Design and Implementation of Software Test Laboratory Based on Cloud Platform

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Abstract—Software testing has become an essential indicator of students' professional level. To improve students' software testing ability, the construction of software testing laboratory has become an urgent need for many institutions. With the development and popularization of cloud computing, more and more software industries rely on cloud computing, which also brings new ideas for the construction and development of software testing laboratories in colleges and universities. This paper designs and implements a software testing laboratory based on a cloud platform, which can reuse the traditional hardware devices such as the servers in the laboratory. It is an intelligent and convenient laboratory environment with rich functions and powerful management functions, such as antagonistic experiments, programming communities, developer testing, and so on. Students can also connect to the cloud platform through the campus network to carry out various experiments. The experimental results of students will be stored on the cloud platform to facilitate the management of teachers, which can effectively improve the level of resource utilization of university laboratories. Through the cloud platform, we can arouse the enthusiasm of students and improve their professional skills, and improve the quality of experimental teaching in colleges and universities as well.

Index Terms—Cloud Platform, Laboratory, Software Testing, Antagonistic Experiment

I. INTRODUCTION

In recent years, software engineering has developed rapidly, and various software products are ubiquitous in our life. However, the software is the embodiment of the high degree of intelligence of the human brain. This feature makes it different from other fields of technology and production. However, software defects are inevitable in most software products. Therefore, software testing is an indispensable part of the software life cycle, which is still the most effective way to eliminate and prevent software defects. Software testing is the process of using manual or automated techniques to run or test a system. The purpose of software testing is to verify whether the software meets the specified requirements or to whether the actual results match the expected results. In the process of software testing are found out the defects in the software. With the significant development of the IT industry in recent years, various fields are related to the software industry, and the quality requirements of the software are getting higher.

Software testing plays a more and more critical role in software development. At present, from the recruitment information of several large software companies, such as Alibaba and Tencent, we can see that the gap in the software testing industry is still huge. Now is the era of the Internet plus, almost all kinds of industries are related to the software industry, the market demand for software testing professionals is also getting higher and higher.

To improve students' software testing ability [1], many colleges and universities urgently need to build a software testing laboratory which can meet the needs of students' software testing experiments[2]. With the development and popularization of cloud computing, more and more software industries rely on cloud computing, which also brings new ideas for the construction and development of software testing laboratories in colleges and universities[3]. At present, there are some problems in the existing experiments in colleges and universities, such as a single function, unable to save students' experimental data, heavy workload of teacher management and maintenance, difficulty in updating system and so on [4], which brings great resistance to students' daily experimental courses.

This paper mainly introduces how to build a software testing laboratory based on the cloud platform, which aims to solve above issues and provides a laboratory environment with multi-functions and friendly user experience[5].

We make the following goals.

- Providing students with a variety of software testing experiments [6]. In taxonomy,software testing involves several fields, including developer testing, web testing and embedded testing. The software testing laboratory based on cloud platform should provides these type of software testing experiments.
- Realizing the diversity of laboratory functions [7]. The traditional laboratory experiment method is relatively simple. Students can only carry out test-related experiments in the laboratory where the testing experiment system is installed, and they can only carry out development-related experiments in the laboratory with the development experiment system installed. It severely affects the students' enthusiasm for the experiment. The software testing laboratory based on cloud platform should integrate different experiments into one laboratory to meet the needs of students' experimental diversity.
- Achieving intelligent and convenient student management and teacher management [8]. Traditional laboratories are difficult to manage student information and teacher information. Software testing laboratories based on cloud

platforms should provide teachers with intelligent and convenient student management functions and administrators with teacher management functions [9].

- Realizing personalized experimental teaching. Usually, the content and form of the experiment are fixed and unified. It seriously affects students' interest in teaching experiments. In our cloud-based software testing laboratory, experimental teachers are allowed to customize personalized experiments according to the course schedule and content needs. This flexible setting not only stimulates students' interest, but also realizes teaching students in accordance with their aptitude.
- Realize the maintainability of the laboratory [10]. Traditional laboratories include servers, switches, terminal computers and other entities. If the system has problems or needs to be updated, administrators or teachers need to check or update each machine. The software testing laboratory based on the cloud platform centralizes all the services on one cloud platform. If there is a problem or needs to be updated, the cloud platform can be maintained and updated.

