

## GÉANT CLOUD FRAMEWORK

### CASE STUDY – CLOUD SERVICES IN FURTHER EDUCATION

#### SETTING

This case study was conducted in a post-secondary education course named “Installation and Configuration of Windows Server” (ISEWI). It is a two-part course spanning two semesters. For the purposes of this case study, the first part ISEWI<sup>i</sup> was conducted with the school’s traditional on-premises computing equipment, while the second part ISEWI<sup>ii</sup> was switched over to the GÉANT framework cloud services at CloudSigma. It is thus possible to compare the two approaches directly.

The students were adults with a completed secondary school education who are currently in an industrial placement/internship where they spend two days per week in the further education class and the other three days per week in their actual job. This type of education model is known in the country as “diplôme d’aptitude professionnelle”<sup>iii</sup>.

This particular course is designed to deepen the participants’ knowledge in the area of Microsoft Windows ActiveDirectory services and Windows Server administration in general. The students are expected to possess advanced Windows operating system knowledge as a prerequisite.

Ten students attended the course.

#### CLOUD REQUIREMENTS

The schoolteacher, Claude Sibenaler, worked with RESTENA to find a suitable cloud provider for the cloud hosting of the teaching material. The following constraints had to be satisfied

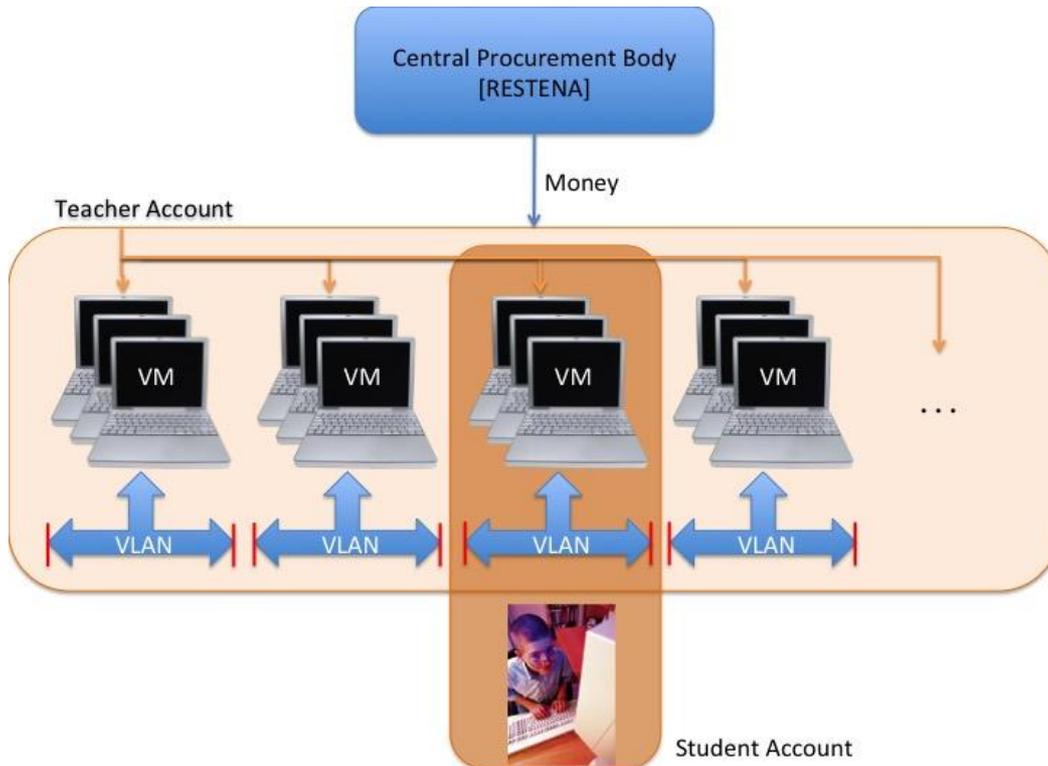
- Ability to let individual students work on their own virtual machines (but no other)
- Keeping billing and cost away from the student
- Ability for the teacher to take control over Virtual Machines if needed (e.g. turn off if student forgets it)
- Isolated networking environment for a group of virtual machines per student
- Enable the teacher to have full control over incurred costs

#### CLOUD SOLUTION

RESTENA consulted with CloudSigma (<https://www.cloudsigma.com>) to determine whether their technology solution fitted the needs of the course.

