Digitization and Improvement of the Distance Learning Platform at the University of Montenegro During the COVID-19 Pandemic

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Abstract: This paper presents the improvements implemented at the University of Montenegro Information System in the Distance Learning (DL) segment during the COVID-19 pandemic. A comparative view of old and new DL systems was made. The integration of all parts of DL is presented, with a description of the digital services, their technical characteristics, and the method of implementation. Comparative statistics on the use of the DL platform before and during the pandemic were also presented.

1. INTRODUCTION

Due to the COVID-19 pandemic [1] and the limited presence of students and faculty members on the premises of the University [2], digital technologies have taken precedence and become a means of living and working. Adapting to this situation, the University of Montenegro (UoM) has replaced traditional teaching with digital one, using distance learning platforms.

This paper describes the technologies and the way the Center of the Information System (CIS) of UoM implemented the new Distance Learning (DL) platform in the existing Information System (IS). The technical implementation of the DL platform and the services included in it: Moodle, BigBlueButton, and "Activate your account" are also presented.

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A comparative analysis of the integration and functionality of the old DL platform versus the new platform in the UoM IS was also performed. *Google Analytics* data for the ucg.ac.me domain and the number of accesses to the system with a graphical representation are also presented.

2. CONDITION BEFORE THE PANDEMIC

Before the pandemic, UoM used the DL platform Moodle version 2.5 [3]. This platform was not widely used and was not integrated into IS, but operated as a stand-alone service. Complete platform administration was performed manually, without automatic synchronization with IS. It was administered by CIS engineers on request from certain UoM units. In open courses, students and lecturers received credentials from the administrators, so in some cases, there were duplicate credentials for different courses.

Table 1 shows usage data for the old DL platform with Moodle version 2.5 that was active from 2006 to 2020 [3]. It was used by five organizational units, for 58 courses, and the total number of registered users on the platform was 7.302. In addition to the aforementioned CIS platform, there were DL platforms at the Faculty of Economics, the Faculty of Maritime Studies, and the Faculty of Philology, which also functioned as independent services.

Table I
Usage data for the old DL platform

***Moodle* platform version**	***Number of UoM organizational units that had used the DL platform CIS***	***Number of Courses***	***Number of students***
Moodle 2.5	***5***	**58**	**7.302**

In the academic year 2019/20, the centralization of IS UoM was completed by installing student LDAP and student email servers, creating the possibility for all students and staff to access all services developed by CIS UoM with their academic credentials [4].

3. IMPROVEMENT AND DEVELOPMENT OF NEW SERVICES

After the decision of the UoM management to suspend the classes in the amphitheaters and classrooms with a physical presence, it was necessary to technically improve the DL platform and integrate it into the IS to enable the holding of online classes. Given the obsolescence of the DL platform based on Moodle version 2.5 and the fact that it was hosted on old server infrastructure and that its innovation into an improved version and transfer to the new server infrastructure would take a lot of time, it was decided that the new platform would be installed.

A. Moodle

Fig. 1 shows the scheme of the new DL platform based on the Moodle 3.8 version, which was built on the new server infrastructure [3]. Due to the pandemic, a large number of users, uploaded materials, and simultaneous accesses to the platform were expected, so significant server resources were allocated for the intended virtual machine: 24vCPU, 192 GB of RAM, 650 GB of storage space, with the possibility of dynamic upgrade.

