

APPLY OPEN RESOURCE CODE SYSTEM TO AUTOMATICALLY PRODUCE PROGRAMMING SKILLS AT HANOI METROPOLITAN UNIVERSITY

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***Abstract:** The article proposes the development of an automatic assessment system for programming skills for students in information technology at Hanoi Metropolitan University. This system supports the organization of the exam to assess programming skills and allows applicants to take the exam online via the Internet or Local Area Network (LAN). The system accepts applicants' work and automatically scores completely objectively on predefined test sets, without being influenced by subjective opinions or the examiner's psychology.*

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1. INTRODUCTION

Programming languages are an important subject within the computer industry. Learning to program on a computer is difficult, demanding students to do much effort and work. Students have to do a lot of exercises and write a lot of programs to enhance their programming skills. To improve the programming skills of students, an effective and widely utilized method is to evaluate through programming tests. Students assigned to a problem need to construct a program to process the input and output data according to the objective of the problem. Instructors will provide experimental input data and compare program outputs with examples of output values consistent with the purpose of the problem. The efficiency of the problem is determined by the accuracy of the processing results and the processing time of the data...

With manual grading, the lecturer takes a lot of time and it is difficult to check and correct all students in a class. Especially, in the period when students are just learning to program, a program can make a lot of mistakes, requiring the lecturer to check and correct

them many times. With the current situation of over 30 students/practice groups, it is very difficult to guide and shape practice skills.

With each practice in programming, it is necessary to satisfy the following properties: correctness, efficiency, and universality. However, students often do not argue all cases of the problem or do not know whether their implementation algorithm has achieved efficiency or not. Therefore, to support students to self-check their results in the learning process, practice programming skills while minimizing the time and effort of lecturers, we propose to build a grading system automatic programming. The system receives student work and automatically scores completely objectively on pre-built test sets. Then the system will display the results of the student's work.

2. CONTENT

2.1. Theoretical and practical basis for the construction of an automatic evaluation system for programming competencies at the Faculty of Science and Technology, Hanoi Metropolitan University

For students in the Information Technology sector, the evaluation of algorithm quality in terms of program runtime, efficiency, and ability to cover difficult situations cannot be comprehensively assessed through analysis, program. Therefore, to support students to self-check their results in the learning process, practical programming skills while minimizing the time and effort of lecturers, building an automatic grading system Teaching support is essential.

The main advantages of using automatic grading software over traditional grading are:

1. Automate scoring operations, avoid confusion when scoring and ranking.
2. The scoring process is completely objective on pre-built test suites, unaffected by subjective opinions or the judge's psychology.
3. The printing of tables, retrieving the statistics is done completely automatically and accurately. Those statistics can be integrated into other software to make reports and draw lessons for the following exams.
4. After the exam is over, the data for the exam can be published and the other candidates can practice on the tests and then use the automatic grading program to self-assess instead of having to invite a panel of judges, to re-dot.

With the development of information technology, the process of passing the test can be done entirely through the computer network environment, the use of these systems is often referred to as the test environment, program. There has been much different software to do this work such as Codeforce, SPOIJ, DMOJ, SPHERE, Themis, etc. This software has been deployed to serve the computer Olympiad in the world and the Informatics Olympiad in water as well as self-learning programming for users.

For the university teaching environment, the programming test environment will greatly support the learning and self-study process of programming languages and algorithms of students because students can access a library of exercises, very large with all difficulty

levels. The assessment process is also automatic, so that students can self-study, improve their programming ability as well as test the algorithms they have learned. Students can register to these servers to participate in the testing and evaluation process.

In the training program of the information technology industry, the total amount of knowledge of the whole course has 130 credits, of which the number of programming-related modules accounts for 18 modules of 46 credits, accounting for 35.4% of the total number of courses. These modules are distributed from the base of the industry and have a strong focus on the major. With such a large number of programming subjects, they are a big challenge for students of information technology.

The knowledge foundation of programming subjects is based on mathematics and students' logical thinking ability. In addition, to learn programming well, students need to have love and passion, practice as much as possible. However, the actual source of students entering the IT industry of the school is only in the middle. Therefore, students' ability to absorb, self-discipline in learning, and passion for the field of study are still not high.

For lecturers of information technology, the number of lecturers is 7, of which each semester has to undertake a large amount of teaching, especially the number of students in each class is quite large, so the close attention Getting to each student is quite difficult. In the face of such situations, in the process of teaching programming subjects and assessing the subject, the lecturers of the information technology industry have used some supporting tools. For students' daily practice, use Codefun to increase their programming ability and passion for programming. For the evaluation of the end of programming courses, the faculty uses Themis software to automatically grade students' work.

