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Management and Distribution of Virtual Laboratories for Researchers and Students

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Abstract
In this article you will get know with unique solution for management and distribution of virtual laboratories, which are designed for researchers and students. It would be interesting for you if you ever wanted to prepare a private lab environment to deliver a training or a class, or maybe you if you ever needed to share a test environment before launching a new product. Probably you spent a lot of time on preparation, even if you used some scripts to make it easier. At the same time you needed to remember that the prepared user environment available locally and throughout the access period, and you want to use your valuable assets, such as PCs in the classrooms. Many things to do, huh? We were in the same place at our Education Center, so that's the main reason why we create CloudLabs and why we want to share it with you. With CloudLabs you can automatically deploy and distribute hundreds of predefined lab environments, which are available 24/7, to users within minutes. Students and teachers can use the courses and perform laboratories from any computer, which is connected to the network.
Index Terms — cloudlabs, laboratory in the cloud, virtual laboratories.

1. Introduction
Widely expressed education of IT representatives, due to increasing complexity of information systems, requires from the university or other education center classes complex laboratory environments. These environments oven consist of several or even dozen cooperating computers. Building such complex environment involves growing costs, especially when administrator decides to use classic solutions without using any of methods of virtualization. The use of server virtualization is very helpful for costs optimizing and for saving time for new lab preparation. But it still requires a separate virtualization server for each student.

2. Needs and Expectations

2. 1. Economy and time
Computer science education needs to make far-reaching investments, which significant part is absorbed by lab environments used during in all process of learning. This challenge affects both economic aspect, as well a huge amount of time associated with frequent updating of existing environments, what takes additional meaning in case of computer science, which is so fast-developing field of knowledge. In addition to the cost of the preparing the laboratory, very important is the time it is generated. Such environments are often appointed at the request and the time of their lives does not exceed duration of the training, which usually takes few days. Related to this is a lot of work devoted to "retooling" laboratory for the needs of another group of listeners. Universities such changeovers are performed less frequently, perhaps once per semester, but the number of potential students for whom these laboratories are intended, presents us another challenge related to the problem of the scale of the project.

2.2. Availability
In the era of growing distance learning, educational institutes need laboratories available for 24 hours from any place in the world. Laboratories which work in such convention would help to present much wider educational offer addressed to long distance students, who are not able to study on-site because of work or family situation. The same situation applies to people with disabilities and for those who are not able to visit university in regular way because of the health state.
One of the advantage that goes along with cloud using is possibility to increase SLA (Service Level Agreement) of the lab environment as a parameter resulting directly from the infrastructure. This

parameter in case of a private cloud depends on the redundancy used in the solutions. In public clouds this parameter is strictly defined. SLA for most of the services based on Microsoft Azure is 99,9%. It means that maximum time of the unavailability of particular service cannot exceed 87 hours per year. Getting so high SLA using "own servers" requires funding, which ensure minimum redundancy of services, infrastructure and data centers location. The solution which eliminates such problems is CloudLabs platform – it is offered in two ways: as client's own installation and one that uses provider's infrastructure. Trial version of this solution is also available for each user at http://cloudla.bs.

3. Functionality

The analysis of the requirements presented above directly affected the functionality of CloudLabs solution. It provides fast and easy creation of the pre-prepared laboratory environments for students participating in classes. What is more – time of life such environment is fully adjustable. It is also possible to restore it to the initial state or another previously assigned restore point. An administrator can manage the laboratories by using graphical GUI console or in other way: by using PowerShell scripts. It is also possible to monitor the current condition of the environment and generate reports on its use.

Student who has an access to the environment gets unique link to the page which contains basic information about laboratory such as login and password. The lecturer has his own set of virtual machines and he can also provide remote support for his student trough an application installed on the station. He can also distribute additional software to students in the form of ISO images. The administrator using the administrative tools may invoke a single machine or entire environment and manage them. His remit is to perform advanced tasks, for which neither the student nor the lecturer conducts classes, are not authorized. These include increased productivity by adding resources, or to migrate machines to another node in the cluster.

4. Architecture

CloudLabs can be implemented in two forms. In the first case it is based on a private cloud on customer's infrastructure, which is located in the datacenter fully managed by him. The second form of implementation is the ability to use the application as a SaaS (Software as a Service) based on cloud hosted and managed by the service provider.

4. 1. Cloudlabs in private cloud

The use of private cloud (On-Premise model) requires from educational institute, that wants to use Cloudlabs, taking care of every aspect of the basis by which the environment is going to function. Starting with infrastructure, which will consist of elements such as disk space (shared matrixes), virtualization servers (Microsoft Windows Server 2012R2 with the HyperV function) and network infrastructure, through operating systems machines which manage infrastructure and ending with CloudLabs and services to support its operations. Client who wants to have a high availability solution must take care of it by designing a geographically dispersed data centers, duplicating services, thus increasing the initial costs of implementation.

The functionality that the client gets within the lease SaaS is identical to the functionality of the On-Premise model. The only difference is that the customer is not required to have any infrastructure.

