

Cloud Services in Higher Education

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Abstract: *This paper presents analysis of using Cloud Services in an educational institution in Serbia, as well as some background information on the contemporary trends in Cloud Computing and Cloud Services. Cloud Services offer great possibilities for improvement of education processes in Serbia, especially bearing in mind lack of funds to properly equip computer classrooms with computer configurations required by modern desktop software. Also, collaboration in teaching and research is much easier with using Cloud Services than traditional desktop-oriented computing.*

Keywords: *cloud services, higher education; collaboration; integration; e-learning*

1. INTRODUCTION

The first idea of Cloud computing [1], [2], [3], [5] was introduced as a proposal for creating "intergalactic computer network" in 1960s by JCR Licklider, who later was one of the key people responsible for the development of Advanced Research Project Agency Network (ARPANET) in 1969, the precursor to the modern Internet. This proposal promoted the idea of all people on Earth being interconnected by using computers and accessing information everywhere. In 1963 MIT developed technology for Project MAC, proposed by the Defence Advanced Research Projects Agency (DARPA), which required that two or more people can use one computer simultaneously. The word *virtualization* was used to describe this situation and the computer that was used acted as a primitive cloud service [1], [4]. During 1970s the term virtualization described creation of virtual machines that act as real computers with fully functional operating system. This concept has evolved with the Internet, firstly as some companies began to offer *virtual private networks* as a rentable service.

During the 1990s cloud services became more popular as companies understood better the use and usefulness of such services. In 1997 Professor Ramnath Chellapa of Emory University defined *Cloud Computing* as the new "computer paradigm, where boundaries of computing will be determined by economic rationale, rather than technical limits alone". From today's point of view, this couldn't be more true [4].

Salesforce became one of the first examples of successful use of Cloud Computing in 1999, offering purchase and download of software by anyone with Internet access. This provided cost-effective way for businesses to buy software without leaving the office.

During the early 2000s Amazon introduced its web-based retail services [6]. They had enough server capacity to accommodate peak number of visitors and buyers during days like Christmas, Thanksgiving Day, etc. But, for the remaining time of the year, only 10% of their capacity was used. Amazon was the first major company to think of solving this 10% usage as a problem, while at that time it was considered normal and acceptable to any business to use only 10% of their server capacity on average [6].

Amazon Web Services appeared in 2006 as online services available to other websites and clients, while Amazon Mechanical Turk provided various cloud-based services to their clients, like storage, computation and human intelligence. The most prominent Amazon cloud-based service was Elastic Compute Cloud (EC2), which allowed others to rent virtual computers and used their own software on those virtual machines [7].

IBM, Google and several universities joined forces in 2007 to develop a server farm for research projects that needed high CPU power and huge data sets. The first university to join the project was the University of Washington, followed by the University of California at Berkeley, MIT, Stanford University, Carnegie Mellon University and the University of Maryland [5].

The same year Netflix launched streaming video service based on Cloud, while Eucalyptus was the first to offer AWS API compatible platform to distribute private Clouds in 2008. At the same time, NASA started OpenNebula, the first open-source project for deploying private and Hybrid Clouds [5].

In 2011 IBM introduced IBM SmartCloud framework, Apple launched iCloud, and Microsoft began to advertise the Cloud on television.

In 2012, Oracle introduced Oracle Cloud, offering three different *aromas* of Cloud Services: IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service) and SaaS (Software-as-a-Service) [8].

2. BACKGROUND

Contemporary trend in business is to use Cloud Services for more reasons, just a few of them being the lower costs of IT departments, faster adaptation to new requirements and technologies and more options for integration of processes and sharing of data between different departments [4].

Although some software companies invested lots of effort to make potential and existing customers to use their *on-premise* software (which is installed on the user’s computer or local server), the last 10 years saw the opposite situation, the same companies trying to persuade users and business clients to move to their Cloud Services.

On the other side, the development of Internet redefined the way people learn, collaborate and exchange knowledge, while at the same time, educational institutions are making efforts to adopt new teaching and learning methods supported by the latest IT advancements [9]. While in the developed countries universities, both government and non-government, put much effort into providing their students and staff with the latest technologies, universities in Serbia lack not only funding, but also staff with enough knowledge and experience to introduce such technologies.

