology, an online examination app is designed, researched and developed in this paper for China's earthquake disaster loss investigation and evaluation training based on the Android system. Moreover, through this APP, mobile terminal devices such as mobile phones and tablet computers can be used to provide functions such as online exams and self-tests for the majority of earthquake disaster assessment team members under the mobile Internet network, which is not only a new set of learning, training, and assessment methods conforming to the needs of the rapid development and application of mobile internet networks nowadays, but further strengthens the professional level of disaster assessment team members, so that each team member can more smoothly complete the investigation and assessment of earthquake site disaster losses in the future, and comprehensively improve the comprehensive quality of the disaster assessment team.

3. SYSTEM OVERALL ARCHITECTURE DESIGN

As is shown in Figure 4, the overall architecture design of the earthquake disaster loss investigation and evaluation simulation exercise system should involve the interface between the infrastructure layer, the resource layer, the support layer, the application layer, the software system and the earthquake emergency command technology system, as well as the interface between the software system and the internal professional database of each professional seismic organization. Meanwhile, the information security assurance system and operation maintenance and support system are used as support.[11] The specific description is as follows:

1) Basic layer

The basic layer mainly includes software resources, hardware, resources, and network infrastructure related to the entire system. Among them, Software resources refer to system server operating system software, workstation operating system software, database platform software, etc. Hardware resources refer to server equipment, workstation equipment and other equipment. The network infrastructure includes the national seismic dedicated network, public network systems, network infrastructure, communication equipment, and other transmission channels.

2) Data layer

The data layer is the storage layer of application data in the APP, which mainly includes test question bank, test paper bank, score bank, personnel bank, etc. In addition, every time the operation and application of APP needs to retrieve relevant data from the database, and then complete data interaction, storage, deletion, replacement, etc.

3) Business layer

The business layer is the application technology skeleton and technical foundation of the entire system, providing application function support for each module and sub-module of the system application layer. What is more, based on the business layer, the connection

between users, terminals and databases is realized, which completes the transmission process of the application and plays a key role in connecting the previous and the next, mainly including online examination module, self-test module, question bank management module, examination paper management module, examination setting module, examination management module, scoring management module, checking management module, and statistical management module. In addition, with the support of data, management functions such as online examinations, self-tests, test questions and test papers are realized based on the Internet.

4) Application layer

The application layer is the presentation and use layer of all the functions in the system, directly facing the end user. Moreover, earthquake disaster assessment team members apply mobile phones or tablets to completing the operation and use of the APP through the Android system under the support of the mobile internet network.