II. DESIGN OF LABORATORY
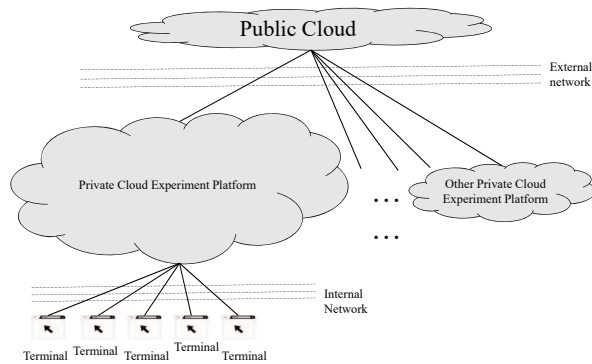
A. Overall

Fig. 1. Overall Cloud Structure Diagram of Laboratory

The overall cloud structure of the software testing laboratory based on the cloud platform is shown in Fig.1. The entire cloud platform is composed of a public cloud platform and multiple private cloud platforms [11]. Each private cloud platform corresponds to a laboratory. Multiple browsers can access each private cloud platform via either the private network or the public network (colleges and universities generally choose private network environments for security). Each university can deploy a private cloud platform which is connected to the public cloud platform. If the experiments in private cloud need to be updated, they can be obtained from the public cloud platform through the network (public network environment). Students can use the private network to access private cloud platforms through a browser to carry out experiments [12].

The architecture diagram of the private cloud platform is shown in Fig.2. The virtualization manager is built based on
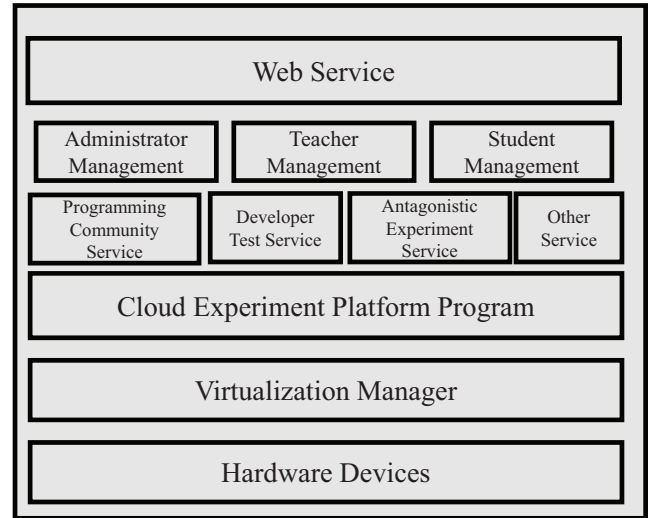

Fig. 2. Architecture Diagram of Private Cloud Platform

the original hardware of the laboratory, the virtualization manager can realize the portability of the cloud platform program. The cloud platform program is installed on the virtualization manager, which provides developer testing service, antagonistic experiment service, programming community service, and so on. Besides, the cloud platform sets up three kinds of role management of administrator, teacher, and student. The cloud platform provides web services to the outside world.

B. Function Design of Laboratory

The laboratory is an important resource for training computer and related professionals [13]. In the curriculum arrangement of computer and related majors, experiments teaching accounts for a large proportion [14]. To meet the needs of students' diversified experiments diversity as much as possible, we should optimize the experimental system in the laboratory continuously. With the emergence of cloud computing, the experimental system and management mode of the traditional laboratory have been impacted, which promotes the development of a new type of laboratory which is based on the cloud platform with convenient management, convenient use, high maintenance, and powerful function.

Different from the traditional experimental system, which requires the installation of experimental software on each terminal computer, the laboratory based on cloud platform integrates all the computing services into a central server [15]. Students can use the lab computer or their computer to connect to the lab cloud platform server and carry out experiments by browser or plugin. The laboratory based on cloud platform includes programming community, developer testing, programming community and developer testing antagonistic experiment.

1) Programming Community: The programming ability is an important standard to measure the ability of computer and related majors. Therefore, the cloud platform of the laboratory

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integrates the functions of the programming community. In the programming community, students can choose the corresponding programming experiments. These experiments can be brought by the system or be customized by the teacher. In programming community experiments, students should ensure that as much of their code passes as many test cases as possible. The more test cases the students' codes pass, the higher their scores. The programming community can also show the experiments that the students have done and the students' pass rates. Teachers can evaluate the students' programming ability according to the number of experiments and the pass rates. A scoring mechanism has been introduced into the programming community, which can increase the enthusiasm of students for programming through their desire to win.