The concept of Cloud Services usually depends on the needs of users and the level of control they have (Figure 1).

Traditional systems provide the user with full

control over hardware (computers, servers, network equipment, etc.) and software (Operating System, applications), since the user have full physical and software access.

The next level in Cloud hierarchy is Software-as-a-Service (SaaS), like Google Apps, Microsoft Office 365, Cisco WebEx, etc. This is the most common kind of Cloud Services, representing the largest Cloud market, where everything is managed by service provider, while users only have access to the applications by using the web browser. Some applications may also require a plugin for browser to be installed.

Platform-as-a-Service (PaaS) is a kind of Cloud service where clients manage only applications (e.g., develop and deploy or just customize existing applications). By using this kind of Cloud services, developing, testing and deployment of applications is quick and simple, as well as cost-effective.

Infrastructure-as-a-Service (IaaS) gives users additional control over operating system and related software functions, like databases.

Latest addition to this scheme is Enterprise IT (or legacy IT), where users manage everything, from data center to applications. This is practically a kind of Private Cloud, where users don’t share any hardware with other Cloud users, e.g., they have dedicated servers within data center for their storage and processing power. Examples of IaaS are Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), etc.

3. CLOUD SERVICES IN EDUCATION

In the last 10 years Cloud Computing saw tremendous expansion and development, offering

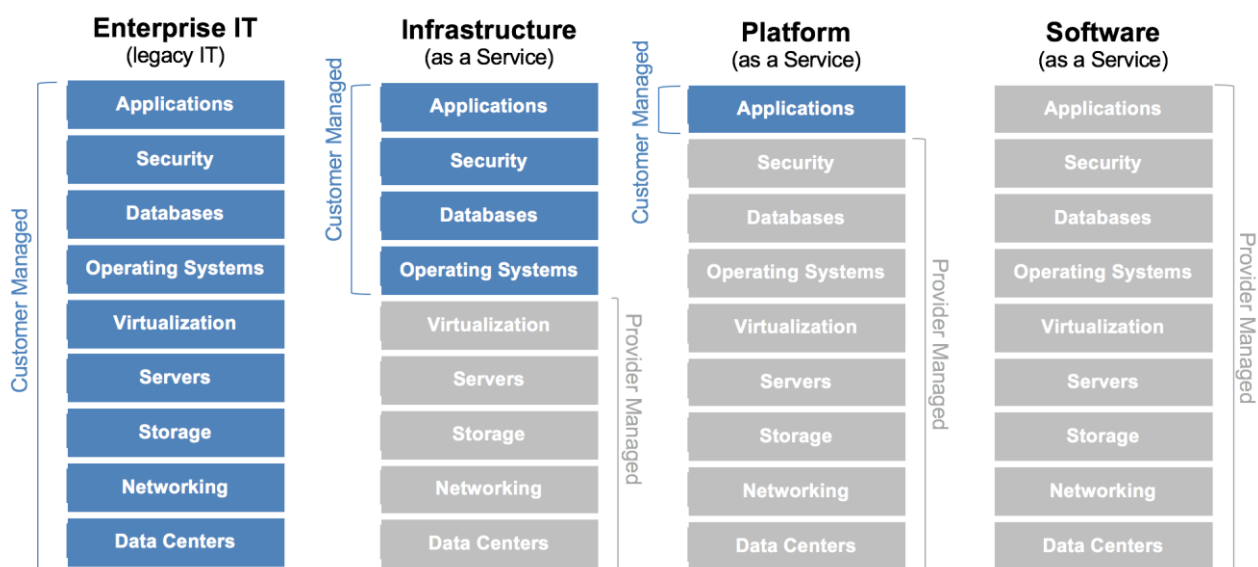


Figure 1. Cloud Service provider and Customer roles for different levels of Cloud Services. Image source: [The Enterprise Cloud Blog](#).

wide range of different services and integrations of services for the purpose of various businesses, research and education [5].

Cloud-based services can provide teachers and students with opportunity to improve the process of teaching, collaboration, communication, creating and sharing new course materials, as well as better coordination and team work on research and student projects [21].