The above four levels are dependent relationships. The application layer depends on the business layer, the business layer depends on the resource layer, and the data layer depends on the base layer.
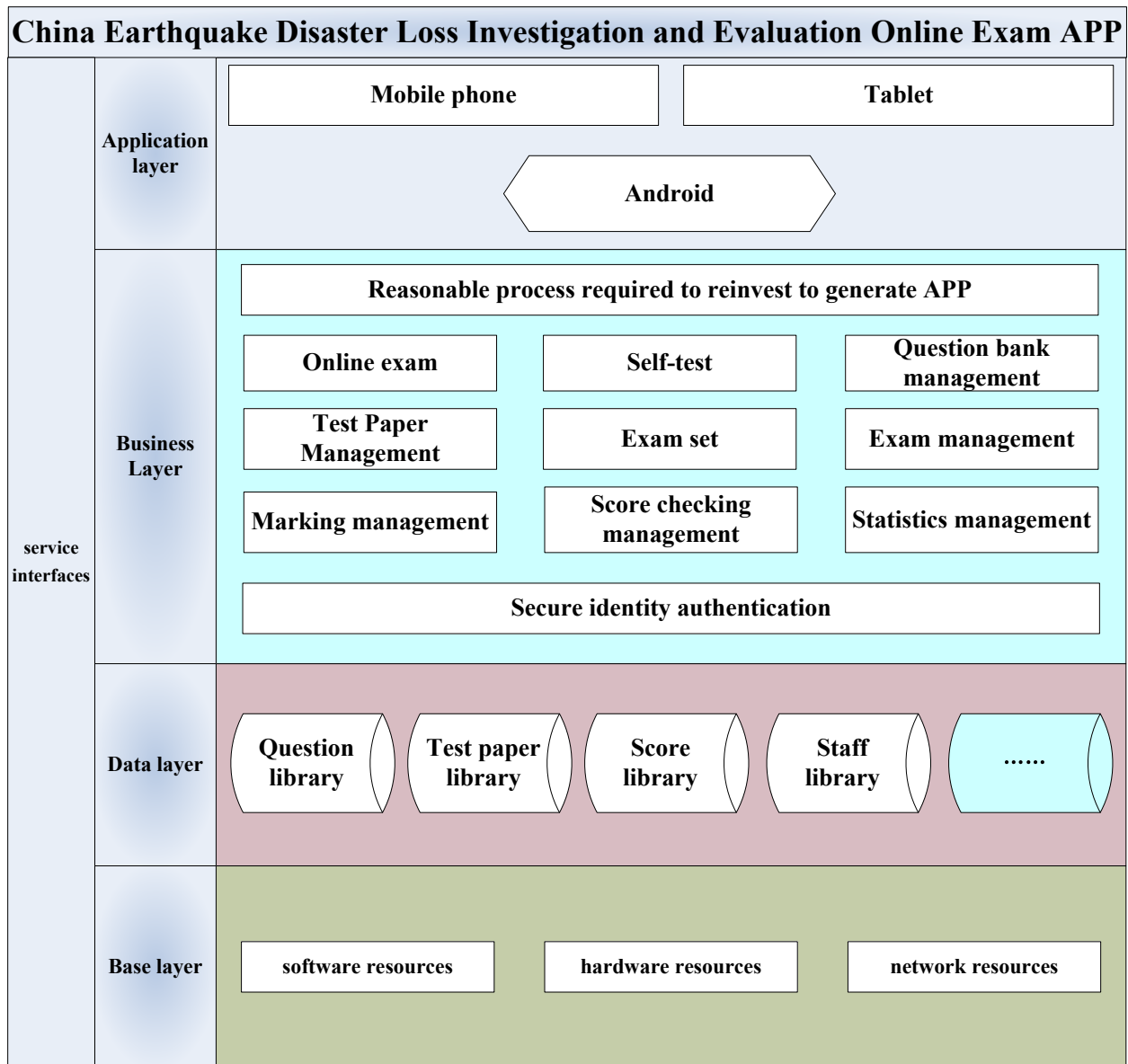

