

Development of a Calculation Method for a Credit System in an Educational Cloud Environment

M. Diepold, M. Edelhofer, B. Grübl, C. Makas, and B. Pohn

Abstract—Cloud infrastructures are a very common way to provide IT services nowadays. Any cloud provider is interested in designing appropriate systems and optimizing usage rates. Within an educational area elastic IT services can support administration and also students' courses. Therefore this paper scopes onto the calculation needs of an educational cloud environment. The primary intention is to get a generally valid counting algorithm which fits for different universities and colleges, no matter if they have apprenticeship training or not. The presented credit system does not focus on maximum income but aims to achieve the optimum output rate and operating grade of the available hardware resources. The paper explains furthermore the basic facts and possible presumptions which are necessary for designing a credit system that shall be easy and universally applicable. Finally a formula is presented, which allows educational institutes to forecast their demand of virtual resources and a key to partitioning.

Index Terms—Cloud computing, credit system, Linux, resources, right sizing, virtualization.

I. INTRODUCTION

In modern IT architectures many servers or services are running on virtualized hosts or infrastructures. Main reasons for this development are the flexibility and scalability of virtualized systems [1]. Machines can be easily added on demand and removed if they are not needed anymore. Within those architectures there are three common distinguishing features defined: processor performance, central memory consumption and needed disk space. Common cloud service providers have the aim to maximize the system load on all these three categories and subsequently maximize the profit [2].

Counter draw a cloud infrastructure in an educational environment focuses on the optimal utilized workload for all needed servers or services. To take full advantage of the benefits of cloud architectures, like flexibility and elasticity, the University of Applied Sciences Technikum Wien plans to provide various IT services for administrative and also study purposes as cloud services over the medium-term. Due to various departments and their varying number of study programs, students, courses and finally groups – which depend on IT services-, there has to be criteria for a fair

provision of IT resources. Choosing a credit system allows the assignment of cloud services indirectly. Each department shall receive a basic number of credits, according to the evaluated need, which marks a maximum of available resources. Credits can be exchanged for IT services. If those resources are not needed anymore, they can be returned and credits will flow back to the credit account. This will keep staff and students stay motivated to return unused resources and not block virtual services.

In this paper we will define and calculate a general valid formula for this ambition. This formula should build a base to approximate the needed hardware for an educational private cloud infrastructure and to calculate the amount of credits available to be shared onto the different departments and courses depending onto their needs. Our target is the right sizing of the needed hardware, and the optimal operating grade [3]. The calculation formula is transparent for the hardware, and our system can be scaled easily through adding additional servers or storages.

II. METHODS

A. Requirements

As we started with our analysis we had to gather requirements of the planned system by involving the IT department of the university. Additionally we researched the costs on other institutes for comparison (Cornell University [4]). To get basic information for the calculation it had to be clarified how many resources are required currently during a study year and how the requested resources are expected to increase. Moreover it was necessary to know the amount of operated systems, the planned hardware setup for the new cloud environment and constraints concerning availability and network traffic limits.

Due to the very early stage of the cloud environment project within the IT department not all needed information could be provided. Furthermore many departments are currently running individual solutions which are intended to support the dedicated courses and not transparent.

Therefore we decided to approximate the amount of needed virtual servers or services with the available course data from our university and with the experience of our needed virtual servers the last six semesters within the bachelor program *Information and Communication Systems and Services*.

During our research we found several other issues that had to be handled like capping of CPU performance, variable central memory and CPU core allocations, fixed allocations for cross course systems and finally CPU resource pools.

We decided not to cap the CPU performance in any way,

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because the average CPU load of the systems we reviewed had a very low CPU consumption. Also a variable CPU core allocation was not necessary. As a reason we focused our formula only on memory usage and disk space.

III. RESULTS

A. Calculation Base

To get the base unit of system resources per credit we started to compare other units and prices of several providers of virtual infrastructures. With these values we were able to extrapolate our own units per credit table for the system resources. We determined that one credit composes of 128MB central memory or 8GB disc space.

Fig. 1 shows the costs for central memory within a range from 90 to 173 MB per credit. Therefore we decided to define one credit to 128 MB, because that is nearly the average of the captured values.

