

On the viability of a CSO Architecture for on-demand virtualized Cloud Planning and Provisioning

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Abstract— As bandwidth requirements and computing capacity for future applications have been predicted to exceed current network and IT infrastructure capabilities, providers face the need to adapt their provisioning models. This article presents the benefits of Cross Stratum Optimized architectures (provision of network and IT resources in a coordinated way) in support of Cloud-based applications. We also present the architecture’s potential impact and benefits for operators, based on MACTOR methodology. MACTOR results show the interactions among value-chain actors and identify their business convergences and divergences, revealing the architecture feasibility.

Keywords—component; Cloud, CSO, Network management, Resource virtualization, IT

I. INTRODUCTION

The recent evolution of Cloud-alike services entails a new service paradigm which needs to be accommodated in a cost-scalable way. Within the process, networks constitute the key to efficiently connect users to applications, so they are converging towards Cloud architectures based on Cross Stratum Optimization (CSO) strategies. The objective of CSO [1] is to optimize the resources usage and the service delivery by means of a coordinated provision between the two layers.

Enhanced Cloud computing services (IaaS, PaaS, SaaS...) involve dynamic location of service facilities and virtualization of hardware and software elements. This stresses the communication network and protocols of operators, who could therefore take advantage of CSO architectures, deploying “application-aware” networks that enhance their elasticity, responsiveness, resilience and Quality of Experience [2].

In this paper, we address the joint IT and network provisioning for end-to-end services, by means of a CSO architecture which relies on partitioning the physical resources to create logical infrastructures. Such creation facilitates the provision and increments the efficiency in the resources usage. To this end, we propose a layered CSO architecture based on innovative control entities, together with a practical use case illustrating the benefits that operators can obtain from CSO.

Finally, we evaluate the business viability of the CSO architecture by means of the MACTOR analysis [3]. This

reveals power sources, convergences and divergences, potential alliances and business recommendations, which validate the commercial impact of the proposed architecture.

The remaining sections are organized as follows. Section II describes the state of the art on CSO architectures. In Section III we present the proposed network architecture model. The use case is depicted in Section IV, and the MACTOR analysis is included in Section V. Section VI concludes the paper.

II. TOWARDS CSO: NETWORK AND IT CONVERGENCE

Cloud service providers on many occasions use their own network infrastructure to connect resources of their distributed datacenters (DC). These are typically over-provisioned, but still have limited capacity for the ever-increasing requirements [4].

In the literature, some alternatives have been presented that include per-layer optimization solutions, in which on-demand network services between predetermined Cloud infrastructures are provided. For example, the architecture proposed in NIST [5] is suitable when network performance is not critical and in assumption that connectivity is provided as ubiquitous Internet connectivity. Thus, this alternative presents serious limitations, as some applications present strict network requirements. Another limitation is that it cannot be easily integrated with multi-domain network scenarios, very common in operators.

The integrated control plane has also been suggested, for example, for grid applications. PHOSPHORUS project worked on a control plane for the coordinated provision of network and grid resources, but resulted in an explosion of control messages. Other approaches, on the other hand, lack support of important Cloud-related features, like anycast provision.

The last component is physical resources virtualization, presented in projects like NOVI, 4WARD or RESERVOIR as the mechanism to efficiently manage physical resources.

In the context of GEYSERS project, we have modeled, implemented and deployed a CSO proposal covering the coordination of optical network and IT resources, controlling and managing the connectivity between end points. This integration definitely entails new technical innovations and business opportunities, based on the latest technical advances

in network virtualization, physical resource partitioning and control plane architectures. GEYSERS proposal has already been demonstrated at events like FNMS 2012 [6].

III. ARCHITECTURE TECHNICAL SOLUTION

GEYSERS architecture performs CSO by providing joint optimization on different layers with different roles. These layers are coordinated for the allocation, provision and management of virtual infrastructures that offer specific on-demand connectivity services to applications.

The GEYSERS stack (Fig. 1) is composed of four layers. First, devices in the Physical Infrastructure (PI) layer are abstracted, and partitioned or grouped into virtual resources. These can be selected to form Virtual Infrastructures (VI) in the Logical Infrastructure Composition Layer (LICAL). Within each VI, controllers in the IT-aware Network Control Plane (NCP+) manage the virtual network resources. Finally, the Service Middleware Layer (SML) is responsible for translating the application requests and Service Level Agreements (SLA) into requests that trigger the procedures at the NCP+.

This stack leads to the adoption of different roles that value-chain actors can play in the CSO business model. The *PI Provider* is the economical owner of the physical resources. The *VI Provider* owns the administrative rights on these resources and is able to offer them as a service to *VI Operators*. Finally, these are able to configure and monitor the VI and to operate them through their own control plane, providing services to end-users.

The GEYSERS architecture is thus able to manage the physical resources owned by one or more providers, compose multiple VI and offer operators access to them. Then, operators are able to provide network optimized services to consumers. From operators' perspective, GEYSERS architecture provides economic benefits in terms of cost savings on the deployment of new services. For providers, revenue increases and costs sharing are enabled by the provisioning of virtual resources to multiple operators over a common physical infrastructure.