Figure 4 System overall architecture diagram

4. SYSTEM FUNCTION DESIGN AND REALIZATION

As is shown in Figure 5, the functional realization of the system is mainly composed of the following 9 sub-modules: 1) Online exam module 2) Self-test module 3) Question bank management module 4) Test paper management module 5) Test setting module 6) Test management module 7) Marking management module 8) Checking management module 9) Statistics management module. Figure 6 shows the home page display of the APP.
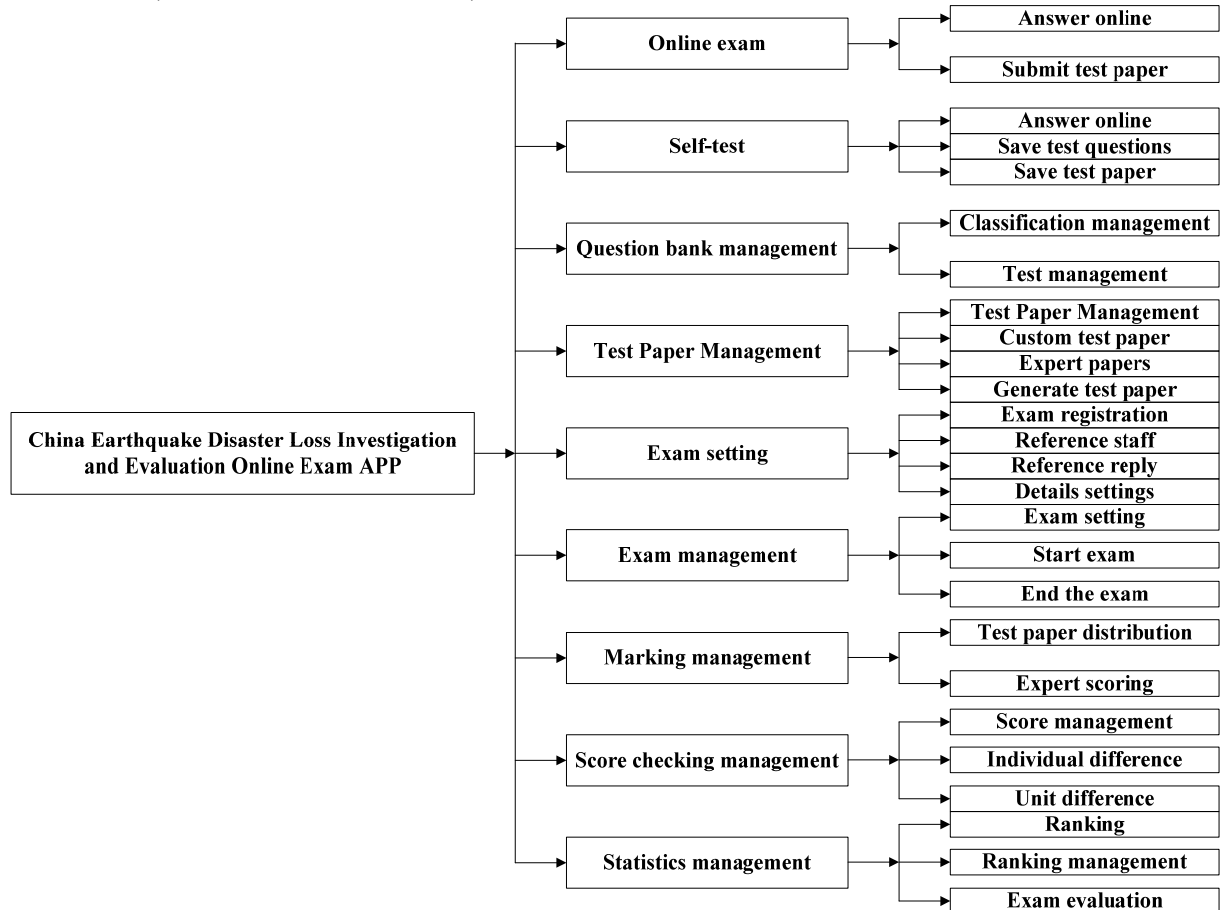

Figure 5 System function module diagram
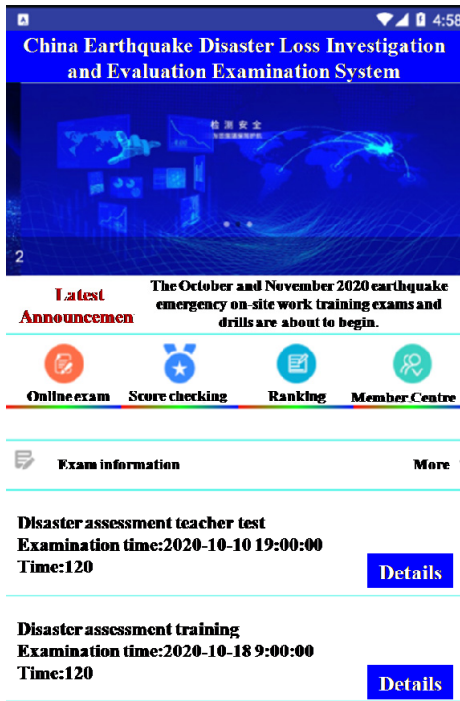
Figure 6 App homepage display diagram

Figure 7 The implementation diagram of the test paper details query function

(1) Online exam module:

Providing users with online assessment and testing functions not only allows each user to easily take the exam without space constraints, but also enables the managers of earthquake disaster loss investigation and assessment to know the true level of each earthquake disaster loss investigation and assessment team member in the field in time, offering an important basis for rational selection of personnel in future earthquake emergency. In addition, the online examination module will also serve as a platform for the China Earthquake Administration to carry out the qualification work of earthquake disaster loss survey assessors in the future.