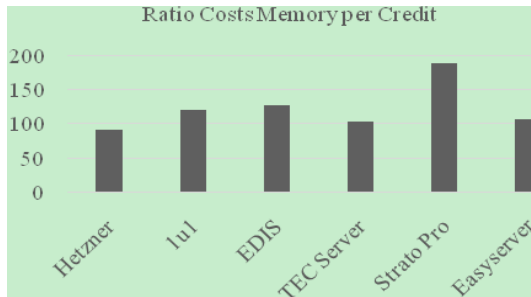


Fig. 1. Ratio costs memory per credit.

Fig. 2 shows the costs for disk space within a range from approximately 4 to over 10GB per credit. Therefore we decided to define one credit to 8GB, because that is nearly the average of the captured values.

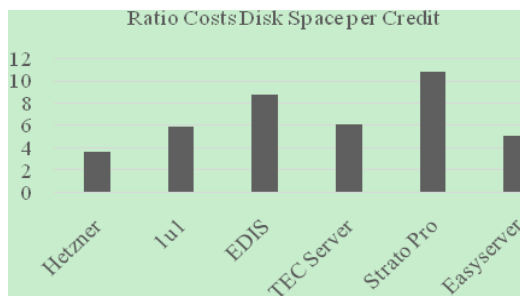


Fig. 2. Ratio costs disk space per credit.

As a result of our capturing we defined the system configurations as shown in Table I.

TABLE I: TYPE CREDITS CALCULATION

vCPU	Central memory	Disk space	Type credits
1	1024 MB	8 GB	9
2	2048 MB	16 GB	18
3	3072 MB	24 GB	27
4	4096 MB	32 GB	36

For example, a system with 1024MB ($8 \times 128\text{MB}$ equals to 8 Credits) system memory and 8GB (equals to 1 Credit) disk space costs 9 Credits, for each 1024MB system memory a VM gets one vCPU.

To simplify the calculation for the optimal physical

hardware occupancy rate and to ensure that minimum system requirements are donated, we defined three standard virtual machines as in Table II shown, with the possibility to upgrade the systems per using credits.

TABLE II: CREDIT HARDWARE DEFINED TYPES

vCPU	Central memory	Disk space	Type
1	1024 MB	8 GB	Low
2	2048 MB	16 GB	Medium
4	4096 MB	32 GB	High

The system with the type *Low* is the smallest orderable system because the most Linux derivatives (Red Hat [5], Ubuntu [6], Debian [7], SUSE [8]) have system requirements between 512 and 1024MB system memory per logical CPU and between 4 and 9GB of disc space. With the definition of standard virtual machines it is possible to determine the minimum hypervisor system requirements.

B. Hardware Credit Calculation

Our aim was to find the optimum size for our hypervisors. But before we could create our formula to extrapolate the right amount of needed virtual machines, we kept an eye on typical hypervisor configurations.

Table III shows for example, that a hypervisor with 32GB central memory can provide up to 39 virtual machines of the type *Low*, respectively provides 356 Credits. If high availability is to provide, it is essential only to use the half of the according central memory to calculate the credits. For example a high availability hypervisor cluster with two machines per 32GB central memory only provides 356 Credits, because you should only user 32GB of the 64GB, to be able to switch all hosts onto one cluster node.

TABLE III: HYPERVISOR CREDIT CALCULATION

Central memory	Credits	VMs
32 GB	356	39
64 GB	512	56
128 GB	1024	113
256 GB	2048	227

In the calculation of Table III we disregarded the view on the CPU, because in our experience and research we found out, that in our educational environment modern CPU architectures are of no consequence. The total consumed CPU value will not be a limiting factor.

C. Resource Extrapolation

One important question was the number of needed virtual systems. As we did not get an exact number, we tried to find a universally valid formula, to calculate and extrapolate the needed amount of virtual systems in order to find the right size of the needed hardware equipment. Therefore we used official data from the university like educational plans and information material available on the webpage <http://www.technikum-wien.at> respectively within the Campus Information System.

D. Raw Data

First of all, we concentrated on the calculation of our bachelor degree course, because additionally to the official

information available we derived data from our experiences concerning the need of virtual resources through the last six semesters. Therefore we had to separate courses which needed IT support from those which did not and so we defined two types of categories for the courses offered at university:

- T → Technical course
- A → General course

As a next step we built a matrix of courses, their category in our system and their allocated amount of the European credit transfer system (ECTS) as you can see in Fig. 3.