When educational institutions apply to the Cloud services providers, they are given a tenant account, which is managed by a member of the institution with proficient knowledge and experience in administration of Cloud-based services. Then, this person can create accounts for other institution staff and students, and provide some of them with certain administration-level rights, so that they can create accounts for other staff and students and manage certain resources (e.g. creating new groups, subject pages, etc.) and providing access to them for other users.

The first universities to use Cloud services were, as expected, in USA, which is not a surprise due to the fact that the first global Cloud services providers are companies from USA, which also donate substantial resources to universities. Nowadays, even the most conservative countries have adopted Cloud services in education [22].

In Serbia, these trends are yet to become popular in educational institutions, especially in primary and schools, where the lack of properly equipped computer classrooms is more than evident due to economic situation. Academic institutions are in a better position, not only thanks to the joint projects with universities from EU countries financed by EU academic and education projects, through which advanced computer equipment can be obtained, but also due to the larger sums in their yearly budgets intended for computer equipment and software.

Present situation in Serbia is that most of users in education still dominantly use desktop-oriented applications, and in most cases little care is given to the data security and safety. Also, Learning Management Systems (LMS) are used on local servers, although Cloud hosted LMS would prove to be convenient [11].

Besides the use of LMS for providing course materials to the students, universities in Serbia have agreements with global software companies to provide free student versions of commercial software packages for their students (e.g. Microsoft DreamSpark/Imagine, Oracle Academy, etc.), with both Standard and Premium options, depending on the faculty needs and service provider [19].

While higher education institutions in developed countries are moving to open courses (MIT Open Courseware – OCW, Massive Open Online Courses

- MOOC, Free EdX courses, etc.) and using Cloud services to lower the cost of IT departments, universities in Serbia are still a bit slow to embrace such new trends.

During the last few years, since some global software companies began to offer Cloud services for free of charge to educational institutions [20], but only a few institutions in Serbia adopted this as an opportunity to offer the latest technologies to their students and staff.

At present, all educational institutions are eligible to offer educational services provided by global software companies, like Microsoft (Office 365 Education), Google (Google for Education), Apple (Apple for Education), Amazon (Amazon Education) free of charge to their students and staff. Also, these companies offer some advanced services to educational institutions for a small fee per month per user.

A few faculties in Serbia have already adopted the use of Cloud Services and their experience may be of great use for others to follow the same path.

Two of these institutions, Faculty of Sciences in Kragujevac and Faculty of Technical Sciences in Čačak (FTN), both members of the University of Kragujevac, were among the first academic institutions in Serbia to adopt the use of Cloud services. Thus, we can say that the University of Kragujevac is not much behind the top world universities in using the latest computer and IT technologies in the process of education.

At FTN Čačak the importance of using all the advantages of the latest IT technologies is of great importance due to the three important graduate and postgraduate study programs:

- Professor of Technics and Informatics
- Information Technologies
- Computer Engineering

For future Professors of Technics and Informatics knowledge and experience with the latest IT technologies is important due to the fact that they will teach informatics at primary and secondary schools, thus, providing future students with better knowledge of technologies that even today is dominant choice for not only advanced users, but also for companies involved in the processes of software development, testing and deployment.

Future Information Technologies and Computer Engineering graduates will be more competitive on the job market if they possess good knowledge of Cloud computing concepts, whether from the point of development, testing and deployment of apps for Cloud-based services, or from the point of using Cloud services for research and cooperation with other developers or researchers.

4. CLOUD SERVICE IN EDUCATION AT FTN

In this section we give a case study of using Cloud services at Faculty of Technical Sciences in Čačak (FTN), University of Kragujevac. FTN is a registered tenant of Microsoft Cloud Service [14]. Microsoft Cloud services consist of Microsoft Office 365 applications and Microsoft Azure. More details on Microsoft Cloud Services and Platform Options can be seen in [15], as well as other technical documentation related to Microsoft Cloud services [16]. As a matter of fact, Office 365 is SaaS that uses Azure Active Directory to manage users and Identity Management.

4.1. Microsoft Office 365 Education (A1 plan)

Office 365 A1 plan include "Completely free online version of Office with email, video conferencing, voicemail integration, customized hub for class teamwork with Microsoft Teams, compliance tools, and information protection" [12]. This plan does not include off-line version of Microsoft Office applications (Word, Excel, PowerPoint, etc.).

