



**HAL**  
open science

## A metric for resource usage evaluation in cloud computing environments

Tiago da Silva Nascimento, Emanuel Coutinho, Carla Ilane Bezerra, José Neuman de Souza

► **To cite this version:**

Tiago da Silva Nascimento, Emanuel Coutinho, Carla Ilane Bezerra, José Neuman de Souza. A metric for resource usage evaluation in cloud computing environments. 7th International Workshop on ADVANCEs in ICT Infrastructures and Services (ADVANCE 2019), Prof. Claudino Mendes, Jan 2019, Praia, Cape Verde. pp.1–8. hal-02442477

**HAL Id: hal-02442477**

**<https://hal.science/hal-02442477>**

Submitted on 16 Jan 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## Communication Technologies integration into the Electrical System of the city of Praia

Tiago da Silva Nascimento, Emanuel Coutinho, Carla Bezerra, José Neuman  
de Souza

► **To cite this version:**

Tiago da Silva Nascimento, Emanuel Coutinho, Carla Bezerra, José Neuman de Souza. Communication Technologies integration into the Electrical System of the city of Praia. 7th International Workshop on ADVANCEs in ICT Infrastructures and Services (ADVANCE 2019), Prof. Claudino Mendes, Jan 2019, Praia, Cape Verde. pp.1–8. hal-02442477

**HAL Id: hal-02442477**

**<https://hal.archives-ouvertes.fr/hal-02442477>**

Submitted on 16 Jan 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# A Metric for Resource Usage Evaluation in Cloud Computing Environments

Tiago da Silva Nascimento<sup>2</sup>, Emanuel Coutinho<sup>1,3,5</sup>, Carla Ilane Bezerra<sup>3,5</sup>, and José Neuman de Souza<sup>4,5</sup>

<sup>1</sup> IBITURUNA – Research Group of Cloud Computing and Systems

<sup>2</sup> Federal University of Bahia, Salvador (UFBA), Bahia, Brazil

<sup>3</sup> Campus Quixadá – Federal University of Ceará (UFC) – Quixadá, Brazil

<sup>4</sup> Master and Doctorate in Computer Science (MDCC)

<sup>5</sup> Federal University of Ceará (UFC) – Fortaleza – Ceará – Brazil

tiagodasnascimento@gmail.com, emanuel@virtual.ufc.br, carlailane@ufc.br, neuman@ufc.br

## Abstract

Cloud Computing (CC) has become a subject of considerable research in the scientific and industrial communities, as well as other technologies. Although there are several studies and recent developments stating CC is still in the process of evolution and increasingly new technologies are emerging that can be added to it, such as Software Defined Networks (SDN) and Network Functions Virtualization (NFV). The quality evaluation of these technologies tends to become increasingly important, and this directly impacts the users. Due to the emergence of CC, SDN and NFV technologies, and the fact that they are highly related, it was necessary to evaluate the quality of these environments in an integrated way. This work proposes a metric for the quality evaluation of integrated environments.

## 1 Introduction

Over the years, Cloud Computing (CC) has become a subject of considerable research in the scientific and industrial communities, as it represents a new era for the availability and use of Information Technology services through the Internet [15]. The cloud computing paradigm is based on a usage-based payment model, and suggests the integration of various technology models to provide hardware infrastructure, development platforms, and applications such as on-demand services [7].

Although there are several studies and recent developments, CC is still in the process of evolution and increasingly new technologies are emerging that can be added to it [1]. This is the case of Software Defined Networks and Network Functions Virtualization.

Software Defined Networking (SDN) represents a paradigm that promises to change the state of traditional IP (Internet Protocol) networks, which are considered complex and difficult to manage, because they have the control plane and the data plane grouped into the network devices. SDN breaks vertical integration with the separation of these planes (control and data). In this way, the control functionality is removed from devices, which become simple packet forwarding elements [11].

Network Functions Virtualization (NFV) emerged as a solution to the challenges faced by telecom service providers, as it leads to virtualization technology to provide a new way to design, deploy, and manage network services [2]. NFV disassociates the Network Functions of the physical equipment where they are executed, which can lead to significant reductions in operating expenses (OPEX) and capital Expenses (CAPEX), in addition to promoting greater return and agility in the implementation of new services [13].

Cloud computing network infrastructure is shared with a number of independent entities. Therefore, network management is a challenge. In this context, SDN has highly valuable features for cloud computing systems, and also plays an important role in NFV technology infrastructure by making networks more flexible, dynamic and cost-effective, while simplifying the operational complexities [2].