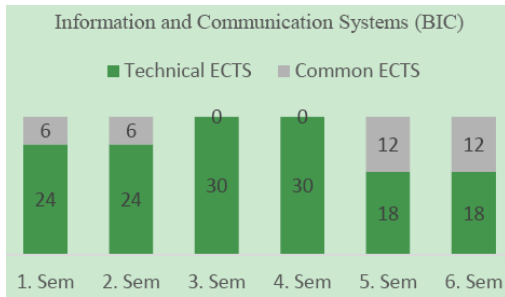


Fig. 3. Overview ECTS statistics BIC.

This data was compared with the virtual machines needed in practice during our bachelor study program. One presumption we made was that every virtual instance should at least be valid for two semesters. This was due to many projects and courses that have common topics over two semesters. It would be a big disadvantage of the system, if needed virtual instances would not be acquirable subsequently, although they were needed.

One of the key information we found out is, that common ECTS points do not affect our amount of needed virtual instances which reduced complexity of our formula.

Fig. 4 gives an overview of technical ECTS points during six semesters compared with the needed virtual machines in that time period.

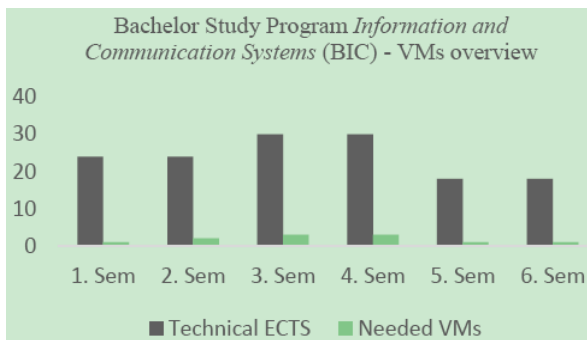


Fig. 4. Overview ECTS and needed VMs.

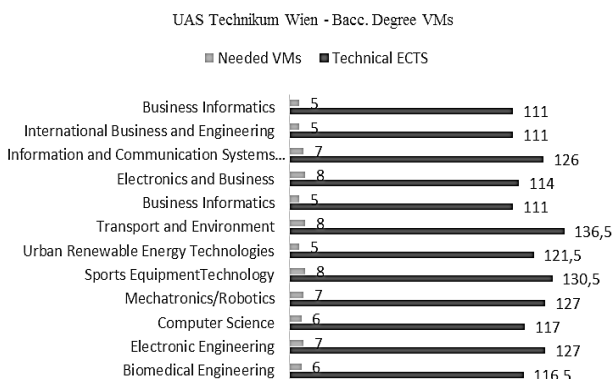


Fig. 5. Statistics Bacc. degree UAS Technikum Wien needed VMs.

With our experience from BIC we started to extrapolate our findings onto other departments of our university. In Fig. 5 an overview of the complete bachelor degree program of the University of Applied Sciences Technikum Wien is presented. The chart concerns full time and part time study programs with all their included courses.

Based on this information we calculated a value per department of the estimated needed virtual machines. Fig. 6 shows that 18.81 ECTS points correspond to one estimated virtual machine as average value for all bachelor programs.

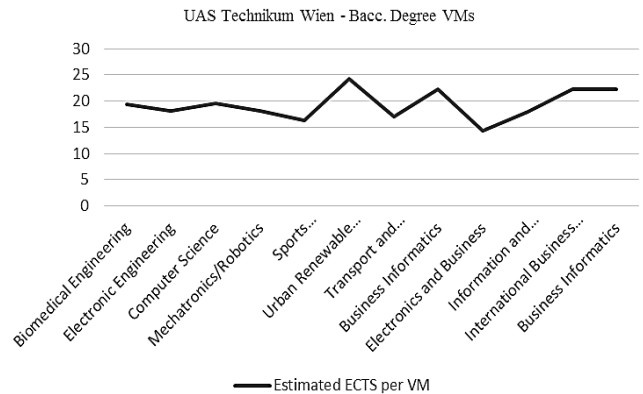


Fig. 6. Statistics Bacc. degree UAS Technikum Wien estimated VMs.