If only a few users require non-free Education plans (A3 or A5), faculty can provide only their accounts with one of A3 or A5 plans for insignificant price per user per month, which is an affordable solution to provide just a few staff with needed services that are beyond A1 plan, which, besides other options, include off-line version of some Office 365 apps, like Word, Excel and PowerPoint. In this paper we show only a case study of using A1 plan, which is completely free of charge.

In Microsoft Office 365 Education A1 plan each user is provided with Web versions of Word, PowerPoint, Excel, OneNote, and Outlook apps, Desktop version of OneNote, Microsoft Teams – "a digital hub that integrates the conversations, content, and apps your school needs to be more collaborative and engage" [12] – Class and Staff notebooks, Self-grading quizzes with Forms app, Digital storytelling with Sway, Compliance solutions with a unified eDiscovery center, Rights management, data loss prevention and encryption, Enterprise video service for creating, managing, and sharing videos securely across an organization, e-mail with 50 GB box, 1 TB of space on OneDrive, video conferencing in HD quality, etc.

The maximum number of users is not limited, so, in effect, it is possible to create accounts for all faculty students and staff for free of charge, each user having 50 GB e-mail box and 1 TB of storage on One Drive. This means that all communication and correspondence, as well as sharing of course and other materials between teachers, students and administration staff, would hardly hit any storage limit problems, which often is the case with classical use of computers, not to mention problems with security and safety of data.

Microsoft is responsible for backup and safety of all data, as well as security in compliance with requirements specified in ISO 27001, European Union (EU) Model Clauses, the Health Insurance Portability and Accountability Act Business Associate Agreement (HIPAA BAA), and the Federal Information Security Management Act (FISMA) [13]. Microsoft was the first cloud provider to adhere to the ISO/IEC 27018 code of practice, which covers privacy protection for the processing of personal information by cloud service providers. Also, Office 365 obtained some national or regional certificates from certain countries and regional organizations, e.g., UK G-Cloud and ENISA IAF (The European Network and Information Security Agency Information Assurance Framework).

Office 365 Education A1 plan service is available to all faculty staff and students at FTN Čačak [14] free of charge. Teachers can be provided with administration account (Figure 2) with more options to create and control resources, e.g. creating new Outlook groups, Sharepoint pages, Yammer groups, etc. Besides personal details, users can add other contact information, like phone number and private e-mail address, which can be used for sign-in with 2-step verification or password reset [21].

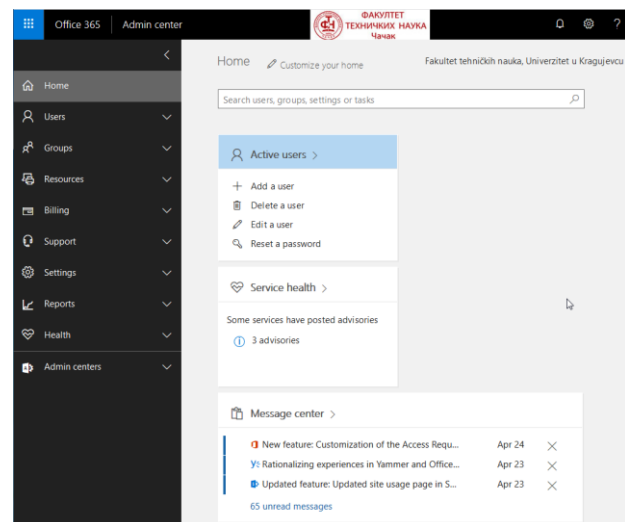


Figure 2. Admin center in Office 365

4.2. Microsoft Office 365 apps

The most used Office 365 application is Outlook (Figure 3), with 50 GB e-mail box and options for advanced management of e-mail communication by using Outlook groups (Figure 4), creating categories or dedicated folders and rules for managing large quantities of e-mails, etc. Outlook also provides Calendar (Figure 5) for creating, changing, deleting and sharing calendar events, and also importing events from other calendars.

Here we mention a few other Office 365 apps, which can be of great use in improving the process of teaching, communication, collaboration,

management of student projects, research and other processes in higher education.