With the great use of Information and Communication Technologies at all levels of human activity, the evaluation of the quality of these technologies tends to become increasingly important [8]. Thus, due to the emergence of CC, SDN and NFV technologies, and the fact that they are highly related, it was necessary to evaluate the quality of these environments in an integrated way. A quality evaluation can be performed by measuring the quality attributes of the technology in question [10].

In this context of cloud quality assessment, this work proposes a metric for the evaluation of the quality of integrated Cloud Computing, Network Defined by Software and Network Function Virtualization environments, with the main target audience being the researchers areas.

This work is still in progress, and therefore the experiments only used the environment of a computational hybrid cloud. This paper presents an initial idea of a metric to analyze the quality of the environment. It is also a way of knowing the used tool, to analyze its flexibility in the inclusion of new metrics. However, the environment did not use SDN or NFV resources, remaining for future work and application of the tool in these environments.

## 2 Related Work

[12] presented a proposal for a comprehensive quality model for assessing the quality of Software as a Service (SaaS) cloud services. Based on ISO/IEC 9126 [9], these authors identified characteristics, quality attributes and defined metrics to measure the quality of these attributes. This work does not make any practical application in a real environment of defined metrics and its quality assessment model is directed to a specific model of cloud computing (SaaS).

[16] proposed a quality model for cloud services called CLOUDQUAL, which specifies six quality assessment metrics that serve cloud services in general. In this work, the authors designed a case study involving three real-world storage clouds: Amazon S3, Microsoft Windows Azure Blob Storage (Azure Blob) and Aliyun Open Storage Service (Aliyun OSS). By the use of experimental results, the effectiveness of CLOUDQUAL was analyzed and its use for evaluating the quality of cloud services is feasible.

[14] performed a systematic mapping on the current state of the art of the proposed Web service quality models, using ISO/IEC 25010 [10] for articulation of the analysis. This work presented characteristics and attributes of quality, with the definitions most used in Web service quality models for these dimensions.

[5] proposed same metrics for elasticity evaluation in cloud environments, based on concepts from Physics and Microeconomics. This metrics could be used in some future work in SDN and NFV environments for evaluating the elasticity effects under different workloads.

The idea of these works was to discuss quality assessment for cloud computing environments, as well as aspects, characteristics and quality attributes. This is one of the ideas of our work.

### 3 Description of the Hybrid Cloud Environment

#### 3.1 Testbed

The experiments used two different cloud computing environments: a private cloud and a public cloud. For the private cloud we used OpenNebula 3.8. All physical machines had 5 or 7 cores, 24 GB RAM, Linux Ubuntu Server 12.04 64-bit operating system and KVM hypervisor. Each virtual machine was created with 1 VCPU, 1 GB of RAM and Linux operating system Ubuntu Server 12.04 64 bit. For the public cloud, the Microsoft Azure platform was used, with instances created with standard type A1 (1 core and 1.75 GB of RAM) and Linux operating system Ubuntu Server 14.04 64 bit.

The experiments used a maximum of four virtual machines, varying the number of instances used in the private and public cloud, according to the design of the experiment. Apache Tomcat was used as web server, NGINX as load balancer and HTTPPERF as workload generator. Figure 1 displays the used testbed, based on the architecture proposed in [4].

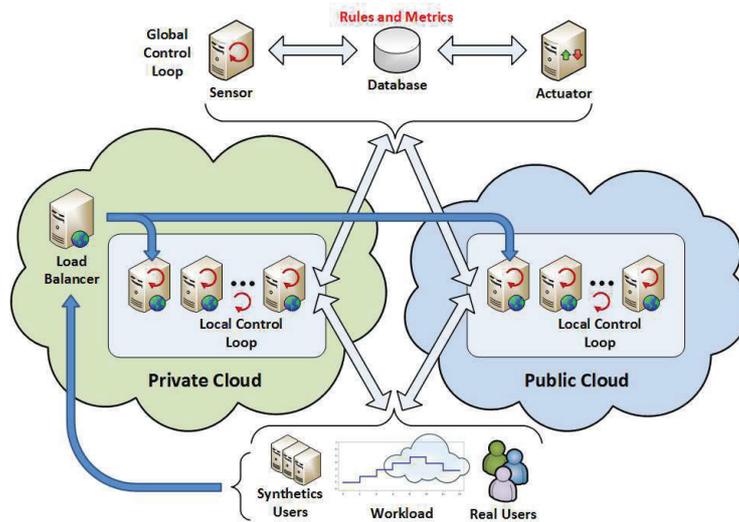


Figure 1: Autonomic architecture for elasticity in cloud computing using private and public clouds [4]