However, the application of test environments on international systems in training information technology students at the Hanoi Metropolitan University is not appropriate because:

1. Not being proactive and controlling the servers as well as the test results[4].
2. Existing systems with large student populations cannot be exploited[4].
3. The language of the title description is not suitable for students[4].
4. Test data and answers are served separately for each system[4].

With the above problems, we have come up with a solution to build an environment for self-assessment of the correctness of a computer program. Based on the program running with different data situations, when compared with the sample results, it will quickly evaluate the correctness of the program. This is a highly feasible solution, capable of solving the above problems.

Build an automatic assessment system for programming skills so that teachers can mark students' papers automatically. Thereby, contributing to increasing the effectiveness of teaching programming subjects. Instructors will put exercises, test sets into the system and see the results of students' work. Students will enter the system, take the test, program it in an external editor and then submit it to the system. The system will automatically grade the test by entering each test set and comparing them in turn, output results. Then the system

will display the combined results of the work. If the student's work has errors, the system will notify the details of the error. The system supports students very well in the process of learning programming, helping students improve their programming skills and algorithmic thinking skills.

2.2. Building an automatic assessment system for programming skills

2.2.1. Select evaluation environment

Exam Management System (CMS) is an open-source marking system that has been used in many international programming exams.

CMS can conduct programming, testing on languages: Java, Pascal, Python2, Haskell, PHP, C, C++, C#, Python3, Rust.

This system has the following basic properties:

1. Secure: even though the main security measure for a contest is to isolate the contestants and the grading networks, obviously there must be at least one point of contact between the two; this must give the fewest possible ways of attacking the system.

2. Robust: an error or a critical condition in one part of the system must not take down the whole system; hot-swapping of services and machines is not an exceptional condition but a standard procedure; the coherence of the state of the contest must always be ensured.

3. Developed for the community: CMS must be easily accessible, free, and open-source (it is licensed under the GNU Affero General Public License (Free Software Foundation, Inc., 2007)); feature requests, bug reports, and patches must be considered and applied whenever possible and without long delays; it must support localization of the contestant's interface.

4. Extensible: new or rare task types and scoring methods must be easy to implement in the form of plug-ins; currently based on the current competition rules for the IOI, CMS should leave the possibility of reflecting the modifications of such rules by future hosts.

5. Adaptable: CMS must not interfere with the first two points listed previously for organizing a contest, namely it must not mandate a minimum number of grading machines, or special network configurations (apart from the ones that prevent security issues), and must not require a particular method of preparing the tasks for the contest.

6. Usable: CMS must be well-documented for contests administrators, developers, and contestants, and it must not require insights into the internals of the system for running a contest.

2.2.2. Overview of the CMS system

CMS is an open-source system written in python. CMS includes many services, services can be installed distributed on many servers[2].

1. LogService: Receiving, aggregating, and displaying all the logs of the system
2. Worker: Running compilations and evaluations of submissions in a safe environment.

3. EvaluationService: Maintaining the queue of the jobs to be assigned to the Workers.
4. ScoringService: Transforming the evaluation results into scores, and communicating them to the live rankings.
5. Checker: Calling the heartbeat function of all the services.
6. ResourceService: Collecting resource usage information about the machine in which it is running, and starting all the services on a machine.
7. ContestWebServer: Serving web pages to the contestants, accepting submissions, and providing feedback.