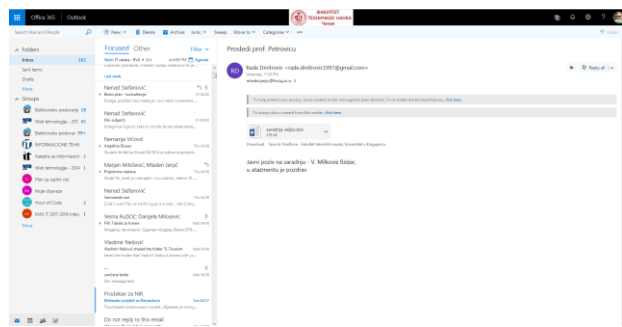


Figure 3. Office 365 Outlook

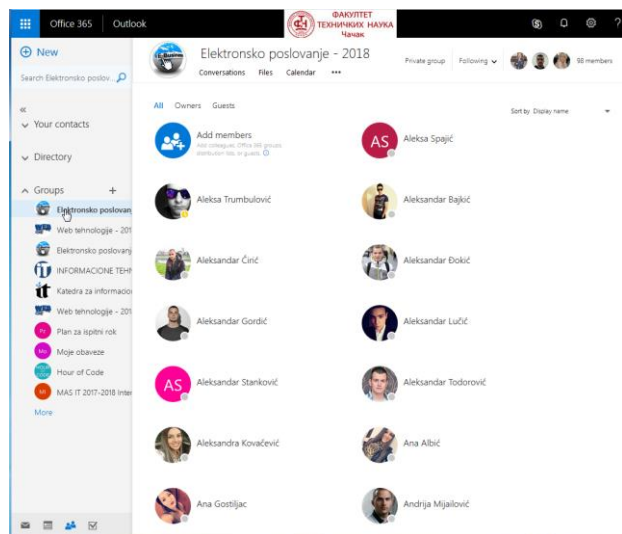


Figure 4. Office 365 Outlook groups

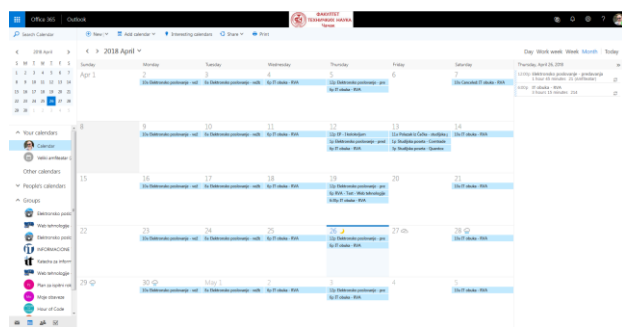


Figure 5. Office 365 Calendar

Teachers can manage preparation and sharing of teaching material with less effort, access and edit all material from any location on-line by using computer or smartphone, manage communication with students and colleagues and benefit from integration with other services used in education (Moodle plugins for Single-Sign-On and OneNote, possibility of integration with Student office information system by using appropriate APIs or custom-developed plugins, etc.).

All apps are available from the Office 365 home page (Figure 6), which is shown to the user by default after successful sign-in. This, as well as many other features, can be customized to the user needs, e.g., user can change the start page

to open any other Office 365 app instead of the home page. For example, user might want Outlook app to be opened after successful sign-in.