#### 3.2 Workload

The workloads generated for the experiments were given by: requests forwarded directly to the load balancer virtual machine, generated by HTTPPERF (with load of a multiplication of matrices) and by web browsers, distributed among the others virtual machines allocated; and requests executed directly on the virtual machines used by the infrastructure. Thus, competition for resources in a CC environment can be emulated [4]. Figure 2 represents the applied workload.

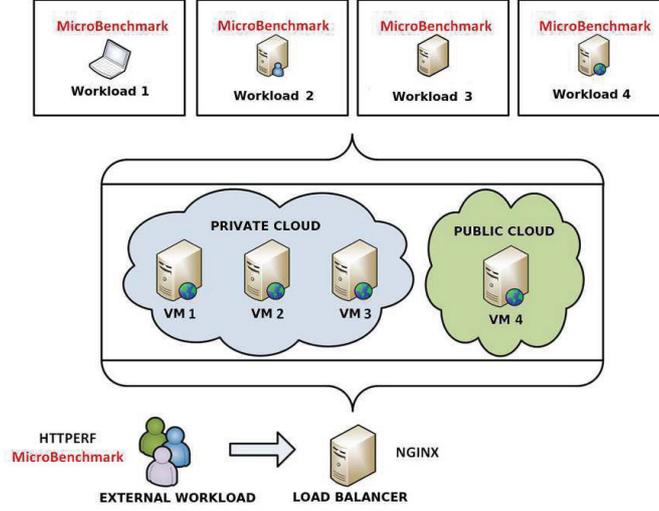


Figure 2: Workload applied to the infrastructure [6]

### 3.3 Metrics Analysis Support Tool

To assist in the visualization and analysis of the collected data, a tool was used that allows the generation of graphs for the various metrics collected from the environment resources [3] (Figure 3). This application was developed with Java programming language. It is based on the reading of text files, which contains information collected from the environment, such as CPU and memory usage, as well as application data such as response time for requests. The log files have their own structure read by the application. Examples of log files are: virtual machine allocation and average CPU consumption. These files are illustrated in Table 1 and Figure 4

File	Structure
Virtual Machine Allocation	Date of collection; Maintain (m), Increase (a) or Decrease (d); Number of allocated virtual machines
Average CPU consumption	Date of collection; Average percentage of CPU value in all virtual machines

Table 1: Structure of the log files

### 3.4 Application of Metrics

For experiments performing, a metric of resource utilization was used. In addition to the resource utilization metric, the average CPU usage metric was used to aid in the evaluation of resource utilization. The following formula was used for the resource utilization metric:

$$R_u = \frac{R_a}{R_p} \quad (1)$$

Where  $R_u$ ,  $R_a$  and  $R_p$  are equivalent to the used resources, allocated resources, and pre-allocated resources, respectively. In our experiments, we used virtual machines as resources.

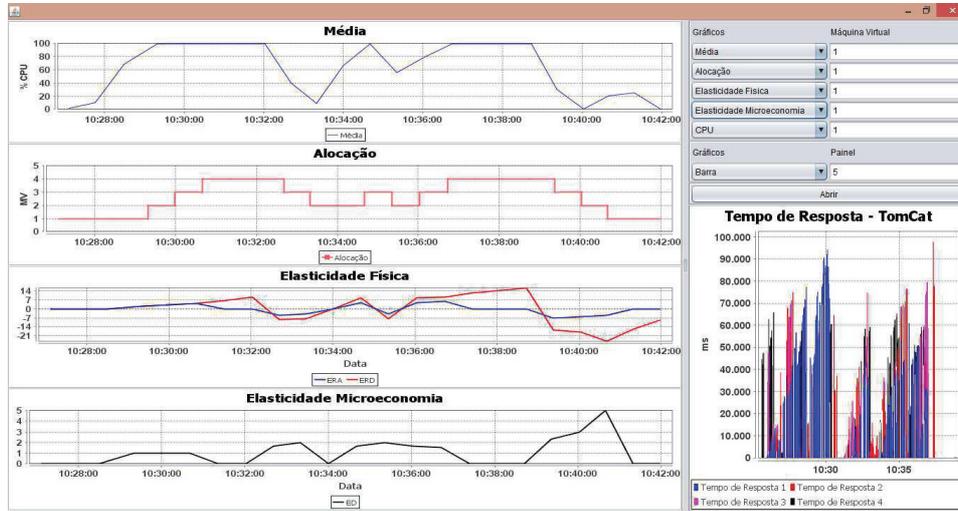


Figure 3: General screen of the application for metrics analysis [3]