(2) Self-test module:

Users can take mock exams through the self-test module, and the system can randomly select test questions from the test question bank to form a complete set of simulation test papers for the earthquake disaster loss investigation and evaluation exam. Moreover, through this module, users can find their own knowledge gaps in time, look for deficiencies, and improve their knowledge level in the field of earthquake disaster loss investigation and assessment.
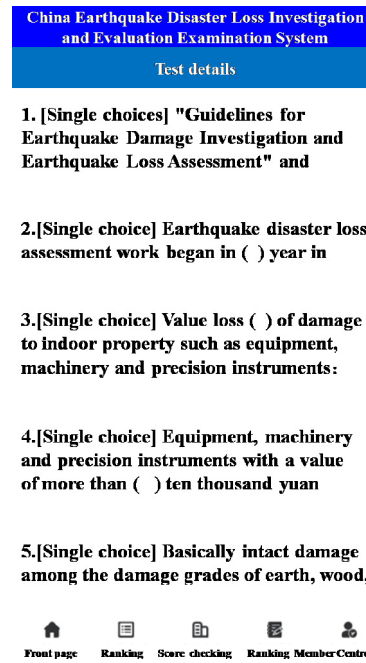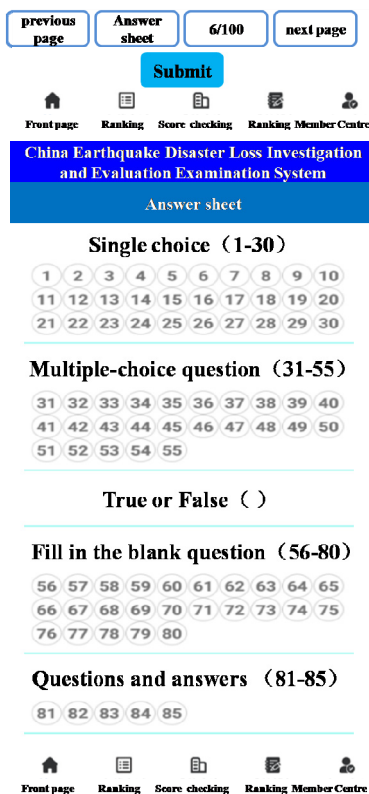

Figure 8 Self-test function realization diagram
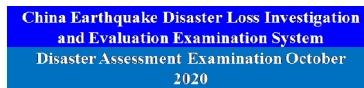
Figure 9 Online examination function realization diagram

(3) Question bank management module:

System administrators or earthquake disaster loss investigation and assessment experts are responsible for maintaining the test question database, and adding, publishing, and querying test question information, as well as modifying and deleting test questions. Moreover, the test question bank is the basis to realize the core functions of the system. Only by constantly enriching and updating the content of the question bank can the system serve the earthquake disaster loss investigation and assessment team members more effectively. What is more, the work enriching the content of the question bank is jointly completed by the system administrator,

the Earthquake Disaster Prevention Department of China Earthquake Administration, and the experts of the Earthquake Disaster Assessment Technical Coordination Group of China Earthquake Administration. The system sets up an expert questioning mechanism and an expert database. The system administrator will occasionally invite industry experts to add new questions to the system. Besides, the additional test questions will be reviewed by other experts in the same industry. According to different categories and different assessment levels, representative test questions will be selected into the test question bank, which will be used as exam preparation questions for future exams.

(4) Test paper management module:

System administrators or experts not only maintain the test paper library, but also add, modify, query, and modify test paper information, as well as add and delete test questions contained in a test paper. The score of each test question is also defined as well. In addition, the test paper has a strict confidentiality mechanism. Before the formal test, the system will fully encrypt the test paper. Except the system administrator, no other users can view the test paper.
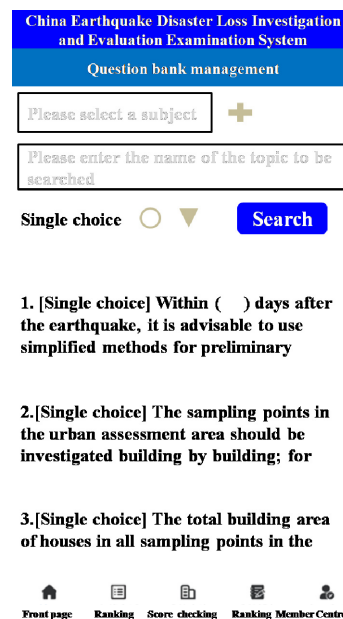