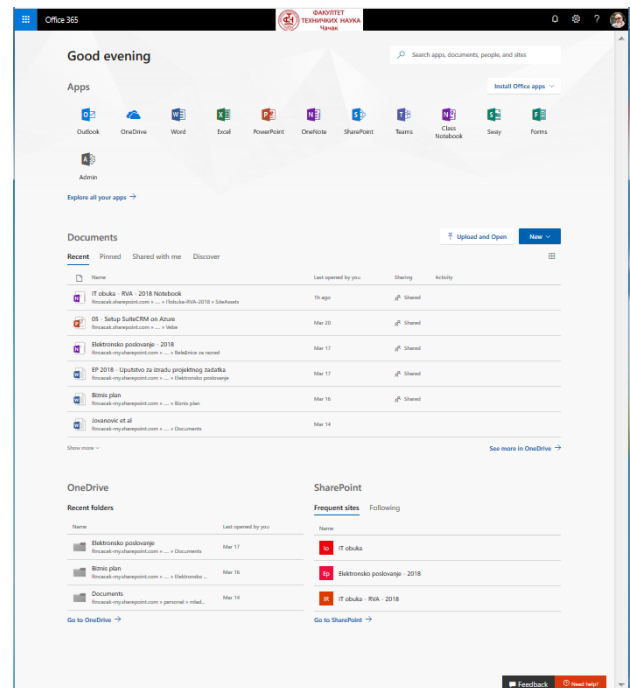


Figure 6. Office 365 home page

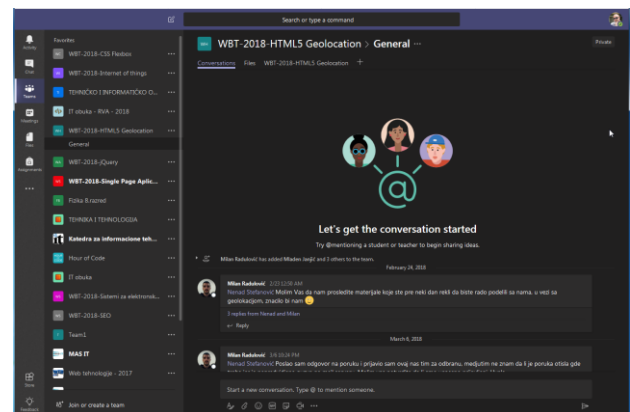


Figure 7. Office 365 Teams

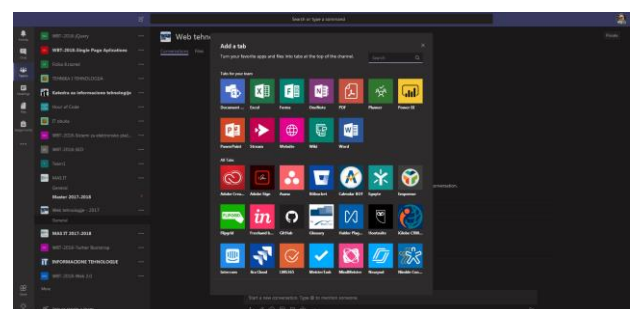


Figure 8. Teams "Add a tab" screen

Teams (Figure 7) is "hub for teamwork", an app that provides a place for cooperation on certain subject, be it a university course for student or a research project, or any other type of team activity at educational institution that can benefit from the use of on-line meetings, live streaming, conference calls. Besides all built-in features,

Teams offer an option to add tabs with other Office 365 features and apps (Figure 8), like Assignments, OneNote, etc.

Office 365 also integrates Business Social Network, known as Yammer (Figure 9), which can be used in education for chat, private and group messaging and sending important information to users in certain groups or everyone within institution. These messages and other posted content is also sent to users' emails and shown on users' mobile version of the app.