2014-06-11 20:30:23,665	m	1	2014-06-11 20:30:23,651	39,9
2014-06-11 20:30:35,555	m	1	2014-06-11 20:30:35,543	59,8
2014-06-11 20:30:47,444	a	2	2014-06-11 20:30:47,430	89,7
2014-06-11 20:31:07,090	a	3	2014-06-11 20:31:07,078	99,7
2014-06-11 20:31:19,486	a	4	2014-06-11 20:31:19,478	95,3
2014-06-11 20:31:31,977	m	4	2014-06-11 20:31:31,963	66,8
2014-06-11 20:31:44,381	d	3	2014-06-11 20:31:44,366	57,7
2014-06-11 20:31:56,819	a	4	2014-06-11 20:31:56,804	71,4
2014-06-11 20:32:09,178	m	4	2014-06-11 20:32:09,166	97,5
2014-06-11 20:32:21,533	m	4	2014-06-11 20:32:21,518	99,3

Figure 4: Excerpts from the log files for virtual machines allocation and average CPU utilization

The implementation of the resource utilization metric was basically due to the relationship of resource utilization data with the total sampling time. The CPU Average metric shows an average CPU utilization of the hybrid system completely. This metric was already implemented in the tool, as previously mentioned. In the same way, as the allocation of virtual machines.

## 4 Experiments

For the metrics application, we used the database of the experiments described in the following subsections (4.1 e 4.2), available in [6].

### 4.1 Experiment 1 - One Virtual Machine in the Private Cloud and One Virtual Machine in the Public Cloud

This experiment lasted 36min10s. Only two virtual machines were involved in this experiment: one in the private cloud and one in the public cloud. In this way, it was possible to verify if the designed infrastructure would provide resources of the two clouds, constituting a hybrid cloud, according to the necessity generated by the workload.

Figure 5 shows the graphs generated from the application of the Resource Utilization and CPU Average metrics, with the allocation of the virtual machines for complementary analysis.

From the analysis of the graph illustrated by Figure 5, it can be seen that the CPU utilization average varied between practically all points of the ordinate axis (% CPU), reaching points of use of 100%. From this information, it can be seen that many requests were occurring and there were few virtual machines to meet these requests. Relating the CPU Average graph to the Resource Usage chart, it can be noted that when the CPU reaches an average usage of approximately 80% the load balancer starts to allocate more resources, in which case it allocates another machine in the public cloud to aid in the processing of excess load.

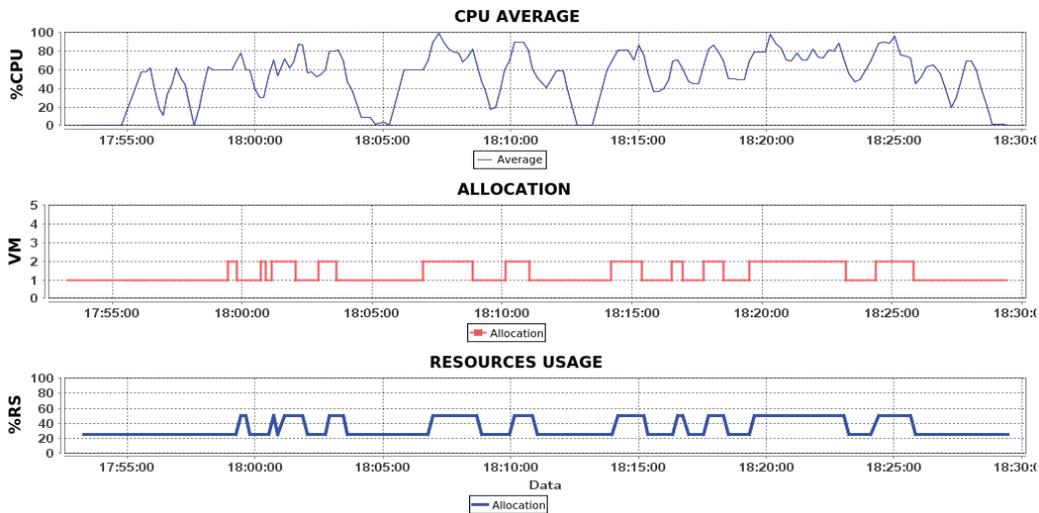


Figure 5: Experiment 1: One virtual machine in the private cloud and one virtual machine in the public cloud. CPU Average Usage, Virtual Machine Allocation and Resource Utilization graphics