2) Developer Testing: Developer testing refers to the software testing work related to code undertaken by developers in the development process. Static testing and dynamic testing are both ways for developers to test. Static testing refers to checking the program code developed by the developer, while dynamic testing refers to that the developer runs the code and gives the input data to check whether the program can run properly and output the expected results. Students should master both testing methods. learning developer testing is one of the most effective methods to improve students' understanding of the software development process and software testing. The students choose the corresponding experiments and develop test cases for the code in the experiments. The higher the coverage of the test cases written by the students, the higher their score. The function of developer testing is like the programming community, which invokes the enthusiasm of students through the scoring mechanism. Through the developer testing experiment, students can gradually master the skills and methods needed for development and testing, and their programming and testing abilities can be improved.

3) Antagonistic Experiment: The antagonistic experiment is a new experimental model proposed by the laboratory based on the cloud platform. The experimental model divides the students participating in the experiment into two groups, the programming community group and the developer testing group. Among them, the students of the programming community group carry out the programming experiment to write the code, and the students of the developer testing group carry out the testing experiment. Students in the programming community group need to ensure that their codes pass as much as possible through the students' testing cases of the developer testing group. The more test cases passed, the higher the score of the students in the programming community group. The students of the developer testing group need to ensure that their test cases can find out as much as possible the bug of the code written by the students of the programming community group. The more bugs are found, the higher the score of the students of the developer testing group. This experimental model can attract the interest of students. In the process of experiments, the students of the two groups improved the test cases of the experimental code and the detection code. This experimental model can improve the students' programming

ability and software testing ability.

4) Other Functions: In addition to the programming community, developer testing and antagonistic experiments, laboratories based on cloud platforms should also provide experimental functions such as mobile application testing, web testing, and embedded testing.

C. Role Permissions

For different functional requirements and permission requirements, the laboratory based on the cloud platform mainly has three separate roles of permissions, namely, administrator, teacher, and student.

1) Teacher Permissions: In the cloud platform of the laboratory, teachers can create classes for students to join. Teachers can add or remove class members, and they can create experiments for students in a designated class. Teachers can manage the experimental results of the students in the class. The teacher can choose whether the experiment's attribute is public or private if he or she is the creator. If the experiment's attribute is private, only the teacher who created this experiment can use it. If the attribute of the experiment is public, all teachers in the lab can use it.

2) Student Permissions: The students in the laboratory based on the cloud platform can sign up and modify personal information. They can join or withdraw from a class as well. In addition, the students can participate in an experiment and view their own grades.

3) Administrator Permissions: Administrators have the highest rights in the laboratory based on the cloud platform. They can view the list of users in the laboratory and create competitions for all students in the laboratory. They can manage all user information in the laboratory as well. In addition, the administrators also have all permissions for the student and teacher roles.

III. APPROACH

Cloud experimental platform has three different roles, namely, students, teachers and administrators. The student function module diagram is shown in Fig.3, including programming community function, developer test function, antagonistic experiment function, mobile application test function, Web test function, embedded test function, etc. The teacher function module diagram is shown in Fig.4, including class management function, topic management function, student information management function, etc. The administrator function module diagram is shown in Fig.5. This chapter mainly introduces the implementation of the teaching experiment function involved in the role of students.
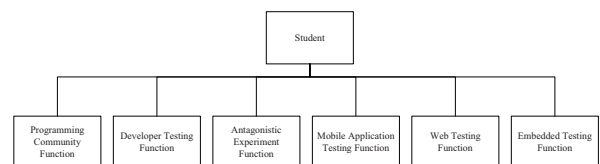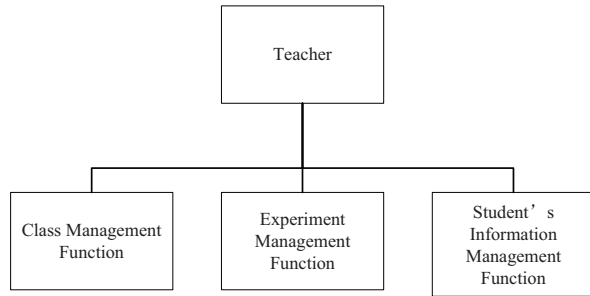