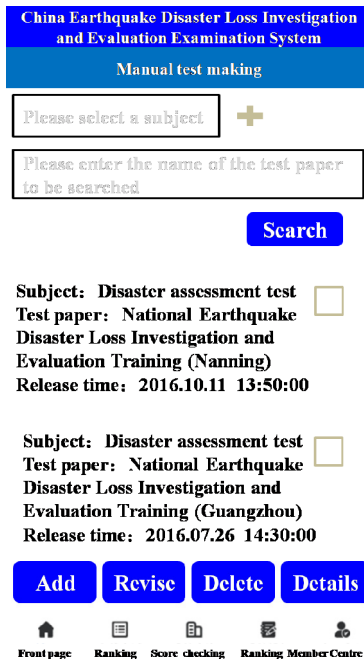**Figure 10** Implementation diagram of question bank management function

Figure 11 Implementation diagram of test paper management function

(5) Exam setting module:

Before the start of each test, the system administrator or the China Earthquake Administration will formulate the test plan, and specify the test papers, test questions, test time, reference personnel information, test pass scores, test disciplines and requirements for the test plan. Besides, users are designated to take the exam, if other users interested to the exam want to take the exam, they can also register online, and take the exam after being reviewed and approved by the administrator. At the same time, users who are going to take the test must make a confirmation response online before the start of the test, informing the administrator whether they can guarantee to take the test. If there is no response, it will be treated as abandoning the exam, and if the confirmation response is completed but the user who did not take the online exam will be automatically recorded as "0" by the system. In addition, the exam module can meet the requirements that different units and different types of exams can be performed at the same time, and multiple users can log in to the exam at the same time. Figure 6 and Figure 7 are the function realization diagram and flow chart of the test setting module.

(6) Exam management module:

System administrators or unit administrators maintain and publish exam information, start exams, and end exams. Reference personnel can take online exams. Meanwhile, the system will automatically record the examination of each earthquake disaster loss investigation and assessment team member, and the test papers and scores will be recorded in the system's back-end database, which is not only convenient for the

team members taking the exam to read the test papers and find their own problems, but also ensures that the management personnel of the China Earthquake Administration can track and fully grasp the construction of the domestic earthquake disaster loss investigation and assessment team. Figure 11 is a flow chart of system examination management.
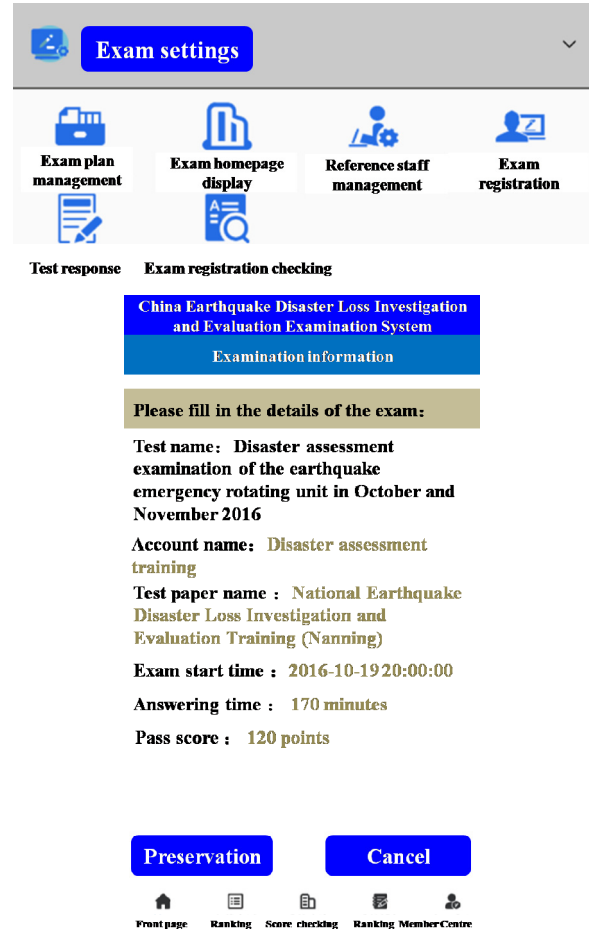

Figure 12 Exam setting and management function realization diagram

(7) Marking management module:

The system will automatically give correct answers and scores to objective questions. System administrators will appoint a marking expert for subjective questions, and the marking expert is responsible for marking and scoring the test papers. Moreover, the system administrator will invite senior industry experts to complete the online scoring work, who not only give the correct answer, but also analyze the answers of each team member. Also, they will point out the errors or deviations in knowledge of earthquake disaster loss investigation and assessment. In addition, experts who participate in online scoring will be paid correspondingly.

