The use of cloud computing technology in professional training of future programmers

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Abstract
The article provides a brief analysis of the current state of the study of cloud technologies by future software engineers at foreign and Ukrainian universities. The author experience in the application of cloud technologies in the training of future software engineers in Ukraine is presented. The application of cloud business automation systems, online services to monitor the implementation of the software projects, Google services for collaboration, planning and productivity while studying professional disciplines and carrying out diploma projects is described. Based on the survey conducted at Stackoverflow, the state of application of cloud technologies by software engineers around the world has been analyzed. The cloud technologies that are not studied at the analyzed universities of Ukraine and those that are not popular with software developers in the world, but studied at Ukrainian universities by future software engineers are outlined. Conclusions are made on the modernization of training programs for future software engineers. Topics for the study of cloud technologies by future software engineers in the content of professional disciplines are proposed.

Keywords
future programmers, cloud technologies, content of professional disciplines, training of software engineers

1. Introduction

According to International Data Corporation (IDC), leading global provider of market information and consulting services, in the world over the past decade there appeared technology and services in the market of "cloud computing" [1].

According to the Bureau of Labor Statistics [2], the development of cloud computing has promoted an increase of the demand for the information technology specialists. In the United States, in particular, there exists a perspective that this demand will grow by 12% by 2024.

The National Skills Bulletin [3] based on the analysis of the Irish labor market data, systematized from 2013 to 2018, indicates a shortage of skilled workers in the field of information and communication technology (ICT), in particular, in the field of cloud computing.

The growth of the cloud market in Ukraine is evidenced by the following: results of a research, done by leading cloud service operators De Novo and GfK Ukraine [4], a policy brief of the Department of Information Society and Information Strategies Research of the National

Institute for Strategic Studies [5] and search results in Ukrainian vacancy databases. This fact has been also emphasized by Jan Peter de Jong, CEO of Microsoft Ukraine, in his interview with Interfax-Ukraine [6]. Thus, the growing market of cloud computing leads to the demand for IT professionals, who are able to work with this technology. Therefore, there appears a need to study cloud computing in the process of training of future programmers in the institutions of higher education.

The *aim of the research* is to compare the current state of the future programmers training for cloud computing during their study in the institutions of higher education with the labor market requirements for the training of IT professionals in the field of cloud computing.

2. Results

2.1. Brief analysis of the current state of future programmers' training for the use of cloud computing technology

Due to the development of cloud computing technology, in universities, where future programmers are trained, courses on cloud computing are being introduced.

In particular, at the University of Liverpool at the Faculty of Humanities and Social Sciences, students are introduced to cloud-based systems while doing their Master's Degree and postgraduate study [7]. In addition, for all students, The University of Liverpool provides a range of cloud-based tools and platforms, allowing them to access their network drive (M drive) and campus applications when they are off-campus [8]. According the Nanyang Technological University curriculum, first-year Bachelor students have the opportunity to study such elective course as Cloud Computing and its Applications [9]. Such issues are not fully covered in the process of future programmers' training in Ukraine. Only in the last few years the students of Ukrainian universities have been offered to study cloud computing technology. It is proved by the results of Google Search and analysis of curricula of Ukrainian universities (table 1).

Thus, future programmers study cloud computing technology during their professional training in the institutions of higher education at different educational levels (Bachelor's, Master's, Doctor's). It has to be mentioned that from 2 to 6.5 ECTS credits are allocated for these courses. Content of the courses includes the study of different cloud systems (IaaS, PaaS, SaaS), virtualization and distributed systems, private cloud systems (Microsoft System Center, OpenStack), cluster solutions, grid systems, cloud platforms (Microsoft Azure, Amazon Web Services, Google Cloud Platform, Google Compute Engine, IBM Cloud).

2.2. The use of cloud computing technology in the professional training of future programmers in Ukraine

It has to be said that cloud technology is used in the training of future programmers in Ukraine. In particular, for enhancing communication [10], in STEM education [11, 12, 13], for organizing laboratory and practical classes [14, 15, 16, 17, 18, 19, 20, 21, 22], for studying databases by future IT-specialists [23, 24], etc.