Fig. 3. The Student Function Module Diagram
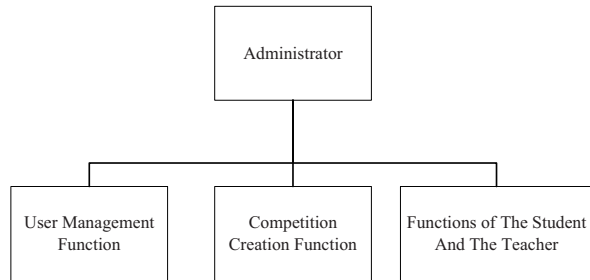
Fig. 4. Functions of Teachers

Fig. 5. Functions of Administrators

A. Resource Planning

Cloud platforms need to be deployed on laboratory servers, which are compatible with the existing laboratory equipment. In order to ensure the smooth operation of cloud platforms, the server needs at least 16GB of memory. The laboratory based on the cloud platform can be accessed by wired network and wireless network. The original computer equipment of the laboratory can be connected to the server of the cloud platform using the star-shaped topology shown in Fig.6, and students can also access the laboratory cloud platform wirelessly through the campus network.
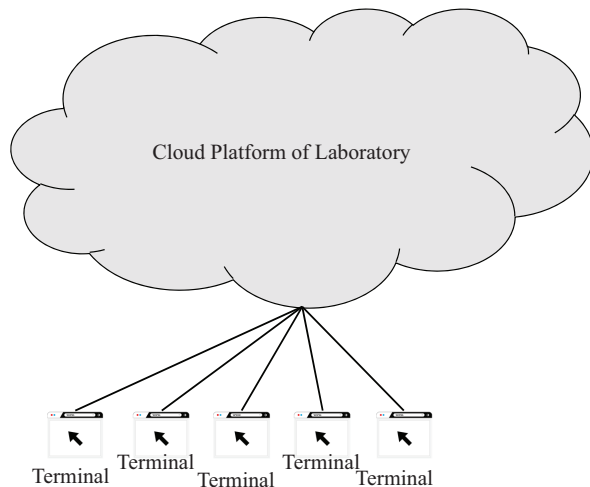

Fig. 6. Topology of Laboratory

B. Programming Community

Programming community provides students with the function of practicing programming. After a class is created by the teacher, attributes could be chosen as a programming community. Students who join the class can carry out programming experiments on the cloud platform of the laboratory. Students can no longer carry out programming experiments after the class is removed. The main functions of the programming community are code edition, code runing and students achievement management function, as shown in Fig.7.
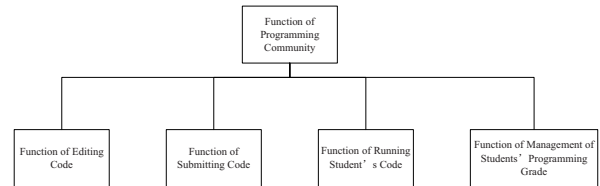

Fig. 7. Function of Programming Community

The operation flow of the programming community is shown in Fig.8. Some experiments in the programming community are included in the lab's cloud platform when it is installed, and the cloud platform also provides teachers with the ability to create personalized experiments. Teachers can create experiments according to the actual teaching situation. Teachers need to upload the requirements of the experiments and provide several cases to facilitate students to understand the meaning of the experiments firstly. Secondly, the attributes of the experiments should be set. The public experiment will be shared with all the teachers on the experimental platform, while the private experiment can only be used by the teacher who created it. Then teachers should set the limit of the experiments and set the maximum memory and maximum time for the code submitted by the students. Finally, they should add test cases, which are a measure of the quality of the code submitted by the students. That is, the more test cases the students' codes pass, the higher the scores students can get. To detect the students' code more effectively, the test cases added by the teacher should be as rich as possible.