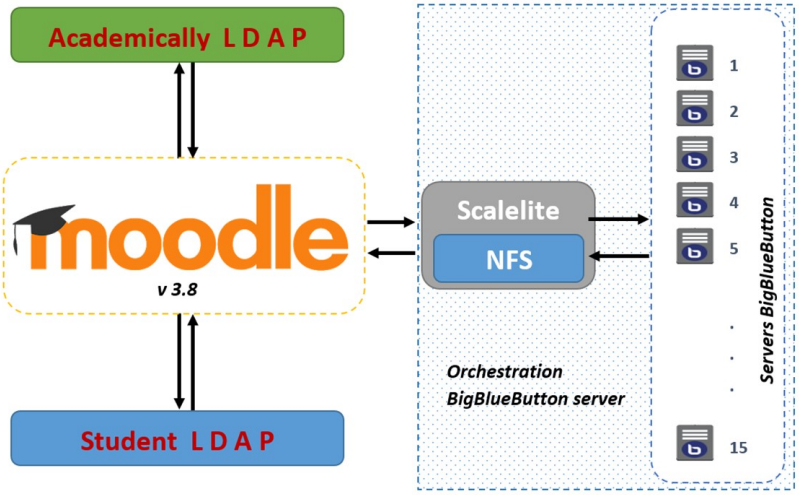

Fig.1 Schematic representation of the UoM Distance Learning platform

As for the operating system, Ubuntu 18.04 was selected, since the latest version of Moodle 3.8 at that time was supported by this operating system and its system libraries, while on the Ubuntu 20.04 version, there were newer versions of libraries that Moodle 3.8 could not work with.

After the installation and initial configuration of the database and administrator account, the layout of the front page with all the necessary data for users was prepared. Then, the integration of the DL platform user access method and the connection to two user account databases (two LDAP servers), which are also used for other IS services, were defined.

As a modular platform, Moodle uses an LDAP plug-in or extension to validate user accounts. Since there are two different LDAP servers, two plugins (LDAP server and LDAP server Sync Plus) have been added [4]. Basic authorization credentials for access to services, as well as details for authorization of users, were set initially in these add-ons.

Checking the credentials in the system is scalable, so the database of employees at the University of Montenegro is searched first, and then the student database. Moodle is organized in such a way that each authorized user must have a locally created profile, so each authorized user has to enter adequate details when logging onto the DL platform for the first time [3].

The existing modules included in Moodle for the organization of courses have fully met the needs of the teaching staff. In coordination with the administrators of university units,

courses were created by year of study and semesters, and adequate rights were granted to the appropriate users. Since there was no unique correlation between student accounts with the courses they were taking, a plug-in bulk user enrolment was installed, which enrolls the list of accounts in a particular course. CIS allowed administrators of units limited access to the central database using the Oracle Publisher service.

The service enabled them to obtain a list of students who are enrolled in certain courses and to enroll them in the appropriate courses on the DL platform, ensuring consistency between the student service database and the student database on the DL platform.Usage data on the new DL platform are presented in Table 2.

Table II
Usage data on the new DP platform

***Moodle* platform version**	***Number of UoM organizational units that had used the DL platform CIS***	***Number of Courses***	***Number of students***
***Moodle* 3.8**	***19***	**2.615**	**13.232**

In Table 2, significantly increased numerical data can be observed concerning the same data from Table 1. All organizational units, 19 of them, use the DL platform. In 2020 there are 2.615 courses created on the platform and there are 13.232 active users accessing the platform.

B. BigBlueButton Video Conferencing System

Due to the requirement for teaching staff to hold video lectures and that the platform should have the capability for video-conferencing interactions with users, CIS was looking for a solution that could be integrated within the DL platform. After considering the large number of modules that can be activated on the DL platform, some of which allow integration with commercial external services, CIS opted for the open-source version of BigBlueButton [5], [6].

BigBlueButton is an HTML5 open-source software solution that provides the most capabilities offered by commercial solutions. The roles of speakers and video conference managers, screen sharing/applications, conference recording, permission for conference participants to download screen sharing/applications, and the like are highlighted. Based on the above characteristics, BigBlueButton was selected as the video-conferencing solution that was integrated into the DL platform. Fig. 1 shows the connection between the BigBlueButton video conferencing system and the Moodle platform. The Moodle module can connect to an external BigBlueButton server and present it as one of the services that can be activated on courses so that course managers can add BigBlueButton activity alongside other course activities [5].