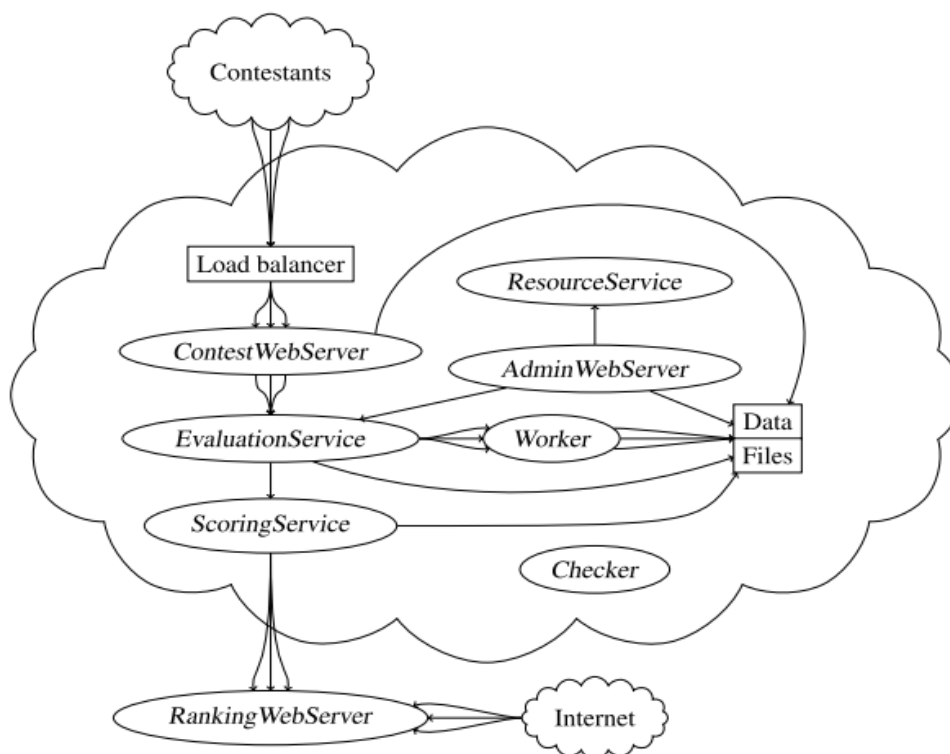


Fig 1: Services and their interactions in CMS

8. AdminWebServer: Serving web pages to the administrators, configuring and managing the contests.

9. CMS is managed in a distributed form (many modules), with many utility services (services), and can be managed on many computers. At runtime, utility services can adjust to a major competition.

2.2.3. System requirements and settings

Requirements: The system is installed on Ubuntu 18.04 operating system platform.

System settings:

1. Install library packages: PostgreSQL, gettext, Python, setuptools, Tornado, Pycopg, simplejson, SQLAlchemy, psutil, PyCrypto, BeautifulSoup, ...[3]

2. Download and install CMS at: <https://github.com/cms-dev/cms/releases/download/v1.4.rc1/v1.4.rc1.tar.gz>.

3. Setting Up CMS:[3]

1. Step 1: Install the necessary packages to operate the CMS system

1. *build-essential openjdk-8-jdk-headless fp-compiler postgresql postgresql-client python3.6 cppreference-doc-en-html \cgrouplite libcap-dev zip*

2. *python3.6-dev libpq-dev libcups2-dev libyaml-dev \libffi-dev python3-pip*

1. Step 2: Install CMS services

1. *sudo python3 prerequisites.py install*

2. *sudo pip3 install -r requirements.txt*

3. *sudo python3 setup.py install*

2. Step 3: Access the database to create an account and password

3. Step 4: Configure CMS

1. Running CMS:[3]

1. Step 1: Run the services with admin rights

1. *sudo su -*

2. */etc/init.d/postgresql restart*

3. *nohup cmsAdminWebServer >>*

4. *nohup cmsResourceService >>*

5. *nohup cmsRankingWebServer >>*

6. *nohup cmsWorker >>*

7. *nohup cmsScoringService >>*

8. *nohup cmsEvaluationService >>*

9. *nohup cmsProxyService >>*

10. Step 2: Initialize service for candidates

11. *sudo su -*

12. *cmsContestWebServer*

2.3. Configuration for the contest

The site for the administrator has the form of an IP address: 8889, for example, <http://127.0.0.1:8889/> (local server address)

1. Contests section: Create a name for the contest

2. Tasks section: Create a question

3. Users section: Create a list of candidates

2.4. Systematic application in assessing programming skills for students of Faculty of Science and Technology, Hanoi Metropolitan University

The system has been tested and operational since November 2021

The main results obtained are as follows:



Fig 2: Admin page

1. Supports programming languages, including a full range of popular programming languages such as Pascal, C, C++, C#, Java, Python, PHP, Haskell, Rust, ...
1. Created more than 70 topics on the system, including topics and test cases.
2. There are more than 170 members who are students of the Faculty of Science and Technology.
3. Organized 2 programming Olympiads during Science and Technology Day of the Faculty. Taking place in 2 days is November 25, 2021, and December 4, 2021.



Fig 3: Result of round

← → ↻ 🏠 ⚠️ Không bảo mật | 14.162.209.87:8080/contest/7/ranking

Hello, admin. [Logout](#)

• Administration

HNMU2021_Vong2

Overview
Resource usage

General
Ranking
Submissions
User tests
Users
Tasks
Announcements
Questions

To end of contest: 0:36:50

Download as [csv](#), [text](#).

