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TESTING OF A DATA CENTER ENVIRONMENT WITH A GENERIC MODEL OF A CLOUD-BASED TELECOMMUNICATION SERVICE

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Summary
The following article describes the issue of a Data Center environment testing with use of a generic model of a cloud-based telecommunication service. The Authors present a process of creation and selection of unique system properties, in order to design the generic model of a cloud-based telecommunication service. Layered structure of the presented model depicts complexity of resulting testing procedures. Definition of a genuine polynomial state equation of a cloud service, as well as a generic architecture of the cloud service testing environment are therein discussed.

Keywords: Data Center, cloud computing, benchmarking, generic model of a service

TESTOWANIE ŚRODOWISKA CENTRUM DANYCH
GENERYCZNYM MODELEM USŁUGI TELEKOMUNIKACYJNEJ

Streszczenie
Artykuł przedstawia problematykę testowania środowiska typu Data Center z użyciem generycznego modelu usługi telekomunikacyjnej opartej na rozwiązaniach chmury obliczeniowej. Autorska propozycja modelu została uzyskana w procesie tworzenia oraz selekcji parametrów opisujących unikalne właściwości usługi telekomunikacyjnej wdrożonej na środowisku z rodzaju Centrum Danych. Warstwowa struktura proponowanego modelu przedstawia złożoność wynikowych procedur testowych. Zdefiniowano autorską metodę w postaci *wielomianowego równania stanu* usługi opartej na chmurze obliczeniowej. Jako rozwinięcie rozważań utworzono propozycje architektury środowiska testowego.

Słowa kluczowe: Centrum Danych, chmura obliczeniowa, testowanie, model generyczny usługi

1. INTRODUCTION

In the contemporary systems deploying telecommunication services the core element of the mechanism is a Data Center unit. Since every modern telecommunication product utilizes multilayered structure of a service, identification and definition of the intrinsic components contributing to the generic model of a service is of the upmost importance. Analyzing concepts presented in [1,2] positioning of categorized attributes of the Cloud-based telecommunication service is achieved (depicted amongst Table 1.). Specified abstraction layers contribute to the overall quality model and thus incorporate appropriate performance parameters, given for the specific abstraction domain: from the hardware-related factors [3-5] to the service layer parameters [6-8]. Grouped sections of the juxtaposition in Table 1. reflect complexity of the resulting quality model, as well as the generic architectural layout for testing purposes [9-11]. Depending on applicability of the estimated testing procedures, an unique model of a service shall be delivered. In the cloud-based telco services there is a strong shift towards X-as-a-Service models (where X may be defined as: Infrastructure, Platform, Software, Testing, etc.), hence the scope of the work over the generic form of a resiliency metric has to deliver factorized set of performance parameters, cloud capabilities and productivity aspects.

2. UNIVERSAL STATE EQUATION

Realizing assumed path for evaluation of generic models, propositions based on aforementioned factors are herein stated. The generic approach to the evaluation of quality (and as a result resiliency features) of the deployed service is presented in a form of an Universal State Equation (*UnStEq*) and its contribution to the generic model of a Cloud Service Quality and Resiliency Evaluation (*C-SQuaRE*, C^2).

Table 1. Cloud Service metrics within inherent abstraction layers

Abstraction Level	Performance Metric	Notation	Description
Basic Performance Metrics	*Execution Time*	*T*	Time elapsed during program or job execution, (sec., hours).
	Speed	*S*	Number of operations executed per second, (PFlops, etc.).
	Speedup	S_u	Speed gain of using more processing nodes over a single node.
	Efficiency	*E*	Percentage of max. speedup or utilization achievable (%).
	Scalability	*S*	The ability to scale up resources for gain in system performance.
	Elasticity	E_l	Dynamic interval of auto-scaling resources against workload
Cloud Capabilities	*Latency*	*D*	Delay from job submission to receiving the first response (sec.).
	Throughput	*H*	Average number of jobs/tasks/operations per unit time (PFlops).
	Bandwidth	*B*	Data transfer rate or I/O processing speed, (MB/s, Gbps).
	Storage Capacity	S_c	Storage capacity with virtual disks to serve many user groups.
	Software Tooling	S_w	Software portability, API and SDK tools for developing cloud apps.
	Bigdata Analytics	A_n	The ability to uncover hidden information and predict the future.
	Recoverability	R_c	Recovery rate from failure or disaster (%).
Cloud Productivity	*QoS of Cloud*	*QoS*	The satisfaction rate of a cloud service or benchmark testing (%).
	Power Demand	*W*	Power consumption of a cloud computing system (MWatt).
	Service Cost	*C*	The price per cloud service (processing, etc.) provided, ($/hour).
	SLA/Security	*L*	Compliance of SLA, security, privacy or copyright regulations.
	Availability	*A*	Percentage of time the system is up to deliver useful work (%).
	Productivity	*P*	Cloud service performance per unit cost (TFlops/$, etc.).