Based on projections for the possible use of video conferencing in the CIS, a large number of parallel video conferencing was expected, so one BigBlueButton server (set on a

virtual machine with the following configuration: 8vCPU, 32 GB of RAM, 300 GB of storage, the operating system Linux Ubuntu 16.04 LT) would be insufficient to adequately serve the needs of the University of Montenegro. In order to meet the mentioned needs, a system of 15 BigBlueButton servers was created with the specified configuration presented in Fig. 1 [5]. Depending on the need, this number of virtual servers may increase or decrease.

Video conference lectures (sessions) connect dynamically to servers depending on a load of individual BigBlueButton servers [5]. In order to monitor and distribute the load, Scalelite open source load balancer was installed on the virtual machine with the following configuration: 16vCPU, 32 GB RAM, 1.2 TB HD, the operating system Linux Ubuntu 20.04 LTS (Fig. 1) [7].

Scalelite allowed us to manage multiple BigBlueButton servers, while the user sees a unique machine, installed as a docker container. In this case, not all video conferencing sessions can be recorded on BigBlueButton servers. It is necessary to configure a shared space, which both the Scalelite load balancer and all BigBlueButton servers that are part of the architecture have access to [7].

For DL purposes, a separate partition has been set up within the Scalelite load balancer and the Network File System (NFS) has been enabled, so that other BigBlueButton servers can add (mount) that partition as their disk [7].

After installation of the Scalelite load balancer and generation of a unique access code, BigBlueButton instances were configured. In addition to the standard configuration, it is necessary to associate the NFS disk with the Scalelite load balancer and modify the BigBlueButton configuration, so that all its recordings (spool, temp, published) are stored on the NFS disk. When an NFS disk is unavailable, BigBlueButton stores the recordings on the local disk, and all these recordings can be synchronized with the NFS disk after the intervention. Since Scalelite presents itself to the platform as a single BigBlueButton server, all videos that are not uploaded to the NFS disk cannot be seen from the DL platform [7].

After completing all the configuration settings, it is necessary to add all BigBlueButton servers in Scalelite.

The management of Scalelite can only be done from the command line, and for this purpose, Scalelite has provided a set of commands to add, remove, and view BigBlueButton.The required commands are:

docker exec -i scalelite-api bundle exec rake servers:add[url,secret,loadMultiplier]
docker exec -i scalelite-api bundle exec rake servers:remove[id]
docker exec -i scalelite-api bundle exec rake servers:disable[id]
docker exec -i scalelite-api bundle exec rake servers:enable[id]
docker exec -i scalelite-api bundle exec rake servers:panic[id]
docker exec -i scalelite-api bundle exec rake status [8].

C. "Activate your account" service for sending credentials by SMS

During the COVID-19 pandemic, CIS developed a service named "Activate your account" for sending credentials by SMS, at the website https://aktivirajnalog.edu.ucg.ac.me to make it easier for students to get their credentials, which were usually issued at the student service desk of their faculty.