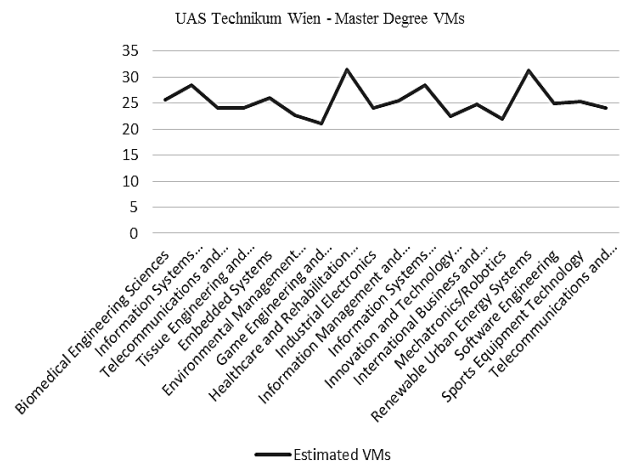


Fig. 7. Statistics master degree UAS Technikum Wien estimated VMs.

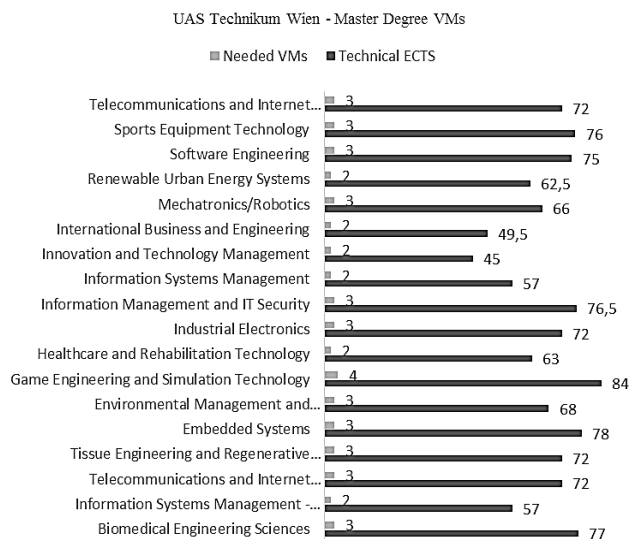


Fig. 8. Statistics master degree UAS Technikum Wien needed VMs.

For our general valid formula we decided to use the rounded up value of 20 as factor for technical bachelor ECTS

points. The same calculation was necessary for all master degree programs as shown in Fig. 7.

The calculation for the master degree program has been conducted equal to the bachelors'. As shown in Fig. 8 the average value of ECTS points per virtual machine is 24.94. For our formula we use the value of 25 as factor for technical master ECTS points.

E. Credit System Formula

With this gathered data we can point out a common valid formula as following:

- On a bachelor's degree program the estimated value of virtual machines is one per 20 technically ECTS points.
 - On a master's degree program the estimated value of virtual machines is one per 25 technically ECTS points.
- Moreover we regard following data:
- *dep* = single department of the University of Applied Science Technikum Wien
 - *eb* = technical ECTS points per bachelor department
 - *em* = technical ECTS points per master department
 - Max. Credits = estimated maximum value of credits for our system

$$\text{Value of VMs} = \sum_{dep=1}^{dep \text{ bachelor}} \frac{eb}{20} + \sum_{dep=1}^{dep \text{ master}} \frac{em}{25}$$

$$\text{Max. Credits} = \text{Value of VMs} \times 9$$

F. Calculation Example

Based on the formula we can calculate our estimated value of needed virtual resources. With this value we can define the maximum amount of credits available within the University of Applied Sciences Technikum Wien.

$$\text{Value of VMs} = \sum_{dep=1}^{dep \text{ bachelor}} \frac{1449}{20} + \sum_{dep=1}^{dep \text{ master}} \frac{1222}{25}$$

$$\text{Value of VMs} = \frac{1449}{20} + \frac{1222}{25}$$

$$\text{Value of VMs} = 122$$

$$\text{Credits} = \text{Value of VMs} \times 9$$

$$\text{Credits} = 1098$$

The evaluated numbers can be used as basis for designing a cloud infrastructure for educational purposes and segment the provided resources among departments and related courses. Through relation of technical ECTS points and cloud service needs, a fair allocation of resources can be provided.

IV. CONCLUSION

As you have seen in this paper we found a common general and valid formula to calculate an estimated value of virtual machines in an educational environment. With our formula virtual infrastructures can be easily planned and a detailed forecast of the needed hardware and the maximum available credits for such systems is possible.

The two key features are the right sizing of hypervisors for an optimal efficiency of the system, and an exact value of maximum credits to fit onto this hardware hypervisors. Next step is to validate our formula and our extrapolation with a proof of concept as a project within the University of Applied Science Technikum Wien.

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