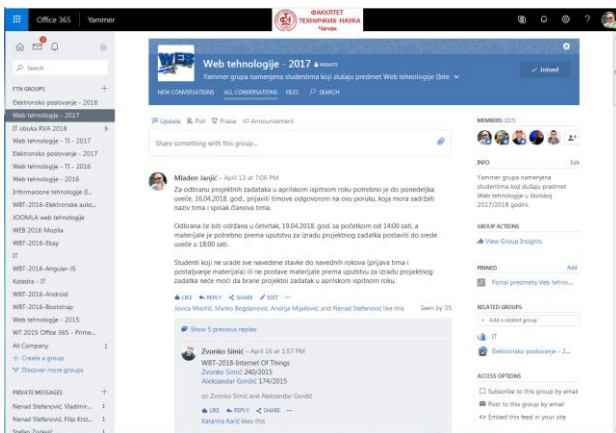


Figure 9. Office 365 Social Network app

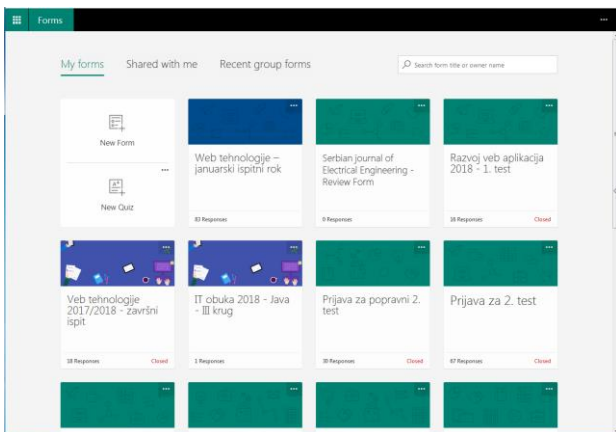


Figure 10. Office 365 Forms app

Forms, shown in Figure 10, is another very useful Office 365 app, which provides one place for creating and sharing of forms and quizzes. Making a new quiz for students is easy even for users with moderate knowledge of using computers, correct answers can be marked, which is very useful with "Show results automatically" option, which shows the result of the quiz to the user after submission. Also, *Forms* is supported by "Take a Test app", which can lock student computers so that nothing else can be done on the computers before the *Forms* quiz is submitted.

Class Notebook is OneNote for teachers, with separate personal workspace for each student, a content library for handouts and a collaboration space for lesson material and other activities related to the class.

Other useful Office 365 apps include *Delve*, app to "discover and organize the information that's likely to be most interesting to the user now – across Office 365", *Stream* for uploading and sharing videos, *Tasks* for managing tasks and to-do events, and many other tools to connect more services and exchange information between them.

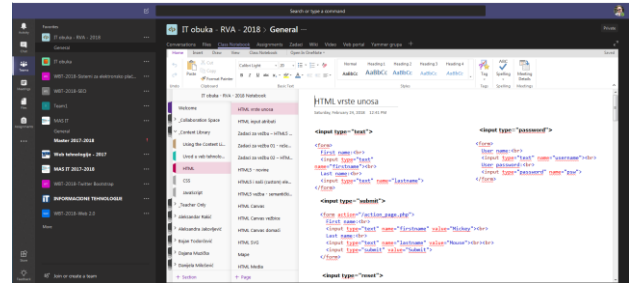


Figure 11. An example of Class Notebook integrated with Teams service.

Class Notebook [18] is (officially OneNote Class Notebook) is special kind of OneNote service that have a personal workspace for each student, a content library for handouts and collaboration space for lessons and creative activities.

Microsoft OneNote also supports integration with numerous LMS by using Learning Tools Interoperability (LTI) standard, to name a few: Blackboard, Brightspace, Canvas, Haiku Learning, LoveMySchool, Moodle, Sakai, School Bytes, Schoology, etc. Students enrolled in LMS, e.g. Moodle, can access the notebook automatically without having to add their names. This provide teachers and students using LMS with possibility to try OneNote as a service integrated into their LMS, with an option to include some services not available in LMS in their workflow, e.g., e-mail service, business social network, Sharepoint pages, OneDrive storage, etc.

4.3. Benefits from using Office 365 at FTN

One of the main problems with communication with students at FTN is their use of private e-mail addresses in official communication with teachers and for registering at student services. One solution is to provide students with FTN e-mail server accounts, which would require space for storage and backup.

The other problem for FTN staff, both teachers and administration, is in keeping of emails on their work computers, without any measures applied for data security and safety (e.g., limiting access, employing backup, etc.). Any solution of these problems require substantial financial investment into hardware (additional servers and storage), software and training of staff.

With the use of Office 365 e-mail service (Outlook online), each FTN employee and student get 50GB of space for e-mail box, as well as 1TB of storage on OneDrive, which can be used for storing documents and sending larger e-mail attachments.

4.3.1. Comparison of Cloud and on-premise FTN e-mail accounts

Suppose that FTN provides its staff and students with e-mail accounts on local e-mail server. The current e-mail box size is limited to 200MB, which means that around 120 accounts (teaching staff and administration) require only 24GB of server space. Obviously, this is not an issue, and one 300GB server hard drive for the system and mail boxes would suffice, with an additional one for backup, which, according to the current prices is between 200€ and 300€, depending on the model. If backup of all documents created and used by teachers and administrations is required, probably terabytes of hard drive space is needed, but let us limit to mail server storage.