CloudSigma has a comprehensive delegation model where all the above constraints can be satisfied: all resources can be tagged (e.g. with the name of the student) and an Access Control List can be set up in which access to such tagged objects is delegated. A user with permission to use does not get exposed to any billing; this aspect remains with the owner of the resource. Furthermore, it is possible to purchase a private VLAN: VMs can be connected to the private VLAN network instead of the Internet.

It was also possible to model a typical school setup: one central administration can buy cloud resources (in the form of money on the cloud provider account) and distribute slices of those to individual teachers [this feature is present in CloudSigma, but not publicly advertised]. This alleviates the need for every teacher to make his own payment, and prevents one single course to consume the entire overall budget. RESTENA made the cloud framework Call-Off, added money to its own account, and transferred the estimated sum needed for the course to run to the teacher’s account. The teacher in turn created virtual machines and other resources, and delegated access to them to the individual students.



## RESOURCES PER STUDENT

VM1: Windows Server 2016 (CPU 2 GHz, RAM 2GB), ActiveDirectory Primary Domain Controller

- System Disk (25 GB SSD): system disk with Windows Server 2016 Evaluation Version
- Data Disk (10 GB SSD): data of the users
- Backup Disk (25 GB SSD): backups of user data and full system backup
- Empty System Disk (25 GB SSD): spare disk to restore the system disk

VM2: Windows Server 2016, (CPU 2 GHz, RAM 2GB), ActiveDirectory Backup Domain Controller

- System Disk (25 GB SSD): system disk with Windows Server 2016 Evaluation Version
- Data Disk (10 GB SSD): data of the users

VM3: Windows 10 (CPU 2 GHz, RAM 2 GB) – client machine

- System Disk (25 GB SSD): system disk with Windows 10 Evaluation Version

Network: private VLAN to interconnect the 2 VMs

With all VMs attached to the same private VLAN, but no routing to the Internet at large, the isolated environment could be realized with ease. This was easily combined with ACLs that hid all other students' resources so that no unwanted interaction between students could occur on the network level.

A prerequisite for the isolated resource assignment was that every student had to have their own account in CloudSigma's system. At the time of the course, CloudSigma did not yet have eduGAIN integration, so the students had to set up individual usernames/passwords in the system. Meanwhile, eduGAIN integration is in place, so students can use their existing institutional accounts in the future.

## ADDITIONAL RESOURCES FOR THE TEACHER

The same VM and VLAN setup was also provisioned for the teacher himself. An additional resource were the ISO images of Windows Server 2016 and Windows 10 respectively.

## COURSE

Installation and Configuration of Windows Server

Class: "DAP Informatique"

### PART 1

Main tasks:

- Plan and execute a Windows Server installation
- Configure directory services
- Configure shares and permissions

### PART 2

Main tasks:

- Deploy Windows Server Backup
- Install Backup Domain Controller
- Configure Roaming Profiles and Home Directories
- Monitor the Server

Dates: 19.2.2018 – 9.6.2018

## COURSE PART 1: ON-PREMISES, VIRTUALBOX

For this first part of the course, the students provisioned two virtual machines (MS Windows Server 2016 as Primary Domain Controller; Windows 10 Client; no Backup Domain Controller) using Oracle VirtualBox. The 2 VMs are connected with an internal network. The VMs were stored locally on an internal hard drive on an existing school computer in a classroom.

The specifications of the computers installed in the classroom were very basic:

- Intel Core i3 processor
- 8 GB RAM
- SSD disk only for the base system
- HDD for the VMs

## ADVANTAGES

The course could be run on existing computing equipment that is available to the school without any additional cost.

## DISADVANTAGES

The students experienced very long response times on the local computer.

There was also no backup of the state of the VMs at any time.

As the VMs are stored locally, a student always had to use the same machine in the same classroom. There was no possibility to work at home or at off-times when the premises were closed.

Some students preferred to bring their own computing equipment because they found the existing computers to be not powerful enough:

Some brought an external hard drive or SSD to store their VMs. Transporting an external drive also introduced the new risk that the external hard drive may have a physical crash en route, leaving the students with no backup.

Some students even brought their own laptop computer altogether to work around the local hardware limitations.

In order to alleviate these inconveniences, there are plans to provide external SSDs or even laptops to the students.

## COURSE PART 2: IN THE CLOUD, CLOUDSIGMA

The switchover from on-premise to cloud solutions in the middle of the curriculum introduced an anomaly: students were not able to continue using their pre-built Windows machines but instead had to start fresh on their cloud VM. This led to a loss of time for installing and configuring Windows and an ActiveDirectory domain again.