Due to the demand of the labor market in programmers, who are capable of working with cloud computing technology, since 2016 in Bohdan Khmelnitsky Melitopol State Pedagogical

Table 1

The current state of future programmers' training for the use of cloud computing technology in the universities of Ukraine

University	Academic course	Speciality	Degree	Credits ECTS	Technology
Volodymyr Vynnychenko Central Ukrainian State Pedagogical Universit	Cloud computing technology	122 Computer Science and Information Technology	Master's Degree	6.5	Owncloud, Amazon EC2, Google Apps, LMS MOODLE
Interregional Academy of Personnel Management	Cloud computing	121 Software Engineering, 122 Computer Science and Information Technology	Master's Degree	3	Microsoft Azure, AWS, OneDrive, Google Drive, Google Docs, Microsoft Office 365, Heroku, DigitalOcean, ownCloud
National Technical University "Kharkiv Polytechnic Institute"	Cloud Computing: Cloud Technology and its Use	126 Information Systems and Technology	Master's Degree	3	Microsoft System Center, OpenStack, Google Drive, OneDrive, AWS, Windows Azure
Taras Shevchenko National University of Kyiv	Cloud Computing Technology	121 Software Engineering	Master's Degree	5	Microsoft Azure, Google App Engine, IBM Cloud, AWS
Kyiv National University of Construction and Architecture	Innovative Web-Technology and Cloud Computing	015.10 Vocational Education. Computer Technology	Bachelor's Degree	2	VMware, Microsoft Azure, Amazon Web Services, UTOO, De Novo
Bogdan Khmelnitsky Melitopol State Pedagogical University	Cloud Computing Technology	122 Computer Science	Bachelor's Degree	4	VMware, Microsoft Azure, Amazon Web Services, Google Cloud Platform
Open International University of Human Development "Ukraine"	Cloud Computing	122 Computer Science	Master's Degree	6	Amazon EC2, GoogleApps, Windows Azure
Lviv Polytechnic National University	Computer Science and Information Technology	122 Computer Science and Information Technolog	Bachelor's Degree	4.5	Microsoft Azure, Amazon Web Services
Zaporizhzhia Polytechnic National University	Grid Computing and Cloud Computing Technology	123 Computer Engineering	Bachelor's Degree	6	gLite, Globus Toolkit

University the Department of Informatics and Cybernetics has introduced a course "Cloud Technology" for the students undergoing their training in 122 Computer Science. In addition to the introduction of the course "Cloud Technology" into the process of future programmers' training, the lecturers of the Department of Informatics and Cybernetics constantly use a variety of cloud technology while teaching professional courses to the students of the specialty 122 Computer Science and 015.39 "Vocational Education. Digital Technology".

In particular, while doing the course "IT Project Management" future programmers get acquainted and use cloud business automation systems (Gantter, Basecamp, Bitrix24) in laboratory classes and in their self-study. The students can use the service of placing the system Bitrix24 in the cloud.

After setting up the system and introducing students as its users, the teacher can plan the work of students and manage tasks, controlling the timely completion of these tasks. Students can manage the time and control other resources expenditures for the completion of class assignment. This way they practically learn the term "deadline", learn how to manage their time effectively. The trackers, used in the Bitrix24 system, help to monitor the completion of tasks, keeping to deadlines, and allow users to easily control the work of subordinates. The advantage of the system is that the tasks can be represented in the form of a Gantt chart – a classic bar chart, which clearly shows the time frame of the tasks in the sequence in which they must take place during the project.

Looking at the chart, both a teacher and a student immediately see how many tasks there are on the project, how many of them are completed and how many are in progress, which tasks are overdue, and which of them do not have a deadline. The system also allows users to make and display performance reports; it allows a teacher to identify how well each student is working.

It is also necessary to use information systems to monitor the implementation of the software project. Currently, there exist free systems that are just as good as fee-paying systems: Git based on GitHub or Bitbucket. As it is noted in [25, 26], the use of Git and GitHub helps not only to track changes in versions, but also to show students the ways to organize and collaborate on projects using practice-oriented methods. GitHub [27] is positioned as a web service for hosting projects using the Git version control system, as well as a social network for developers. With this service, students can create an unlimited number of repositories, each of which is provided with a wiki, a tracking system, and there is also an opportunity to review code and collaborate on a project.

While doing professional courses, future software engineers, working on a software project, use the following Google cloud services: Google Calendar – for work planning; Google Meet and Google Chat – for voice and text messaging, Google Groups – for ads and group discussion; Google Sites – for creating an electronic portfolio, for content management and hosting; Google Drive – for saving files; Google Docs – for work with documents; Google Keep – for teamwork and productivity; Google Form – for creating your own surveys.

While doing the lecture course "Software Testing" future programmers are invited, using a cognitive approach, to create metal maps based on the course materials. For example, this is how a mental map of testing types was developed (figure 1).