CloudLabs is divided into the following components:

- administrative application;
- frontend service;
- virtual machines access application;
- database;
- environment lifetime managing service;
- trainer's application.

a) Administrative application
It is a web application, which allows to establish new laboratory environments, define trainer and students and managing them.

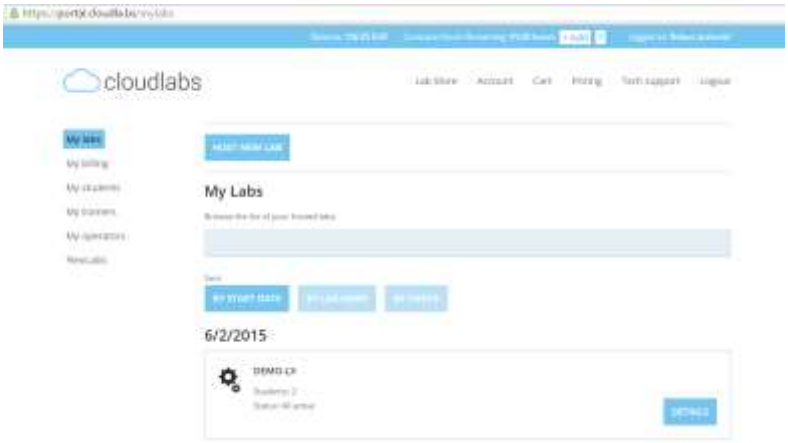

Figure 1 View of the administration application

From this application we can grant rights to portal within the your subscription, and check the status of your accounts. This application gives us the possibility to create labs, planning their availability for predefined students. It also lets you specify the trainer conducting specific classes for explicit group, thereby generating a laboratory environment designed exclusively for him.

- **Frontend application**

Frontend application is also web application that provides student access to previously prepared laboratory environment.

Figure 2 View of the frontend application

On the site you can find information such as: the time remaining until the end of the laboratory lease and button which is generating the RDP file whereby you are redirected to the laboratory environment.

Figure 3 View of the trainer's application

Trainer's version of the same application includes additional possibilities for downloading trainer's applications and access to laboratories for students. In both versions there is the ability to run chat that allows to contact the administrator on the supplier side.

- **Virtual machines access application**

From the frontend application, both student and trainer, have the possibility to initiate a connection to the laboratory environment. After authentication with username and password specified on the page we communicate, using RDP protocol, with virtual laboratory management application. Thanks to that user can start and stop each virtual machine individually. He is also able to monitor the current RAM usage or manage restore points (snapshot). After using *Connect* button user gets an access to the virtual machine, which can be used just like normal direct RDP connection.

Figure 4 View of the virtual machines access application

Figure 5 Monitoring of RAM usage and restore points (snapshot)

- **Databases**

The database contains information about the created laboratory environments and mapping them to specific students. You can find there a list of all the logins and links sent to all participants from specific course. Access to database is available only for administrator – trainer and participant does not have permission to communicate to database.

- **Environment lifetime managing service**

This service is responsible for creating laboratory environment for predefined participants in the laboratory. It sends e-mails with the information necessary to enable access to the platform and takes care of cleaning the environment after the time of access.

- **Trainer's application**

Teacher has at his disposal an application that is used to provide students with additional software in the form of publications ISO files. By using it he can also remotely support or monitor connected students.

Figure 6 Delivering ISO files in trainer's application

Functionalities mentioned above are available after authenticating with the teacher's privileges. This happens by using the same password with which coach gets into a dedicated laboratory environment.

5. Business Modeling

- **Environment's preparation costs**

Authorized trainings are based on a standard and repeatable set of virtual machines. Thus creating environment for next students is associated with duplicating existing models within existing Hyper-V cluster. Standard solutions require a separate virtualization Hyper-V server for each student. CloudLabs consolidates the environment, so adding another student at the last moment, just before classes start, is no problematic at all. Generation time of student's account counts in minutes and does not require any physical work associated with equipment (such is server) delivering. A significant impact on reducing the cost also applies to the student's workstation. It functions as a terminal and does not require large allowance of computing power.

- **Remote access to laboratories**

Thanks to remote access to laboratories it is possible to organize distance learning courses, where students can participate in online training from anywhere in the world. Offering the possibility of remote training helps to reduce customer's costs thanks to saving money on expenses related to the employee's departure to another city, where the training takes place. Moreover, some companies cannot afford 5-days absence of an employee. For such clients there is possibility to offer flexible trainings, where number of contact hours online per day is adjusted to participants.

6. Conclusion

Dynamically growing market determines the flexibility of the training centers, schools, universities or colleges and its education offer. Using such solutions as CloudLabs allows it to expand to variety broadly defined distance education. Moreover, using this solution enables a more efficient way to respond to the needs of students. There are no restrictions with preparing another laboratory or its computing power needed to run it. A multitude of types, in which CloudLabs is offered, ranging from installing it in your server and ending with leases on favorable terms in the form of SaaS, allows to choose the licensing model suitable for every type of customer, regardless of whether it is the leading university, or a small educational center featuring specific educational offer. CloudLabs allows you to much faster building of new laboratories and providing existing at significantly reduced costs