After joining the programming community class created by the teacher, the students choose the experiments assigned by the teacher to program. Students can choose to use plugin or WebIDE. Students who use plugin need to install Eclipse plugin and submit their codes by Eclipse. Students who use WebIDE only need to open the browser to carry out the experiments and submit codes. Students need to choose a programming language before writing codes. Students can use the test cases provided by the experiment to detect their code before submitting the code. Take WebIDE as an example, students can click the run button on the page to check their codes. The browser can submit the student's code to the cloud platform and display the corresponding output according to the student's input. When the student clicks the submit button, the browser will submit the student's codes to the cloud platform and check it according to the test case provided by the teacher
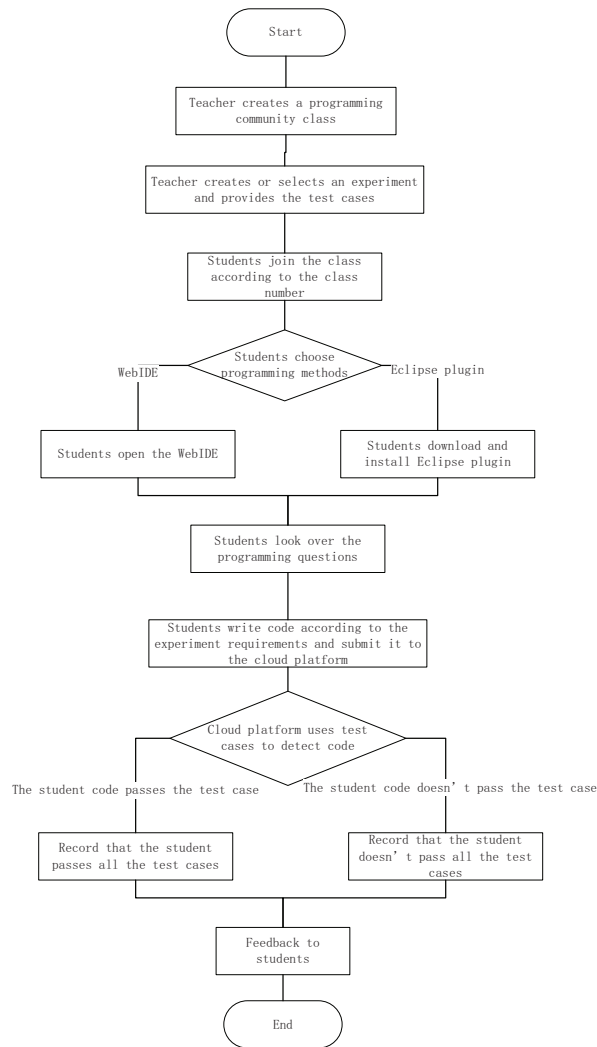
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Fig. 8. Flow Chart of Programming Community Experiments

when the experiment was created. When the codes submitted by the student pass all the test cases provided by the teacher, the message will be fed back to the student through the browser. The space and time that the students have taken up through the experiments and the number of times it has been submitted will be recorded in the cloud platform. If the students submit codes that can't pass all test cases, the message that fails the test case will be fed back through the browser.

Students can search the experiments passing rates and the space and time occupied by the codes running of all the students in the class. When the students notice that the codes of other students take up less space and time than their own, their desire to win prompt these students to optimize the code.

In addition to providing students with the experiments to write code, the programming community also provides a forum-like function in which students can share their questions or experiences in the programming community, and other students can answer these questions. Students can refer to experience sharing to solve their own problems as well.

Through programming community, we can not only improve students' enthusiasm for programming, but also improve students' programming ability and their code quality.

C. Developer Testing

The developer testing experiment includes the students editing test cases edition test case submission, the test case detection function and the developer testing score management function of the students, as shown in Fig.9.
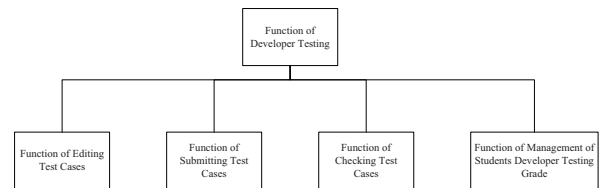

Fig. 9. Function of Developer Testing

Like the programming community, the laboratory based on the cloud platform also provides some developer testing experiments. Teachers can create personalized experiments according to their own curriculum needs. The teacher can create an experiment by uploading the request for the experiment or the need for codes functionality firstly. Secondly, teacher need to set the attribute of the experiment. Finally, unlike adding test cases in the programming community, the teacher needs to upload the codes with bugs.

The flow chart of the developer testing experiment is shown in Fig.10. Students need to join the class before carrying out the developer testing experiments. After selecting the experiment, students can download it by the Eclipse plugin, and then look up the requirements of the experiment uploaded by the teacher and the codes with bugs. Students need to add test cases to find out the more bug in the source code, the higher the score they can get. After the students' submission, the cloud platform will run the codes according to the test cases submitted by the students. The cloud platform will record the students' scores according to the number of bugs found by them. The score is visible to the students and teachers in the same class. Through the developer testing experiment, we can improve the students' understanding of software development and improve the code quality of students in the future.