While doing this course in laboratory classes, students are taught to create UML diagrams and tests for software based on UML diagram variants. To do this, they use such web platforms as Lucidchart, Creately, Draw.io, Gliffy, which have the functions of collaboration (access or
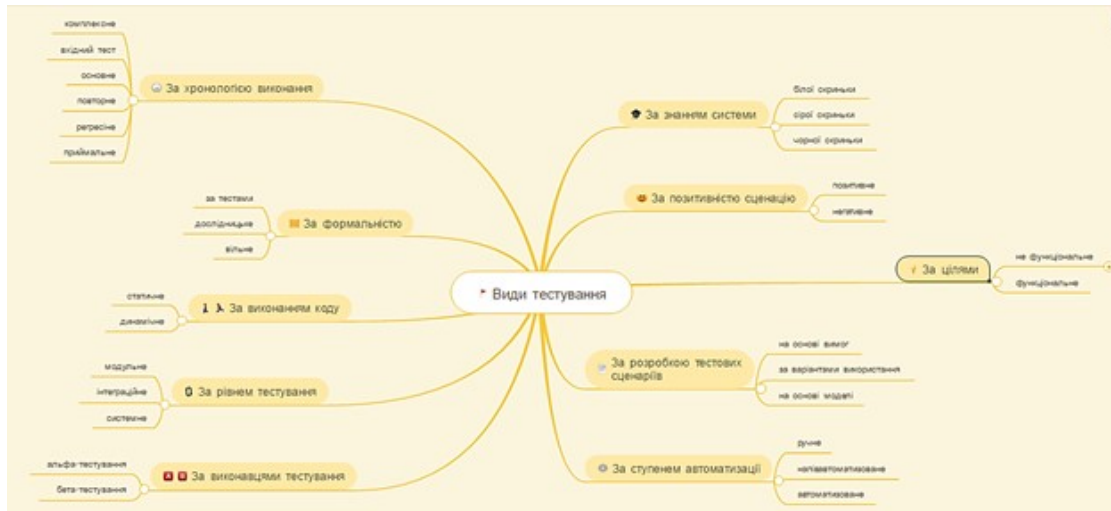
Figure 1: Mental map "Testing Types".

editing).

We consider the use of cloud technology in the future programmers' professional training to be an appropriate one when preparing their graduation work (diploma paper). The students can present the text of the Diploma thesis to the teacher by means of Google Docs. The functions of joint viewing and editing allow the teacher to monitor student's progress in writing the thesis.

It is advisable for a teacher, who is reviewing several thesis projects, done by future programmers, to use Git and GitHub. They provide a teacher with the following opportunities: to put the tasks and assessments online; to look through student listings (program codes), monitoring the time of their placement and authorship; to set a deadline, i.e. to ban the recording of works from a certain moment; to comment not only on the whole project, but also on certain lines of the program; to point out shortcomings in the work performed and give instructions for tasks. Working with GitHub, a student can use his or her own and shared repositories at any time; automatically receive checking reports and teacher's comments.

The methodology of working with Git requires a teacher to: 1) clearly formulate the task, 2) set this task to the developer (student), 3) check the student's understanding of the task, 4) periodically check the result of the task completion during the student's work on it, 5) send back an unsatisfactory result to the developer for revision, 6) mark a satisfactory result, 7) carry out the final check of the software product developed by a student (students), 8) in case of completion close the task as a completed one, otherwise send it for revision.

The functions of a student, using Git, are to receive a task from a teacher, start doing it, present the result in the system, and if the task is returned for revision – to review it and send it back to the system.

The algorithm of work with Git and the general picture of what is going on in the process of students' and teacher's work on the project, can be presented schematically (figure 2).

Work on such algorithm is conducted as follows:

1) a teacher sets tasks for a student (developer),
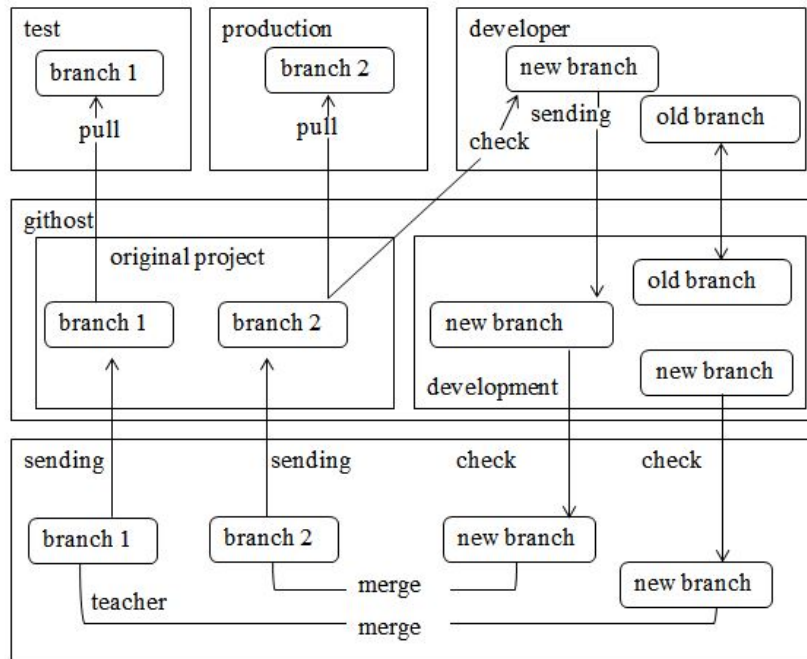
Figure 2: Algorithm of students' and teacher's work with Git while writing the thesis.

