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A CLOUD-BASED ONLINE CODING PLATFORM FOR LEARNING CODING-RELATED COURSES OF COMPUTER SCIENCE

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Abstract. *The college students of computer science and engineering commonly have difficulties in learning coding-related courses, because of lacking effective means to combine theory with practice. This paper proposes a cloud-based online based platform, which has the elegant development environment, to allow students to practice programming online, without any specific configurations (currently only C programming is supported). This platform provides online coding services, and can link teachers and students in a unique social experience by tracking and streaming progress updates in real time. In particular, with the newly proposed platform, it is easy to disclose interesting and unexpected input values during students' practicing, and help them to understand what their codes are actually doing. As a result, the students can effectively learn the coding-related courses, and eventually write high quality programs.*
Keywords: Computer science, Online coding, C programming, Cloud platform

1. **Introduction.** To complete common tasks of teaching in the colleges and universities, the teaching methods are critical to educate students in classes [4, 5]. Since computer science is a typical engineering-related field, there must be certain special engineering courses for cultivating the students majoring in computer science or other similar specialties [7]. It is true that cultivating the skill of programming is the core curriculum of computer science, and the better programming skill may benefit the students to develop high quality applications. For instance, the C language is a popular and widely used programming language, and which is even employed to develop operating systems, such as Unix and Linux. Therefore, to offer better teaching means, then improving teaching quality of coding-relevant courses of the major of computer science is rather important.

However, the current situation is that the students of computer science are short of technical skills at program design, data structure and other background knowledge, to follow coding-relevant courses [6]. As a consequence, the students generally feel abstract, difficult to understand, and cannot be linking theory and practice. In other words, it indicates that the theoretical knowledge cannot attract students' interests, and then the effectiveness of teaching such courses is not as high as expected [5]. Moreover, other coding-related courses in the computer science education, including Java, C++ have the same dilemma in Chinese colleges and universities.

Considering this fact, we propose a cloud-based online coding platform, though currently only C programming is supported, to deliver simply and easy learning with clear, and to-the-point contents on a wide range of coding-relevant courses in computer science, without any preconditions and impediments. To be specific, we integrate the program editors, the compilers, and the relevant libraries into the platform to provide the users with elegant development environments. As a result, students can focus on building and executing their great applications at anytime, anywhere, rather than understanding how to build the compilation and execution environments on the laptops or desktops. Apart from supporting a large number of users' accesses in parallel, all main features needed for the coding task are offered by this platform, making development of programs more productive and fun.

The rest of paper is organized as follows. Section 2 introduces the related work about teaching coding-related courses, as well as other teaching reform approaches to yield better teaching effects. The implementation details are described in Section 3. Section 4 presents the evaluation and relevant results, with respect to the implemented platform. Finally, we conclude the paper in Section 5.

2. **Related Work.** A large number of studies have been proposed to boost teaching effectiveness about coding-related courses of computer science or other engineering majors. Some related work discussed the problems about strengthening student's programming skills and cultivating their innovational ideas with the programming courses of computer science, and further advanced the tentative idea of teaching reform activities [8, 9]. H. Sun et al. discussed how to teach in accordance with students' characteristics and carry out classes which take the students as the center, and then it may find ways to enhance the teaching effect and quality in the class of programming causes.

There is strong practical significance in the aspect of attracting students' specialized interests [10]. Therefore, the reform introduced in [10] has reconstructed task-driven and situational teaching. In other words, their approach intending to teach coding-relevant courses is based on the constructed task, and then the application in the classes shows that the combination of theory and practice is more conducive, to stimulate students interested in learning and increased learning efficiency. Therefore, it eventually helps to develop students' ability to design independently programs. J. Zhao et al. [11] do not only analyze the theory of web-based cooperative learning, learning contents and learning patterns, but also propose relevant implement measures combining the course features of algorithm analysis and design relating to coding. J. Shen et al. [12] had explored the learning strategies for online collaboration examinations. They have conducted some experimental evaluation, and the experimental results show this web-based cooperative learning is fairy attractive, to improve the effect of teaching.