In the following section detailed definition of proposed *UnStEq* equation of the Cloud Service Quality and Resiliency Evaluation module is stated. The general form of the *UnStEq* is given by:

$$poly_{CS} = \sum_{i=1}^{n} c_i x_i \qquad (1)$$

Cloud Service Acceptance Parameter (CSAP; i.e. numerical value presenting acceptable level of the quality of the tested service) is stated by:

$$p_{CS} = v_{CSAP} \qquad (2)$$

where *v* is an empirical, measurable quantity representing CSAP of a specific service deployed in a cloud-based environment. The State Equation allows to determine if the quality of service (with respect to the analyzed performance metric) in a certain time moment is kept, and is described by:

$$p_{CS} \le \max(v) - poly_{CS} \qquad (3)$$

Supporting coefficients in equations (1) - (3) are:

$$n = \{1..19\}; c_i = \{0..1\}; x_i = \{T..P\} \qquad (4)$$

Next, it is important to build a set of empirical functions determining behavior of a performance metric and the impact on the relevant quality metric value (as is given in Fig. 1), for instance:

$$Speed \rightarrow i = 2; x_2 = S; f(Speed) \sim Sv \quad (5)$$

Where *f(Speed)* represents the empirical behavior of a *CSAP* plot and *Sv* corresponds to a value of an acceptable quality level influenced by *Speed*.

Concerning *UnStEq*, a *polynomial state equation*, it is composed of modules defining the importance of selected performance metric in a face of quality assessment of the analyzed telecommunication service. Appropriate weighing of coefficients (c_i) is performed in accordance to the empirically assessed plot of a genuine Cloud Service Acceptance Parameter (*CSAP*). Fig. 1. presents an exemplary plot of the proposed factor.