## 4.2 Experiment 2 - Three Virtual Machines in the Private Cloud and One Virtual Machine in the Public Cloud

This experiment lasted 11min14s. Four virtual machines were involved in this experiment: three in the private cloud and one in the public cloud. Thus, it was possible to verify if the infrastructure performance would be impacted by the addition of a virtual machine from a public cloud, and whether the SLA (Service Level Agreement) would be maintained.

Figure 6 displays the graphs generated from the Resource Utilization and Average CPU metrics application. It also presents the allocation of virtual machines for further analysis.

From the analysis of the graph illustrated by Figure 6, it can be seen that the average CPU utilization in this experiment remained more constant than that of the previous experiment. This is due to the fact that there were more resources, that is, more virtual machines for the distribution of workloads. By relating the CPU Average graph to the Resource Utilization graph, it can be noted that when the CPU reaches an average usage of approximately 80% the load balancer starts to allocate more resources. When the CPU Utilization Average reaches

100%, all resources are allocated to assist in processing the excess load, which includes the allocation of the public cloud machine.

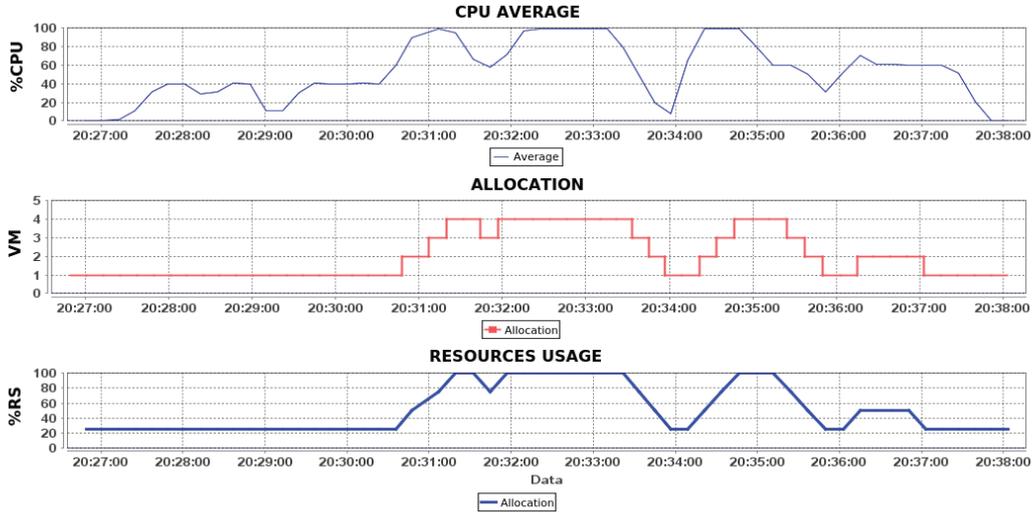


Figure 6: Experiment 2: Three virtual machine in the private cloud and one virtual machine in the public cloud. CPU Average Usage, Virtual Machine Allocation and Resource Utilization graphics

## 5 Final Remarks

Managing resource utilization in CC environments is an essential task. With the emergence of new technologies such as SDN and NFV, and their integrations with CC, this management becomes even more important. Therefore, the need for metrics that assess the quality of service of such environments is real. In the two presented experiments, the Resource Utilization metric shown results that match what was expected of the resource utilization of the analyzed environment. With the aid of the Average CPU metric it was possible to note that whenever the clouds were overloaded, more resources were allocated (virtual machines), which were available in the environment and the resources were being deallocated according to the load reduction.

In an integrated CC, SDN, and NFV environment, there is likely to be a need for resource allocation and deallocation (scaling up and scaling down)). However, the Resource Utilization metric would identify this allocation, but could have different behavior than it did in the experiments performed on the testing environment. This is future work to be planned and executed. Other intended future work is to design new metrics for quality evaluation for integrated environments, and to perform new experiments. Also, to use and scaling containers instead only virtual machines.