Luckily, even this initial time offset was minimised: Another feature of the CloudSigma solution is that it is possible to clone existing virtual machines. This enabled the teacher to prepare a basic installation of the Windows VMs and clone that for each student.

When running the entire course immediately on cloud resources, this time offset does not come into play, so should not be considered a drawback of the cloud solution.

### ADVANTAGES

- The virtual machines were always available to the students. The students could access them from every computer in school and at home.
- The response time was good, enabling the students to work more efficiently. The students completed their final assignment much earlier than in previous years (despite the time offset generated by the move from on-premises to cloud infrastructure!).
- The students could not possibly lose their machines because of a system failure.
- There was no need for additional devices (external HD/SSD, laptop computer)
- The teacher was able to login to the students' machines for evaluation or problem solving.
- The computer room in the school is a resource in high demand. By becoming independent from the location, the room can be used by other courses.

### DISADVANTAGES

According to the teacher, the most inconvenient factor of using the cloud service was the management of the costs.

For one, to minimize the costs, resources were introduced to the students by the time they were needed. Particularly, the disk space for the Backup and Restore exercise were only paid for and provisioned when the students reached the preceding milestone; same for the provisioning of the Backup Domain Controller VM.

For two, students also had to be constantly reminded to turn off the VMs when they were done using them, in order to save money on the CPU and memory resources assigned to running VMs.

With this active resource management in place, the total costs of the course ended up as described in the section "Costs", below.

### OPINION OF THE STUDENTS

The students were overall satisfied with the cloud service, with some elements of critique remaining.

One opinion was that having access to the VM inside a browser window is inferior to having a full-screen view. This point of critique is only due to a lack of information: it is possible to connect a full-fledged VNC viewer to the virtual machine, which has better usability than the in-browser solution.

Another point that was raised was about the mismatch of keyboard layouts. Even though the VMs were configured with a Swiss French<sup>IV</sup> keyboard layout, and the local computers had that same physical layout, and the local OS was set to the same character encoding, ultimately the characters as sent to the VM did not match. A workaround was to

switch the local operating system layout to “U.S. English” – which strangely enough resulted in correct printing of the Swiss French characters in the VM instead. This is counter-intuitive.

## DIFFICULTIES

The teacher did not experience any major problems. The cloud services of CloudSigma were very reliable.

Here are some points that should be addressed:

- At the beginning of the course, the students had to open an account to access their machines. After some students had opened their accounts, the IP address of the school and even from the local eduroam hotspot were blocked by CloudSigma. Other accounts had to be opened from mobile phones or the home networks of the students. This was reported to CloudSigma and the IP-based blocking was lifted shortly after.
- The performance of the VMs was good (especially when comparing to local magnetic disks) but they were created according to the bare minimum requirements as set by Microsoft. More performant virtual machines (in terms of more CPU power and/or RAM) would be beneficial for even better response time, but lead to increased costs. The GÉANT framework discounts certainly help in providing the service at manageable costs, but a more elaborate educational discount would be even more helpful.

## COSTS: PLANNED VS ACTUAL

Managing the cost of the course material was a cornerstone of successful execution of the course. The following calculations were made upfront, knowing that the storage and networking resources would be needed continuously and could be prepaid for entire months at a significant discount compared to spot usage (“burst” price).

### PLANNED PREPAID RESOURCES

For each student, three VMs had to be procured; two of which for the full duration of the course, one (BDC) only for approximately one month. On the PDC, the additional disk for the backup and restore exercise was only needed for one month in total. The teacher also needed extra storage space for VM templates and ISO images.

With 10 students, plus one copy for the teacher, the following total resource requirements applied:

VM1: 11 x 5 months x 35 GB SSD (System and Data Disk)	= 55 months x 35 GB	= 171,60 €
VM1: 11 x 1 month x 35 GB SSD (Backup Disk)	= 11 months x 35 GB	= 34,32 €
VM2: 11 x 1 month x 35 GB SSD	= 11 months x 35 GB	= 34,32 €
VM3: 11 x 5 months x 25 GB SSD	= 55 months x 25 GB	= 122,65 €
VLAN: 11 x 5 months x 1 VLAN	= 55 months x 1 VLAN	= 255,75 €
Auxilliary: 1 x 5 months x 10 GB (storage for ISOs)	= 5 months x 10 GB	= 4,45 €

The prepaid resources thus totalled **623,09 €**.