D. Antagonistic Experiment

Antagonistic experiment is a new experimental model put forward by laboratory based on cloud platform. The idea of this model is to combine the developer testing experiment with the programming community experiment.

As shown in Fig.11, the teacher creates a class with antagonistic attributes in the cloud platform of the laboratory firstly, which divides the students into a developer testing experimental group and a programming community experimental group. Students choose the groups they need to join when they join the class. At the beginning of the experiment, the teacher
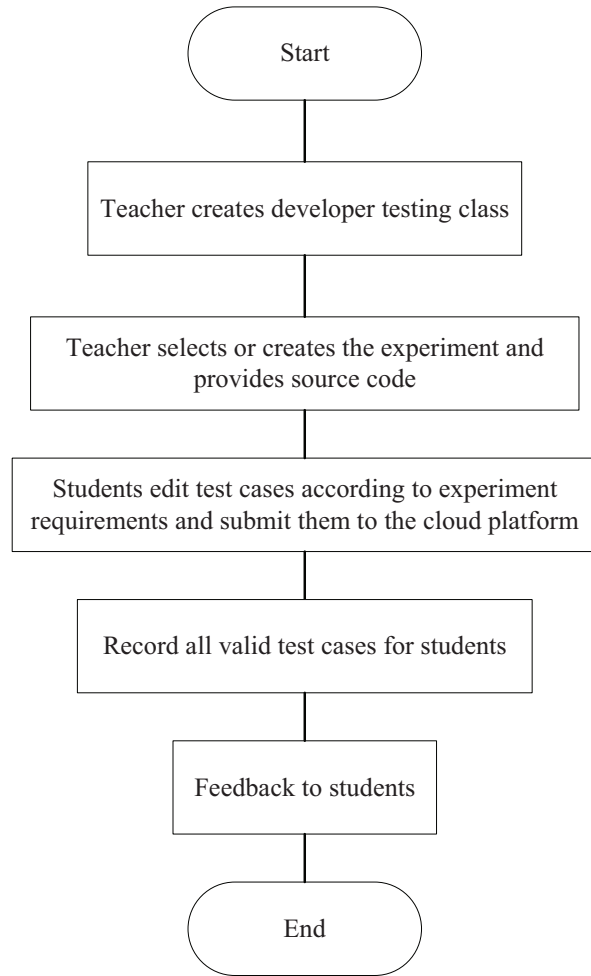
Fig. 10. Flow chart of developer testing experiment

Fig. 11. Flow chart of antagonistic experiment

needs to give an experiment and the requirement and to submit a correct code in the cloud platform. Then the students in the programming community group should write the codes according to the experiment requirement. The students of the developer testing group should write test cases according to the experiment requirements.

The laboratory based on cloud platform uses two queues to store the codes submitted by the programming community group students and the test cases submitted by the developer testing group students respectively. Both queues will pop the item through the FIFO strategy. If one queue is empty, the other queue enters the waiting state. The codes in codes queue will be detected by using the test cases in the other queue.