In addition, a number of online coding platforms are publicly available on the Internet, such as Code School [1], CodeChef [2], and Codecademy [3]. Nevertheless, these commercialized platforms aim to provide general coding services, and fail to offer smart and individualization services for teachers and students, such as tracing the information about students' programming skill. To overcome these shortcomings in the existing platforms, we have studied to construct a consfigurable and personalized online coding services for both students and teachers in the college. As a consequence, both students and teachers have more privileged right to operate on the platform according to their requirements, so we design and implement such a platform in this paper.

3. **Architecture and Implementation.** This section presents the design and implementation specifications of our cloud-based online coding platform.

In order to achieve better scalability and transparency, we employ the cloud technique and the distributed file system as the backend infrastructure of the platform, so that it

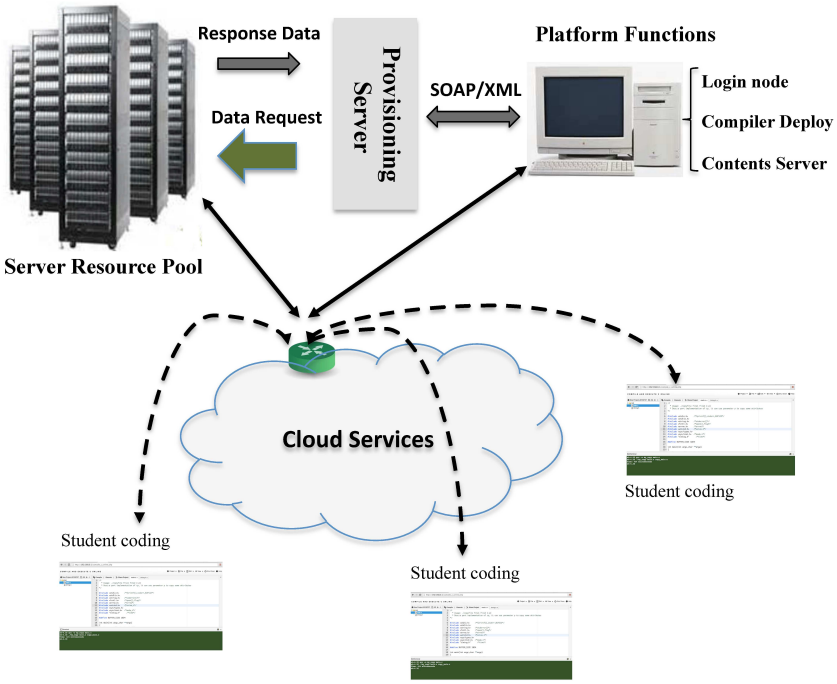

FIGURE 1. High level function overview of cloud-based online coding platform

can support a large number of concurrent coding instances, and ensure responding to the users in time. Figure 1 demonstrates the high level function overview of our proposed cloud-based online coding platform, and it has mainly three kinds of components.

- **Server Resource Pool.** The servers are collected into a resource pool, which is shared across multiple coding instances from students in large quantities. These servers have been installed with compilers, and proper environments to execute programs. Consequently, they can perform certain functions, such as user project management.
- **Front Terminal.** The platform front terminal is a dedicated server, which works like a proxy between servers and client machines. In other words, this terminal machine provides the portal interfaces for administrators to deploy the compilers, manage users' profile, and web portal contents. For speeding up the communication between the front terminal and the server resource pool, the SOAP/XML communication protocol has been used in the communication.
- **Student Coding Browser.** The student opens a web browser on the client machine, for connecting to the platform. In the browser, they can employ an Integrated Development Environment (IDE)-like editor to start coding, compiling and executing the C programs. Note that the students can focus on organizing and developing their own codes, and they are not required to neither installing any libraries, nor configuring the environmental setting.

In fact, the work presented in this paper is a typical engineering work. Then, for demonstrating the effectiveness of the proposed cloud-based online coding platform, we have developed a proof-of-concept implementation of the proposed system based on our previous work [6]. Moreover, in order to manage plenty of data for providing high performance I/O services within less latency, we have adopted the Gmei distributed file system [13] to be the back-end storage system of the platform, to efficiently support concurrent user transactions of coding instances.