(8) Checking points management module:

To inspect and fully control each user's examination situation, the system allows the system administrator

and the China Earthquake Administration to view the examination results and the details of the test papers of all users through the score management module. Moreover, unit administrators can view the test paper scores and test paper details of users of this unit, and each earthquake disaster loss investigation and assessment team member or ordinary user who participates in the test can only view their own test scores and test paper details.

(9) Statistics management module:

The system administrator can inquire about the ranking of a certain test score and the summary of scores according to the unit, personnel, and score segment, and can also calculate the weighted average of multiple test scores to give a comprehensive ranking that can be a scientific basis for the rational selection of earthquake disaster loss investigation and assessment team members in future earthquake site work. Moreover, unit administrators can check the rankings of the personnel in previous examinations, which can be used to control the earthquake disaster loss investigation and evaluation capabilities and levels of the personnel.
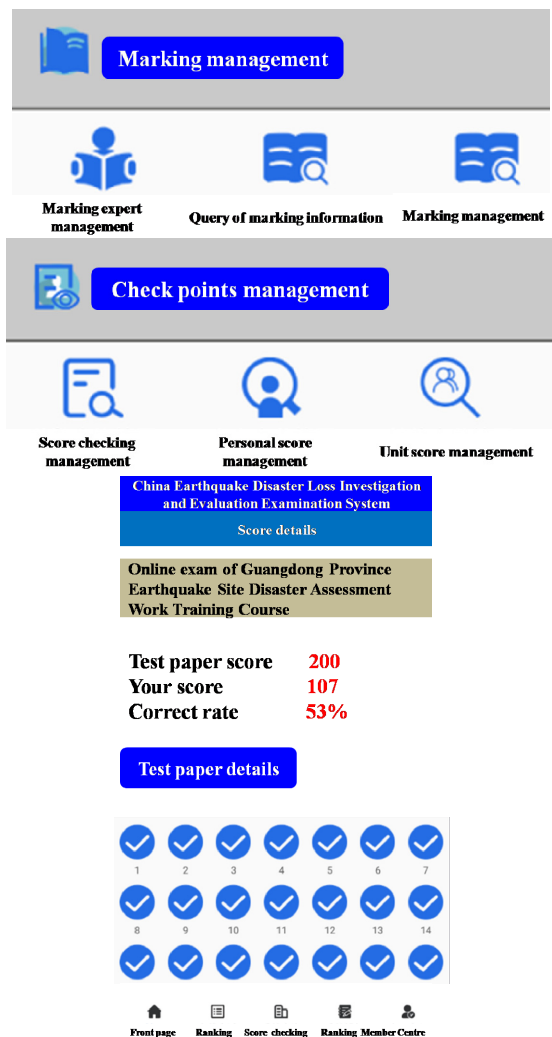

Figure 13 Implementation diagram of marking and checking management functions

5. INTELLIGENT TEST PAPER COMPOSITION MODEL FOR EARTHQUAKE DISASTER ASSESSMENT EXAMINATION

It is the core work of the examination system to establish a set of scientific and reasonable earthquake disaster assessment examination papers, and rigorous and scientific test papers can greatly improve the pertinence of the test. The intelligent automatic paper composition function is used in this system to extract test questions that meet the set difficulty level from the test question bank, which can more scientifically test the knowledge points of the disaster assessment team members under this difficulty.

Intelligent test paper is a set of complete test papers automatically generated by the computer according to the pre-designed parameters. At the beginning of designing the test question bank, in addition to matching the answers to the relevant test questions, different attribute values must be edited for different test questions, which mainly include: 1) the category of the test site that the question belongs to 2) the difficulty and distinction of the knowledge point of the question 3) Question points, etc.