2) a student works on the actual branch of the project and makes it a local branch,

3) in this branch a student solves the task,

4) a student sends the branch with the completed task to the working repository,

5) a teacher takes this branch from the working store and checks it,

6) if the task is completed correctly, a teacher merges this branch with the current branch of the project in the main repository or allows the student to do it.

Using cloud services in this way, future software engineers learn to work with the technology which they will use in their future professional activities.

2.3. Labor market analysis in terms of professional training of IT specialists in the field of cloud computing technology

In the process of professional training of future programmers we are aimed at the fact that the training of future programmers should be a modern one and they should get acquainted with the latest software and the latest technology. In this regard, we analyzed Stackoverflow data as for the tools the developers use.

Based on the analysis of the Developer Survey, conducted at Stackoverflow [28], we have identified which cloud technology is used by programmers in the world (table 2).

Table 2
Use of cloud technology by programmers in the world

Type of tools	Name	Percentage of programmers who use it
Infrastructure as code	Terraform	6.2 %
Cloud database	MongoDB	26.4 %
	Firebase	14.4 %
	Amazon DynamoDB	7.1%
	Cassandra	3.3%
	IBM DB2	2.9 %
Platforms	AWS	26.7%
	Microsoft Azure	14.5 %
	Google Cloud Platform	14.1 %
	Heroku	11.1 %
	IBM Cloud or Watson	1.6 %
Programming languages for cloud computing	JavaScript	67.7 %
	Python	44.1 %
	Java	40.2 %
	PHP	26.2 %
	Ruby	7.1 %
Collaboration tools	GitHub	82.8 %
	Slack	53.0 %
	Jira	47.7 %
	Google Suite (Docs. Meet. etc)	41.5 %
	Gitlab	37.0 %
	Confluence	32.4 %
	Trello	29.6 %
	Microsoft Teams	25.6 %
	Microsoft Azure	14.8 %
	Stack Overflow for Teams	5.8 %
	Facebook Workplace	3.0 %

3. Conclusions

Based on the comparison of this survey data with the analysis of the curricula of the above mentioned universities (table 1), we have identified that technology that is not studied in the target universities of Ukraine and technology that is not popular with software developers in the world but taught in Ukrainian universities (table 3).

Therefore, according to the analysis, in our opinion, curricula for future programmers should be revised and modernized in accordance with current trends in the IT industry. Curricula should include topics, aimed at acquaintance with cloud computing technology used in programming. It is recommended to introduce a separate course (for example, "Cloud Technology" or "Cloud Computing") or separate topics into the process of professional training. Examples of such topics are given in the table 4).

In addition, in the process of future programmers' training the attention should also be paid

Table 3
Comparison of cloud that technology taught in universities and that which is popular on Stackoverflow.

Cloud technology taught in universities of Ukraine	Cloud technology that is popular among software developers in the world
Common technology	
Amazon Web Service	
Microsoft Azure	
Heroku	
Dropbox, Microsoft OneDrive, Google Docs, Microsoft Office 365	
IBM Cloud	
Google Cloud Platform	
Technology that is not popular at Stackoverflow	Technology that is not taught in the target universities of Ukraine
Owncloud	Terraform
LMS MOODLE	MongoDB
ownCloud	Cassandra
Google Apps	IBM DB2
PXE	Firebase
DigitalOcean	GitHub
OpenStack	Slack
Google App Engine	Jira
VMware	Gitlab
UTOO	Confluence
De Novo	Trello
Red Hat OpenShift	Microsoft Teams
gLite	Stack Overflow for Teams
Globus Toolkit	Facebook Workplace

Table 4
Recommended topics of cloud technology to be included into the courses

Course	Topic
Introduction to the programming course	Collaboration Cloud tools
Computer architecture	Grid systems
Operating systems and system programming	Cloud operating systems
Information networks	Visualizing technology
Database management systems	Cloud database
Organization and processing electronic information	Online office suite
Web-programming	Cloud systems for the execution control
Programming	Cloud systems of task control
Software project management	Cloud systems of automation of business
Software testing	Cloud systems of UML diagrams creation

to the use of modern general-purpose cloud technology while studying professional disciplines, namely: services for work planning, messaging, teamwork, creating web resources, saving

files, conducting surveys etc. The introduction of a wide range of cloud technology in future programmers' training will increase the quality of students' preparation for future professional activities.

Acknowledgments

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