The results can be divided into two cases, one is that the code passes all the test cases and the other is that the code doesn't pass all test cases. If the code passes all the test cases, the results will be fed back to the students who wrote the test cases and the students who wrote the code, and the item the queue where the test cases are stored will be popped. Use the new set of test cases to detect the codes that pass old test
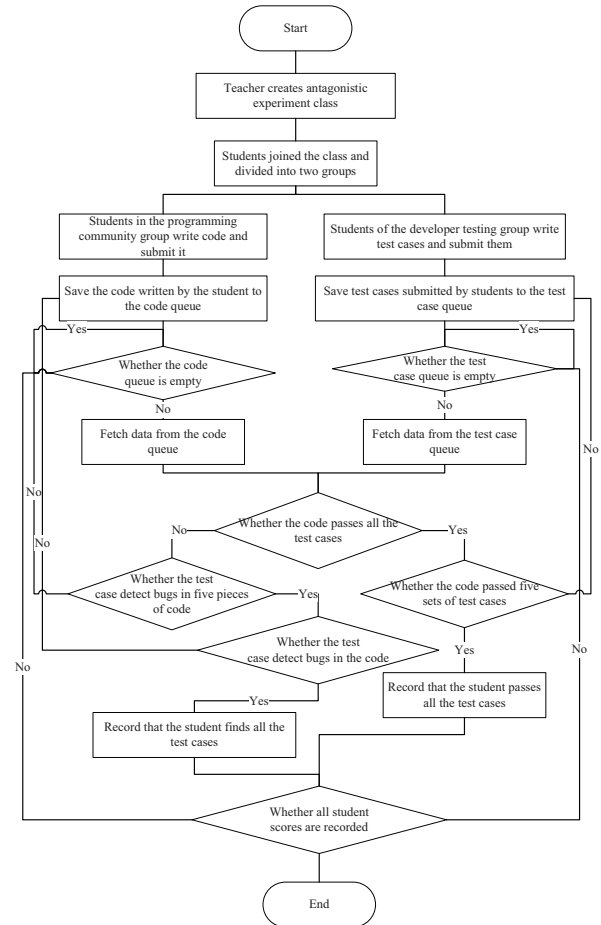
cases. If the codes pass all test cases again, the above operation will be repeated until the codes pass five sets of test cases in a row. The codes will be marked as passing the test. If the codes don't pass all the test cases, the results will be fed back to the students who wrote the test case and the students who wrote the code, and the queue in which the code is stored will pop. Cloud platform will take out another code to be tested with test cases. If the code does not pass all the test cases, the above operation will be repeated until a set of test cases prevents five sets of code from passing. The test cases which prevent five sets of code from passing will be used to detect the correct code submitted by the teacher. If the code passes, the set of test cases will be marked as a complete test case.

In the above way, the students of the developer testing experiment and the programming community experiment can be divided into groups. In the process of confrontation, the students of the programming community group will let their code pass through the test cases written by the students of the developer testing group as much as possible. And the developer testing group students will try their best to find out more bugs in the code written by the programming community group students. This experiment model can arouse

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their enthusiasm and improve the professional skills.

E. Other Parts

In order to meet the needs of students, the cloud platform also provides a variety of other experimental functions, such as mobile application test experiment, web test experiment and embedded test experiment. The cloud platform can be extended according to the needs of the actual teaching situation.

IV. CHARACTERISTICS OF LABORATORY CONSTRUCTION

The construction of laboratory based on the cloud platform is of great significance for improving the experiment environment of students and improving the quality of experimental teaching in colleges and universities [16]. It can train high-level computer professionals as well. At present, the cloud platform has implemented such functions as programming community, developer testing, mobile testing, and so on. In the future construction, these functions will be gradually improved and optimized, and the laboratory will also achieve more and more comprehensive enrichment in order to meet the needs of teachers and students in the process of experimental teaching.

The original server and other equipment can be reused in the laboratory based on the cloud platform. The requirement of the cloud platform for the server is more than 16GB of memory, which is lower than that of the server in the conventional laboratory, so the cloud platform can run smoothly.

The experiment teaching through the cloud platform can lift the restriction that the students' experiments must be carried out in the laboratory. Due to the distance between the school laboratory and the teaching building, students arriving at the laboratory to do experiments may waste more time. On the one hand, it will lead to inefficient teaching. On the other hand, it may lead to more students skipping classes. The cloud platform can be connected through the school's private network, which means that students can experiment in the classroom or dormitory to improve teaching efficiency. If a teacher needs to take an experimental class, the ordinary laboratory needs to make an appointment in advance. The reason for this phenomenon is that there are too many students and too few laboratories. The laboratory administrator will arrange the experiment time in a unified way. The cloud platform can solve this problem very well. The students can do experiments anytime and anywhere.

The cloud platform can realize the rational allocation of resources. In an ordinary laboratory, a server only serves students in one lab, with a maximum of no more than 100. While a cloud platform is deployed on one server, which can serve more than 3000 students. Up to 400 people can be tested.

The cloud platform provides a wide variety of services. The ordinary laboratory has the single function, and the laboratory based on cloud platform can provide students and teachers with different services such as developer testing and programming communities. In addition, it can be updated and expanded according to the needs of the actual teaching situation. The problem of complex and inefficient installation of teaching software in each course can be solved, and the teaching efficiency can be greatly improved [17].

V. CONCLUSION

In this paper, we propose a software testing laboratory on the cloud platform which can make full use of the traditional hardware devices, and offer services, including antagonistic experiments, programming communities and developer testing. We also supply data analysis of data stored in the platform to find and discover useful information hidden and benefit users of our laboratory, especially students and teachers.

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