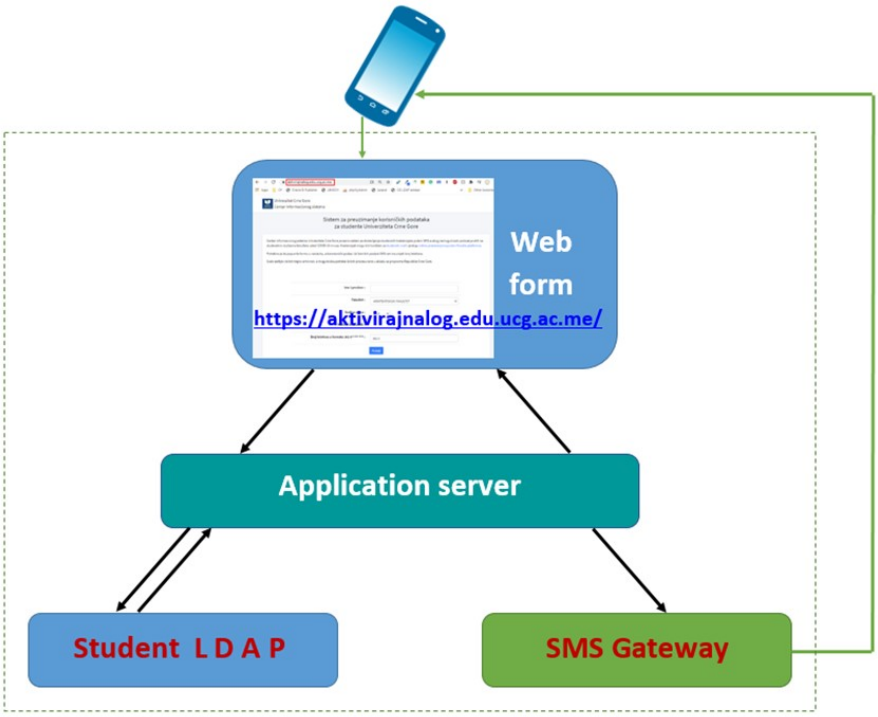

Fig. 2 Schematic view of the "Activate your account" service

Fig. 2 shows the scheme of the "Activate your account" service. Users access the web form at https://aktivirajnalog.edu.ucg.ac.me/, where they need to enter their personal data (name, surname, social security number, faculty, index number, and contact phone).

After they press the "Send" button, the system forwards the request from the application server to the student LDAP (shown in Fig. 2), which returns the required credentials to the application server after the search is performed. Then the application server forwards the request to SMS gateway, which in turn sends the data to the entered phone number. After the data is sent, the system returns the message that the credentials have been sent to the entered phone number (Fig. 2).

The system sent 5.361 SMS messages in the first 10 days and a total of 16.946 SMS messages with user credentials. Students can use acquired credentials for all other student services, in addition to the DL platform.

4. ANALYSIS OF ACCESS TO THE UCG.AC.ME DOMAIN

The analysis of access to the ucg.ac.me domain has been performed using Google Analytics for many years. During the COVID-19 pandemic, an increase in the number of accesses and user's time spent on the university's portal was observed. Comparison of the data obtained for the period from 1.1. 2020 until 31.12.2020, with data from the period from 1.1.2019 to 31.12.2019 is performed. The result of this analysis is shown in Fig. 3 [8].

Fig. 3 Google Analytics for ucg.ac.me portal

The trend of portal visits in 2020 follows the trend in 2019. The graph shows the increase in visits since the beginning of the pandemic in March 2020, as well as the decrease during the summer holidays, then the re-growth during the winter semester, and finally the decrease in visits at the end of December. So, it is clearly visible how the visits follow the periods of teaching at UoM. Based on the obtained data, it is noticeable that the number of recorded visits to the domain ucg.ac.me was 901.498 during 2020, which represents 245.995 more visits compared to the same period in 2019. In terms of percentage, there is an increase in visits to the UoM portal by 37.5% in 2020.

5. CONCLUSION

This paper presents the results and improvements of the UoM DL platform during the COVID-19 pandemic. The part of the Information System related to student services, Distance Learning and accompanying services is presented, which allows online teaching, such as Moodle, BigBlueButton, and the service "Activate your account". The scheme of connection between all segments of the information system with the description of the functionality of each service individually is also presented.

Examples of development services and implementation presented in this paper can provide guidance and serve as a starting point for the further development of IS. All segments of the presented DL platform can be further analyzed and improved, and the results presented in this paper can be used to modernize the system that will find its full affirmation in the academic community in the future.

Statistical usage indicators for the old and new DL platforms illustrate its functionality and improvement, implemented by the UoM CIS, which will continue to further develop and maintain the complete UoM IS and to provide the smooth running of the teaching process.

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