#	Username ↓	User ↓	Q1 ↓	Q2 ↓	Q3 ↓	Q4 ↓	Q5 ↓	Global ↓
1	220001226	Pham Ngoc Long	20.0	20.0	20.0	20.0	20.0	100.0
2	218401140	Nguyễn Thị Quỳnh Trang	20.0	20.0	20.0	20.0	16.0	96.0
3	218401037	Phạm Quốc Tuấn	20.0	20.0	20.0	20.0	14.0	94.0
4	220001234	Đỗ Hoàng Nam	20.0	20.0	20.0	20.0	4.0	84.0
5	221001806	Hoàng Đức Phú	20.0	20.0	20.0	10.0	12.0	82.0
6	218401014	Nguyễn Thị Thu Hoài	20.0	20.0	20.0	20.0	0.0	80.0
7	219401106	Nguyễn Minh Đức	20.0	20.0	20.0	20.0	0.0	80.0
8	219401102	Vũ Thị Phương Anh	20.0	14.0	20.0	20.0	4.0	78.0
9	221001763	Mai Huy Hoat	20.0	20.0	20.0	10.0	4.0	74.0
10	220001260	Lê Thủy Trang	20.0	20.0	20.0	10.0	4.0	74.0
11	220001244	Nguyễn Anh Quân	20.0	20.0	20.0	10.0	0.0	70.0
12	220001255	Trương Quốc Thắng	20.0	20.0	20.0	10.0	0.0	70.0
13	220001172	Lê Đức Chính	20.0	14.0	20.0	0.0	4.0	58.0
14	218401025	Đỗ Thị Ngân	20.0	20.0	18.0	0.0	0.0	58.0
15	220001258	Nguyễn Quang Tiến	20.0	8.0	20.0	0.0	4.0	52.0
16	220001223	Đỗ Cao Long	20.0	0.0	20.0	6.0	4.0	50.0
17	220001744	Bùi Hiếu Hoàn	20.0	14.0	16.0	0.0	0.0	50.0
18	220001230	Bùi Quang Minh	20.0	0.0	20.0	0.0	0.0	40.0
19	218401018	Đào Thị Hường	20.0	20.0	0.0	0.0	0.0	40.0
20	220001276	Ngô Thái Dương	20.0	0.0	20.0	0.0	0.0	40.0
21	220001211	Nguyễn Thu Huyền	20.0	0.0	20.0	0.0	0.0	40.0
22	220001193	Bùi Thanh Hải	20.0	0.0	18.0	0.0	0.0	38.0
23	220001198	Nguyễn Hoàng Hiệp	20.0	0.0	18.0	0.0	0.0	38.0

CMS codebase is released under the GNU Affero General Public License.

Fig 4: Result of round 2

Comment:

1. The system has received enthusiastic participation from students
2. The system has supported well for testing students' programming skills. The use of the system will help improve the quality of training and students' programming skills.
3. The system helps Instructors save time on correcting errors for students. Help Instructors focus on completing assignments and test cases to improve the quality of training for students.
4. The system assesses students' programming skills completely objective and effective.
5. The system can operate on the internet or in the LAN environment.

3. CONCLUSION

The article has solved the problem of assessing students' programming by developing an automatic assessment system for programming skills. The system has full functions: contest management; managing topics and test cases; managing the list of candidates; managing test results of candidates; compilation and grading; candidate ranking.

The system has been installed and operating stably at <http://cms.hnmu.net:8889>. The system initially worked well and proved to be effective in automatically assessing students' programming skills. The system helps students have a daily practice environment to improve their programming skills and thinking. Moreover, the system ensures an efficient and public assessment of the results of students' programming courses.

It is recommended to continue to build a good-classified set of exercises and build quality test cases to ensure the correctness of the problem.

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**ỨNG DỤNG HỆ THỐNG MÃ NGUỒN MỞ XÂY DỰNG
HỆ THỐNG ĐÁNH GIÁ TỰ ĐỘNG KỸ NĂNG LẬP TRÌNH
TẠI TRƯỜNG ĐẠI HỌC THỦ ĐÔ HÀ NỘI**

Tóm tắt: Bài báo trình bày nội dung nghiên cứu về xây dựng hệ thống đánh giá tự động kỹ năng lập trình cho sinh viên ngành Công nghệ thông tin Trường Đại học Thủ đô Hà Nội. Hệ thống hỗ trợ các công tác tổ chức kì thi đánh giá kỹ năng lập trình và cho phép thí sinh tham gia thi trực tuyến qua Internet hoặc mạng nội bộ (LAN). Hệ thống thu nhận bài làm của thí sinh và tự động chấm điểm hoàn toàn khách quan trên các bộ test được xây dựng từ trước, không chịu ảnh hưởng bởi ý kiến chủ quan hay tâm lý của người chấm.

Từ khoá: CMS, hệ điều hành Ubuntu, hệ thống quản lý cuộc thi.