4. **Experiments and Evaluation.** This section describes the experimental methodology for evaluating the implemented online coding platform, and presents relevant results.

4.1. **Testbed specification.** Although the cloud-based platform supports a large number of similar machines to be collected in the server resource pool, we hold a quite limited configuration in the current deployment of the platform. Specifically, the machines comprising the server resource pool are dual-processor Intel(R) E5800 3.20G Xeon-based servers with 4 GB RAM, and there are totally 4 machines connected with a 10 Gbps. The Platform Front Terminal is a dedicated machine having 2 × Intel(R) E5410 2.33G CPUs with 4GB RAM. All of the servers in our testbed run the Debian 6.0.4 operating system, and the server pool is interconnected with the front terminal by using a 100 Mbps switched Ethernet.

4.2. **Response time.** Besides affirming the functionality of the implemented platform, we have also evaluated the newly proposed online coding platform in the metric of response time, while there are a varied number of concurrent access requests. This is because the response time is a critical term to evaluate online services with the interactive mode. In the experiments, the client machine issues coding instances, which is connected with the front terminal by using a 100 Mbps switched Ethernet. Specifically, we measured the time required for processing different types of online operations, including '*create*', '*save*', '*open*', '*delete*', '*compile*', and '*execute*'. Figures 2(a)-2(f) illustrate the experimental results regarding different operations respectively. In the figures, the X-axis represents the number of concurrent coding instances, i.e., the requests, and the Y-axis shows the consumed time, and the lower one is attractive.

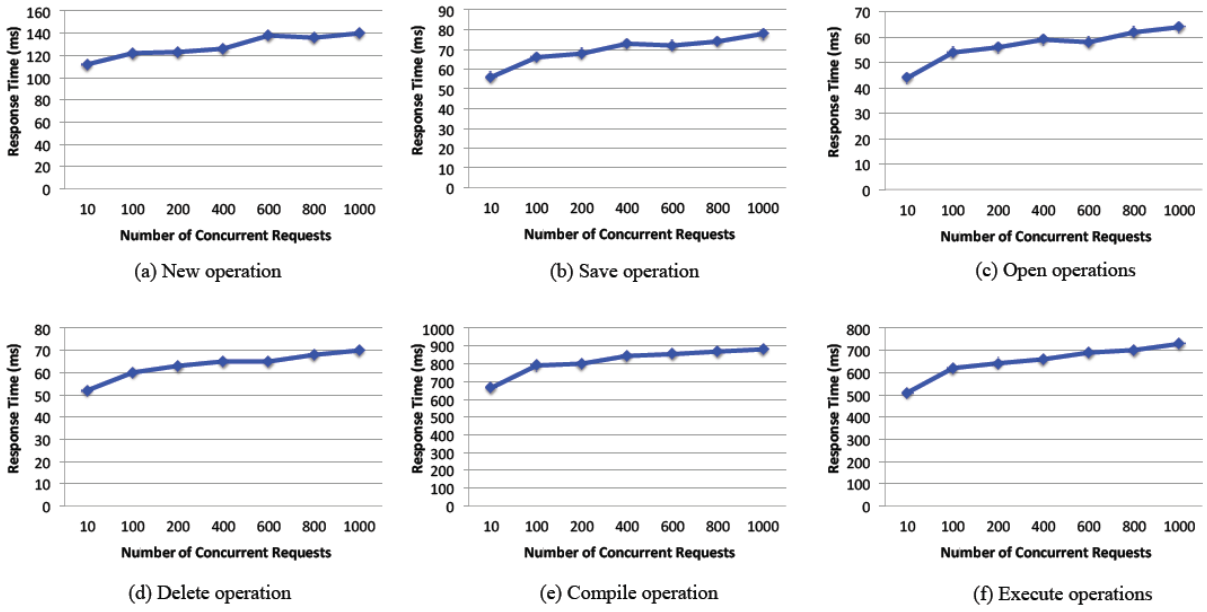

FIGURE 2. Response time of different operations on the proposed online-coding platform

Obviously, the obtained response time to complete the required operations is fairly acceptable when the platform is deployed within the college or university, as we have tested the maximum number of coding instances as 1000. We can also see that the time needed to handle the different operations does not increase greatly, when the number of concurrent requests is getting larger. As a matter of fact, the newly implemented platform adopts the cloud and distributed file system in the background, which is able to process a large number of requests in parallel. Another noticeable clue shown in the figures is about both '*compile*' and '*execute*' operations caused more than 5 times of latency to be completed, in contrast to the other operations, and this is because both mentioned operations need to load the required libraries, which are provided by the platform.