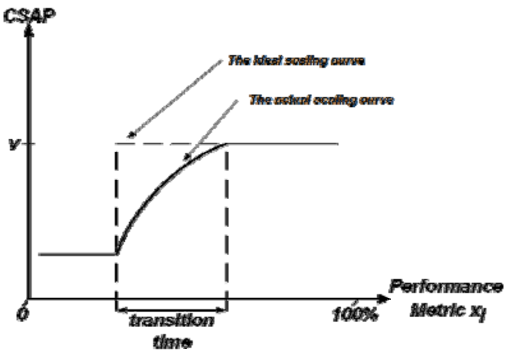

Fig. 1. CSAP factor of a selected performance metric

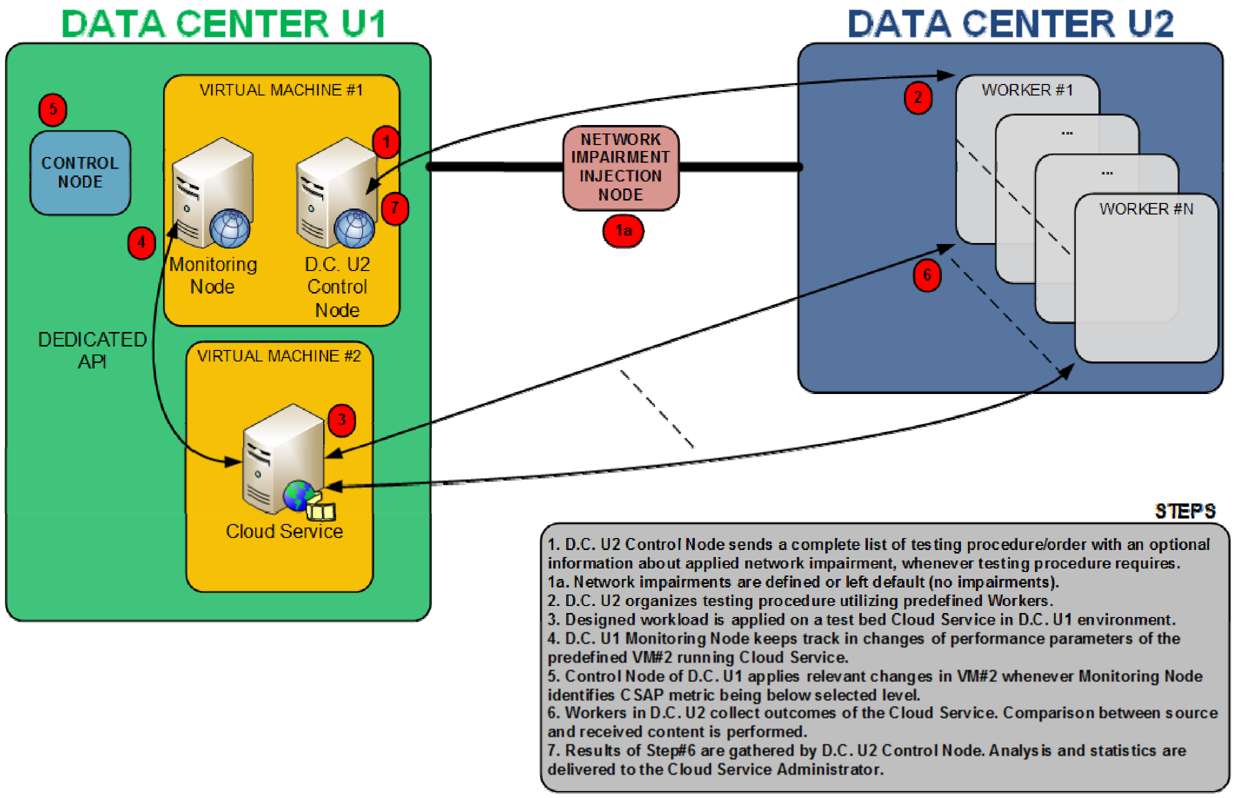

Fig. 2. Generic architecture of C-SQuaRE environment

Table 2. Boundary conditions of Performance Metrics for a video streaming application

Performance Metric	Notation	Video Streaming
Execution Time	T	<1.2 s. per user
Speed	S	800 MHz per stream
Speedup	S_u	YES
Efficiency	E	>10%
Scalability	S	YES
Elasticity	E_l	<2 ms. per user
Latency	D	<1.2 s. per user
Throughput	H	stream specific
Bandwidth	B	>10Mbps per stream
Storage Capacity	S_c	>20GB
Software Tooling	S_w	YES
Bigdata Analytics	A_n	YES
Recoverability	R_c	stream specific
QoS of Cloud	QoS	$v_{CSAP} \geq 40dB(PSNR)$
Power Demand	W	stream specific
Service Cost	C	stream specific
SLA/Security	L	stream specific
Availability	A	stream specific
Productivity	P	stream specific

3. GENERIC CLOUD SERVICE TESTING ENVIRONMENT

Basing on the delivered list of Cloud Service metrics (especially performance-related), approach towards generic model of a service, as well as generic model of testing architecture is presented. Depicted on the scheme on Fig. 2. is the compound layout for C-SQuaRE environment. The Cloud Service test-bed consists of two sub-domains, deployed over separate Data Center units (U1 and U2). Presented recommendation requires creation of the following functional entities in the U1 domain: Virtual Machines supporting Cloud Service realization and control functions over U2 unit; monitoring node of Cloud Service entity and global Control Node of the Data Center. Furthermore, systemic definition of the U2 domain implies creation of a set of heterogeneous workers in order to simulate the desired behavior of the deployed Cloud Service utilization. As an optional node, the proposed model offers implementation of a Network Impairment Injection unit, hence it enables introduction of network characteristic within the designed testing procedure.

What is more, a proposition concerning testing procedures in the deployed test-bed environment is presented as well. Delivered set of seven procedural steps (describing relations between aforementioned entities) reveals testing insights and moments of the generic benchmarking campaign that create a deterministic basis for temporal changes analysis.

Therefore, quality assessment and resiliency features evaluation within the proposed generic model of a Cloud Service may be achieved. As a result, data presented amongst Table 2. defines boundary conditions for the identified performance parameters with respect to the deployed service. In the considered test case a video streaming application was empirically analyzed. Having stated vital values of performance, cloud capability and productivity metrics, one can perceive a reliable frame of reference for efficient comparison of the cloud-based telecommunication services with respect to the achievable levels of the overall Quality of Service (QoS).

4. SUMMARY

Presented propositions define analysis tools, universal model of an environment and testing procedures for an evaluation of a generic model of telecommunication service deployed in a cloud-based domain. Both concepts for the *UnStEq* and *C-SQuaRE* definitions are based upon the layered model of a service's performance metrics, thus reflect appropriate solution for evaluation of the quality and resiliency amongst telecommunication services.

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Prof. **Mirosław SIERGIEJCZYK**, PhD. Eng. - scientific fields of interest of the paper coauthor concern among other issues of architecture and services provided by telecommunications networks and systems, especially from perspective of their applications in transport, reliability and operation of telecommunications networks and systems, modeling, designing and organizing telecommunications systems for transport.