## 6 Acknowledgments

This work was partially supported by Universal MCTI/CNPq 01/2016 program (process 422342/2016-5).

## References

- [1] Siamak Azodolmolky, Philipp Wieder, and Ramin Yahyapour. Sdn-based cloud computing networking. In *Transparent Optical Networks (ICTON), 2013 15th International Conference on*, pages 1–4. IEEE, 2013.
- [2] Laxmana Rao Battula. Network security function virtualization (nsfv) towards cloud computing with nfv over openflow infrastructure: Challenges and novel approaches. In *Advances in Computing, Communications and Informatics (ICACCI), 2014 International Conference on*, pages 1622–1628. IEEE, 2014.
- [3] Emanuel Coutinho, Danielo G. Gomes, and Jos De Souza. A tool for resource monitoring in computational clouds. In *8th Latin American Network Operations and Management Symposium (LANOMS 2015) - Application Session*, Joo Pessoa, Brasil, oct 2015.
- [4] Emanuel F. Coutinho, Paulo A. L. Rego, Danielo G. Gomes, and José Neuman de Souza. An architecture for providing elasticity based on autonomic computing concepts. In *Proceedings of the 31st Annual ACM Symposium on Applied Computing, SAC '16*, pages 412–419, New York, NY, USA, 2016. ACM.
- [5] Emanuel F. Coutinho, Paulo A. L. Rego, Danielo G. Gomes, and Jos N. de Souza. Physics and microeconomics-based metrics for evaluating cloud computing elasticity. *Journal of Network and Computer Applications*, 63:159 – 172, 2016.
- [6] Emanuel Ferreira Coutinho. *FOLE: Um Framework Conceitual para Avaliao de Desempenho da Elasticidade em Ambientes de Computação em Nuvem*. Doutorado, Mestrado e Doutorado em Ciência da Computação (MDCC), Universidade Federal do Ceará (UFC), Fortaleza, 2014.
- [7] Emanuel Ferreira Coutinho, Flávio Rubens de Carvalho Sousa, Paulo Antonio Leal Rego, Danielo Gonçalves Gomes, and José Neuman de Souza. Elasticity in cloud computing: a survey. *annals of telecommunications-Annales des télécommunications*, 70(7-8):289–309, 2015.
- [8] Nelma da Silva GOMES. **Qualidade de Software—uma necessidade**. *Especialista em Sistemas de Informação, com Pós-Graduação em Gestão Estratégica da Informação e Consultora da UCP/PNAFM/MF.*, 5, 2008.
- [9] ISO/IEC. *ISO/IEC 9126-1*, volume 1. ISO/IEC, 2001.
- [10] ISO/IEC. *Iso/iec 25010: Systems and software engineering—systems and software quality requirements and evaluation (square)—system and software quality models*. *International Organization for Standardization*, 34, 2011.
- [11] Diego Kreutz, Fernando MV Ramos, Paulo Esteves Verissimo, Christian Esteve Rothenberg, Siamak Azodolmolky, and Steve Uhlig. Software-defined networking: A comprehensive survey. *Proceedings of the IEEE*, 103(1):14–76, 2015.
- [12] Jae Yoo Lee, Jung Woo Lee, Soo Dong Kim, et al. A quality model for evaluating software-as-a-service in cloud computing. In *Software Engineering Research, Management and Applications, 2009. SERA '09. 7th ACIS International Conference on*, pages 261–266. IEEE, 2009.
- [13] Rashid Mijumbi, Joan Serrat, Juan-Luis Gorricho, Niels Bouten, Filip De Turck, and Raouf Boutaba. Network function virtualization: State-of-the-art and research challenges. *IEEE Communications Surveys & Tutorials*, 18(1):236–262, 2016.
- [14] Marc Oriol, Jordi Marco, and Xavier Franch. Quality models for web services: A systematic mapping. *Information and software technology*, 56(10):1167–1182, 2014.
- [15] Balinder Singh. A systematic review on cloud computing. *International Journal of Engineering*, 2(2), 2013.
- [16] Xianrong Zheng, Patrick Martin, Kathryn Brohman, and Li Da Xu. Cloudqual: a quality model for cloud services. *IEEE transactions on industrial informatics*, 10(2):1527–1536, 2014.