4.3. **Case study.** In this section, we conduct a case study, which creates a project to write a C program for implementing the copy function (i.e., the *cp* command in Shell of Linux). There are several steps to practice programming online by leveraging our coding platform:

(1) Sign in. If we create a coding instance without signing in first, we cannot open and edit it again when we have disconnected from the platform. Because the user's projects are saved on the platform associating with the user ID, these projects can be edited and executed again, after logging into the platform.
(2) Develop a C program. We can edit our programs and compile them by using the corresponding compilers offered by the cloud-based platform. The execution results will be presented in the browser if the program is correct. Otherwise, the error information will be shown to warn the user for revisions.

    For the purpose of emulating the Linux environment or other Unix-like operating systems, we also provide a Shell terminal, and allow users to type commands for compiling and executing the developed programs.
(3) Save the program. The developed codes can be saved on the platform, when we click the 'save' button on the tool bar. As discussed before, we can open the developed programs, after logging into the platform in the next time.

Figure 3 shows the snapshot of IDE-like editor to code a C program in the web browser, and the contents are provided by the implemented cloud-based online coding platform. Clearly, besides writing the program in the browser, the student can also compile and run the program in the browser. Furthermore, the users can save the programs by clicking the functional buttons in the tool bar, and then these programs can be opened again. As a consequence, the teachers are able to read, and even run the codes (i.e., homework or test reports) submitted by the students.

4.4. **Questionnaire assessment.** We did an anonymous questionnaire survey at the end of the fall semester of 2015 to collect feedback on the students' attitude towards the use of the cloud-based online coding service. 69% of students in Class 1 ($n = 59$), and 52% of students in Class 2 ($n = 58$) submitted their surveys. Figure 4 demonstrates the results of students' overall experience, as well as several pieces of students' comments.