The binomial distribution function B (n, p) of discrete random variables is selected in this system to establish a set of intelligent test paper composition model for earthquake disaster assessment examination. According to the degree of difficulty, the difficulty coefficients of the earthquake disaster assessment test questions are assigned as follows: easy=1, easier=2, medium=3, harder=4, difficult=5. Then, the earthquake disaster assessment test questions are randomly selected from the test question bank to automatically form a set of test papers. Assuming that the full score of the test paper is 100 points, if the expected average score of the test paper is 70 points, and the average score is around 70 points, it will be considered that the difficulty level of the earthquake disaster assessment test is moderate, and the team members who participated in the earthquake disaster assessment examination can complete the corresponding earthquake disaster loss investigation and assessment work well. At the same time, disaster assessment team members with more than 70 points are deemed to be competent in disaster assessment work and can properly handle various disaster loss assessment situations that occur at the earthquake site. Therefore, based on the binomial distribution function B (n, p) of discrete random variables, an intelligent test paper composition model for earthquake disaster assessment examination papers is established as follows:

$$p(k)=C_n^k p^k q^{n-k}$$

Both k and n are non-negative integers, $k=0$，1，$2……n$，$p>0$，$q>0$，and $p+q=1$. q equals to the expected

score/full score, and *n* equal to the number of difficulty levels of the situation information plus 1. Normally, when *q > 0.6*, *P(n)* and *P(n-1)* are usually small, and the result can be added to *P(n-2)*. Examples are as follows.

The test questions in an earthquake disaster assessment test paper are divided into five levels according to the degree of difficulty, namely easy, relatively easy, medium, relatively difficult and difficult, and the difficulty coefficients are 1, 2, 3, 4, and 5. Moreover, the full score of the earthquake disaster assessment test is 100 points, and the expected average score is 70 points. Therefore, *q=0.7* and *p=0.3* can be obtained. According to the above formulas.

$$p(0)=C_6^0 p^0 q^6 = 1 \times 0.3^0 \times 0.7^6 = 0.117649$$

$$p(1)=C_6^1 p^1 q^5 = 6 \times 0.3^1 \times 0.7^5 = 0.302526$$

$$p(2)=C_6^2 p^2 q^4 = 15 \times 0.3^2 \times 0.7^4 = 0.324135$$

$$p(3)=C_6^3 p^3 q^3 = 20 \times 0.3^3 \times 0.7^3 = 0.185220$$

$$p(4)=C_6^4 p^4 q^2 = 15 \times 0.3^4 \times 0.7^2 = 0.059535$$

$$p(5)=C_6^5 p^5 q^1 = 6 \times 0.3^5 \times 0.7^1 = 0.010206$$

$$p(6)=C_6^6 p^6 q^0 = 1 \times 0.3^6 \times 0.7^0 = 0.000729$$

From the above calculation results, it can be concluded that the results of *P* (*5*) and *P* (*6*) are relatively small and can be omitted or added to *P* (*4*). Therefore, the difficulty level score area curve of the earthquake disaster assessment examination can be obtained as﹛ *12, 30 , 32, 19, 8*﹜.

According to the intelligent test paper composition model of the earthquake disaster assessment examination paper, it can be concluded that when the expected average score is 70 points, the proportions of various test questions are as follows: easy test questions accounts for 12%, less easy test questions accounts for 30%, and medium difficulty test questions accounts for 32%. More difficult test questions accounts for 19%, and the most difficult test questions accounts for 8%.

6. CONCLUSION

In this paper, an online test app is designed and developed for the earthquake disaster loss investigation and evaluation in China, which can use mobile devices such as mobile phones and tablet computers to implement the earthquake disaster loss investigation and evaluation examination, questioning, scoring, and scoring tasks under the mobile Internet. Moreover, with the help of this APP, training and assessing the members of national earthquake disaster loss investigation and assessment team, members' own business deficiencies and shortcomings can be recognized, which will urge members to improve their own capabilities and levels. Meanwhile, this APP will serve as a right- hand assistant

for China Earthquake Administration to manage the national earthquake disaster loss investigation and assessment team member, understanding and grasping the real professional level of the national earthquake disaster loss investigation and assessment team members in real time, which will provide scientific basis for more scientific and reasonable selection of troops after a destructive earthquake. All in all, the design and development of this APP will provide an important guarantee for the rapid advancement of the earthquake disaster loss investigation and assessment team in China.

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