If FTN decides to provide students with e-mail accounts on local mail server, that decision would, consequently, bring two problems:

- Mail server storage problem;
- Accessing e-mail by different devices;

The first problem is obvious – if each student is granted with 200MB of mail box, for around 1500 students that would mean around 300GB of storage plus 300GB more for backup. That is another 200€ to 300€. Seems not to be an issue.

The second problem is directly related to the first problem. The first problem can be solved in the mentioned way, by providing students with 200MB mail boxes, but that would discourage students to use FTN e-mails for official communication with teachers, since they would have problems with exceeding e-mail box limit too often. Not to mention that students still wouldn't have a way of sending or receiving larger e-mail attachments, but would have to use services like WeeTransfer. Also, accessing e-mail accounts from different devices (e.g., home computer, laptop, phone) would still be a problem, as currently Faculty staff can access their e-mail boxes by using Round Cube web service, but if they don't delete older e-mails regularly, the mail box limit might be exceeded.

Since we cannot expect students to download their e-mails to all devices they use for checking for new e-mails, it is obvious that a Cloud e-mail service with appropriate storage for mail boxes would solve the problem. That would mean at least a few GBs of space for each student's mail box, meaning, a few TBs of drives for e-mails and backup.

The other solution is to use Microsoft Office 365 for Education, for which FTN is already a tenant. That means 50GB of mailbox storage for each FTN teacher, administration and student. This solution is not just very cost-effective, but also helps in improving the user experience and quality of e-mail messaging. Also, FTN staff and students are not provided with free version of basic Office

applications (Word, Excel, PowerPoint) with Microsoft Imagine accounts. Office 365 Education offers free online versions to all users (A1), with an option to obtain A3 or A5 licenses with offline versions for up to 5 devices per user for as little as 3.25\$ (A3) or 8\$ (A5) per user per month. This means that a user with higher-demanding work can get full Office 365 offline for less than 40\$ per year. Student licenses cost even less, 2.50\$ for A3 and 6\$ for A5, which can be used for students who also work as teaching fellows. This is way less than having to pay around 400\$ for Microsoft Office Professional 2016 for each user. Even if the Office would be renewed only after 10 years, there is much additional cost involved in local storage and administration.

This solution has the following advantages:

- 50GB of e-mail box free of charge;
- E-mail attachments up to 150MB, with an option to limit certain users or groups of users to a lower limit;
- Accessing e-mails from all supported devices (desktop and laptop computers, tablets, phones, Outlook app for most popular desktop and mobile operating systems);
- 1TB of space on OneDrive, which can be also used for larger e-mail attachments, accessible with Single-Sign-On (SSO).
- Large e-mail attachments are automatically put on OneDrive and attached as links.
- Automatic backup of data provided by Microsoft Office 365 services.

Table 1. Cost comparison of providing FTN staff and students with on-premise and Office 365 services

| Service | On premise (on-time fee) | Office 365 (per year) |
|---|--------------------------|------------------------|
| Mail box 200 MB | 200 - 300 € | 0 |
| Mail box 500 MB | 300 - 750 € | 0 |
| Mail box 1 GB | 2000 - 3000 € | 0 |
| Mail box 50 GB | / | 0 |
| Cloud storage 1 TB | / | 0 |
| Online Office apps: Word, Excel, PowerPoint (per user) | / | 0 |
| Mobile apps for Outlook, Word, Excel, PowerPoint, Yammer, Teams | / | 0 |
| Offline Office apps: Word, Excel, PowerPoint (per user) | 399.99\$ | 39\$ (A3) 96\$ (A5) |

5. CONCLUSION

On the basis of presented facts and current situation with the use of on-premise Office applications and e-mail servers, it is obvious that educational institutions should embrace the given

opportunity of using Cloud services for free and use them to provide better knowledge and experience for future graduates, thus, making them more competitive on the employment market.

Office 365 Education, with its Classroom app, make virtual classroom system (or LMS 3.0), but additionally with the integrated word processing, spreadsheet, slideshow presentation and cloud storage. Practically, teachers are provided a suite of online tools for easier working with students and colleagues than with classical LMS, or with an option to combine the two worlds as needed for each of the courses.

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