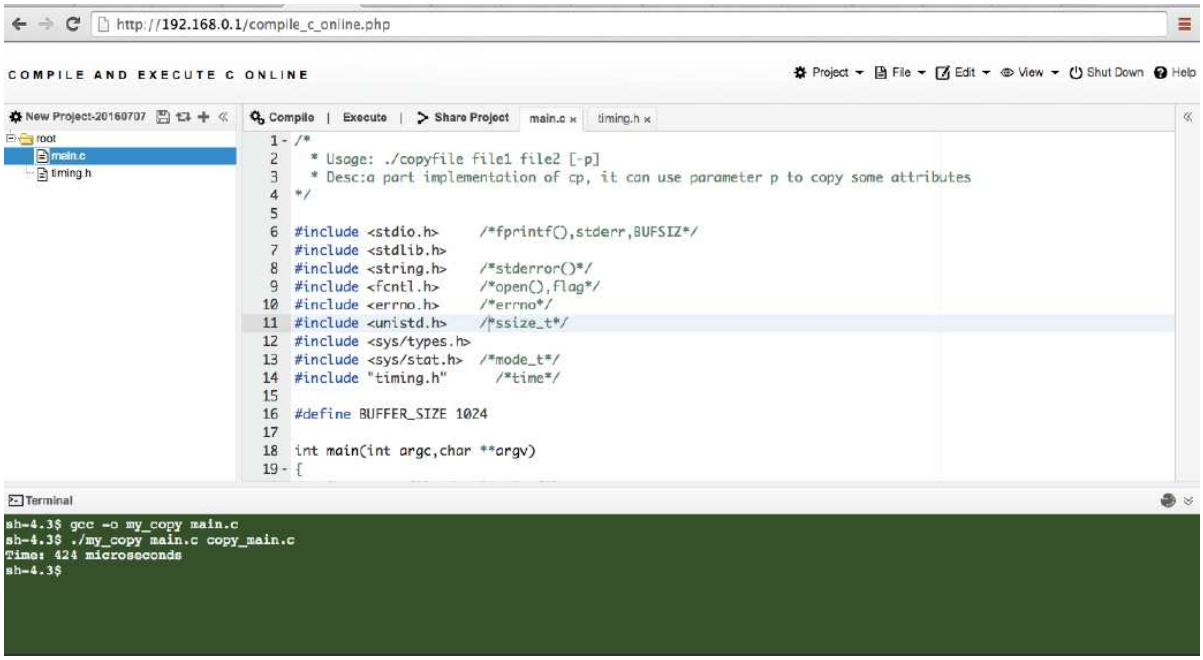

FIGURE 3. A snapshot of composing, compiling, and executing a C program online

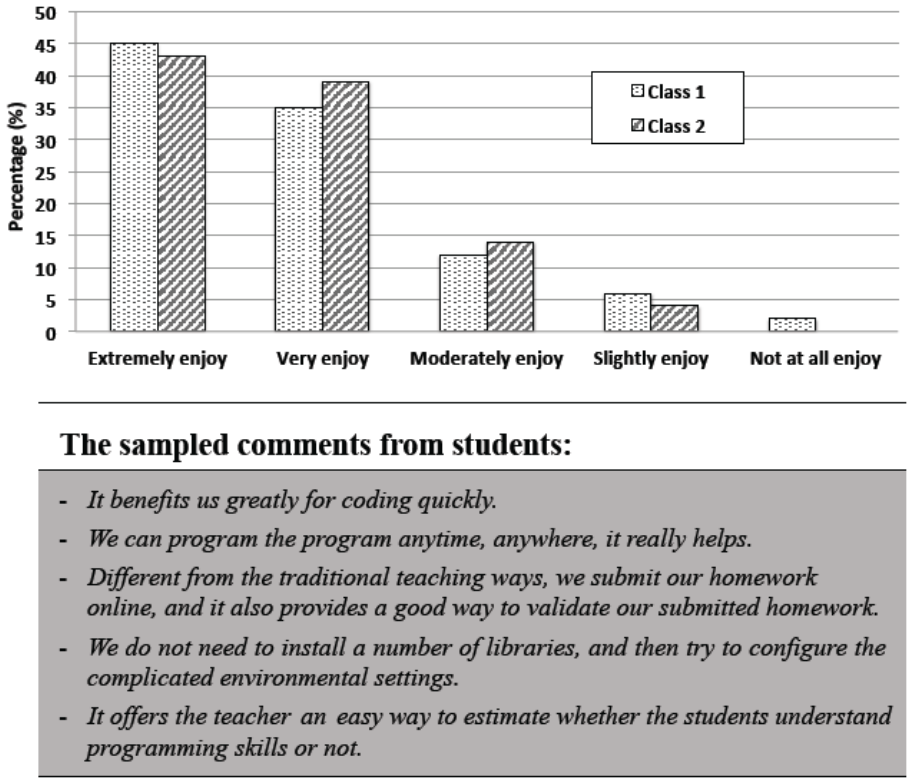

FIGURE 4. Results of the questionnaire survey of student responses from two classes

From the reported information, it is not difficult to disclose that a majority of students enjoy to use the newly implemented platform for helping them to learn coding-relevant courses. For instance, more than 80% students of two classes like the online coding platform, as they extremely enjoy it or very enjoy it. In summary, we can safely conclude that the newly implemented online coding platform provides a much more cost-effective, convenient, and flexible approach to teachers and students, which can contribute to the study of coding-relevant courses of computer science in the universities and colleges.

5. **Conclusion.** This paper has designed and implemented a cloud-based online coding platform, which benefits the students of computer science for efficiently learning coding-relevant courses. To be specific, this newly proposed framework offers the students certain coding environments by using web browsers, so that the students can write, compile and execute their programs online, without installing a number of compilers and configuring environmental settings. By showing a case study of C programming, we can see that it is easily to combine the theory with practice of programming, and improve the effectiveness of teaching the courses of programming.

The current deployment of the platform only supports C programming, and we are planning to support more languages, such as C++, and Java on the platform in the near future.

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