### PLANNED BURST RESOURCES

Students were active only on two days a week (plus possibly additional work at home or off-times), and then only for a few hours each day. This usage profile prohibits the use of prepaid resources for CPU and RAM consumption. At the same time, it is difficult to estimate the amount of resource actually consumed upfront. In addition, the burst price at CloudSigma varies depending on the overall system load. The following calculations were made as an estimate of burst resource usage:

Student activity: 3 hours / week

Course duration: 15 weeks for the main VMs, four weeks for the BDC

VM1	VM2	VM3	Total
45 hours x 2 GHz	12 hours x 2 GHz	45 hours x 2 GHz	204 GHz hours
45 hours x 2 GB RAM	12 hours x 2 GB RAM	45 hours x 2 GB RAM	204 GB RAM hours

At an estimated spot price of 0,11 € per GHz hour and 0,10 € per GB RAM hour, this would lead to a total price of: 42,84 € per student, or **428,40 €** for the entire set of participants.

The expected total cost of the course was thus pre-calculated to be **1051,49 €**.

## ACTUAL COSTS

The teacher was initially assigned a budget of 850 €, to which an additional 100 € were added near the end of the course. This allowed the course to complete. At the request of a few students, their machines were kept active after the official end of the course so they could do some extra studies. This consumed another 55 €, leading to a total expenditure of **1005 €**; in budget compared to planning.

However, given the uncertainties in individual usage time per student and the fact that spot prices vary, a certain variance from that price has to be expected in future iterations of the course.

## CONCLUSION

Working with virtual machines in a cloud infrastructure has many advantages over an on-premise solution inside a school. It gives both the teacher and the students a lot of flexibility. As the case study showed, the students were finishing their assignments much earlier, which is a time win that can be invested into enlarging the curriculum with more content. This is a pedagogical win, and came at the comparatively small price of approx. 100 € per student for the entire semester.

When using local hardware, as the size of the class grows, the potential for issues with that hardware and BYOD devices from the students get more pressing because the number of moving parts increases. Furthermore, the compute resources needed for a given teaching project can quickly go beyond what a typical school computer can manage, and insufficient resources ultimately lead to slow progress and disgruntled students. This is especially true when working with Windows machines where compute and RAM resources are critical for performance.

Having all these aspects managed automatically removes many possible breakage points, leaving the teacher only with one administrative task: keeping an eye on the expenses. This is admittedly a new and unusual task, but certainly manageable.

## QUOTE FROM CLAUDE SIBENALER, TEACHER



“My first experience in working with a cloud service was very positive. My impression is that the students worked much more efficiently, and they definitively finished their assignments earlier than during the other years. All in all, the cloud service, in my opinion, offers many advantages in teaching scenarios on ICT topics.”

## ABOUT RESTENA FOUNDATION

The RESTENA (“Réseau Téléinformatique de l’Education Nationale et de la Recherche”) Foundation operates the National Research and Education Network in Luxembourg. It supports the scientific development by providing and maintaining high quality network infrastructures and associated services for the needs of education and research in Luxembourg. To achieve its mission, a national network infrastructure, RESTENA, has been set up, connecting educational institutions from primary to higher education as well as the public, private research centres and cultural institutions. The more, the RESTENA Foundation is an active partner in the operation of the Internet traffic exchange platform LU-CIX.

RESTENA is an integrated part of the backbone network GÉANT on an international level, a state-of-the-art network providing fast network connections, where public and private research centres can connect to more than 6000 institutions, research centres, universities, scientific libraries and scientific centres.

A second mission of the RESTENA Foundation is the coordination of Internet services, where it operates the registry for the top-level domain .LU. Here it assures the top-level domain name management for .LU and actively contributes to the development of a stable and secure national Internet.

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<sup>i</sup> [https://ssl.education.lu/horpro/pgmfor/PGMFOR\\_2017\\_2018\\_DAP\\_IF\\_SERVE\\_ISEWI1\\_31\\_F.pdf](https://ssl.education.lu/horpro/pgmfor/PGMFOR_2017_2018_DAP_IF_SERVE_ISEWI1_31_F.pdf)

<sup>ii</sup> [https://ssl.education.lu/horpro/refeval/REFEVAL\\_2017\\_2018\\_DAP\\_IF\\_SERVE\\_ISEWI1\\_31\\_F.pdf](https://ssl.education.lu/horpro/refeval/REFEVAL_2017_2018_DAP_IF_SERVE_ISEWI1_31_F.pdf)

<sup>iii</sup> <http://www.men.public.lu/fr/professionnel/initiale/offre-scolaire-organisation/organisation-formation-professionnelle/index.html#panel-2>

<sup>iv</sup> Swiss French is the default keyboard layout in Luxembourg.