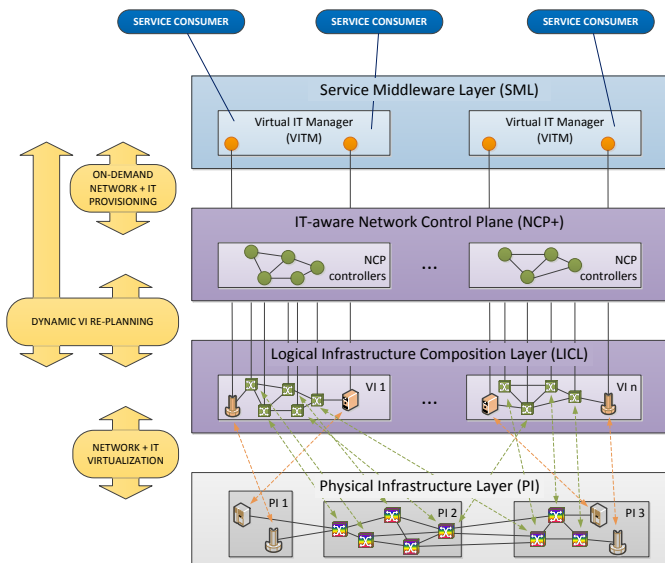


Figure 1. GEYSERS CSO architecture and related value chain roles

A. Novel functionalities description

1) The *SML* represents the top layer of the stack. It is responsible for service management, allowing providers to make requests for distributed applications and data inside VI. The architecture of the SML can be found in [5].

2) The enhanced *NCP+* [6], based on the extended Path Computation Element (PCE – [7]) and ASON/GMPLS protocols and architectures, operates over each VI and controls the virtual resources; it is also responsible for the path computation and the allocation of network and IT resources. More details on its building blocks can be found in [8].

3) The *LICAL*: at this layer the requested VI are provisioned on the PI, based on the joint planning and allocation of network and IT resources. It is itself organized in two sub-layers, the Upper-LICAL and several parallel Lower-LICALs. The Upper-LICAL spans different PI domains, federating their resources. Hence, it can use all of them to create distributed VIs which can be operated through a common layer, no matter the PI domain which hosts them. The Lower-LICAL is responsible for resource abstraction, resource publishing and virtual resources creation, management and operation. Further details on LICAL can be found in [9].

IV. CSO APPLICATION: A PRACTICAL USE CASE

This section presents one use case in which the proposed model permits the deployment of network services to satisfy the application requirements. The use case consists of a VI Operator which manages an already existing VI (virtualization procedures have been previously configured). The goal consists of providing the medical staff of a hospital with storage and processing resources for a certain telemedicine application.

Fig. 2 shows the use case flowchart. It starts when the user schedules an on-demand session (1) from the application layer, requiring data storage capabilities and computing facilities. The SML processes the request, selects the IT end-points (2) and maps the specification in a connectivity request that is forwarded towards the NCP+ (3). Then, the path is calculated over the virtual infrastructure by the NCP+ on the network side, and the IT resources are calculated by the SML (4). The joint IT and network reservation is acknowledged (5), and the SML triggers the deployment of the infrastructure as a service. Finally, it notifies the application layer that all is ready (6).

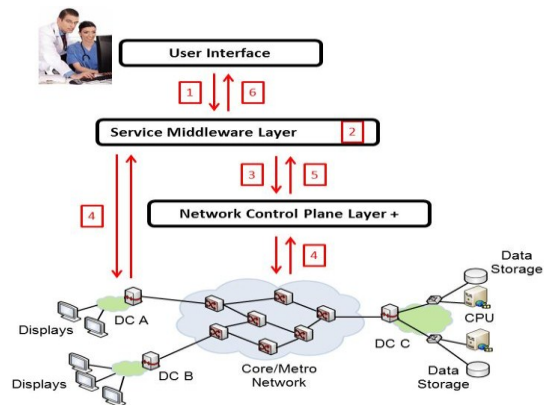


Figure 2. Use case flow-chart description.

As seen, operators provide the connectivity resources from the VI which they manage. This way, they are capable to provide with on-demand customized complex infrastructures while still experiencing savings, time-to-market reduction, efficient resources usage and higher availability and flexibility.

V. MACTOR ANALYSIS

The MACTOR analysis identifies (i) the influences and (ii) convergences & divergences which enable to detect potential alliances and business recommendations for the active actors involved in the CSO value-chain. For the analysis, 16 strategic actors (e.g. operators) and 33 objectives (e.g. maximize revenue) for these actors were identified.

A. Direct and Indirect influences

The identification of the direct and indirect influences that actors exert on one another permits to evaluate which ones are better positioned to lead the CSO market. Results are shown on Fig. 3. A high score on the active axis indicates high influence on other actors, while high scores on the passive axis imply a high degree of dependence from others.

Particularly interesting is the striking low influence of DC-related actors (equipment and software providers, and cloud auditors) and CPE vendors. The overall CSO market power of these actors is not strong. On the other hand, operators and regulators have a high impact on other actors. Reasons must be found on the fact that 1) operators own most of the required network infrastructure, so their decisions have a big influence, especially on service providers, and 2) regulators impact the whole ecosystem with their decisions.

B. Convergences and Divergences

Based on the influences and the position of all actors on the defined objectives, an overall map of convergences and divergences for each actor has been obtained. In this paper we show the individual results for telecommunication operators (Fig. 4), which show relevant divergences with most actors: their centric position in the CSO market entails a clash of interests while adopting certain market positions. However, convergences overcome them in most cases, so there are chances for telecoms to adopt strategic alliances. For instance, partnerships with vendors may be fundamental to enable CSO functionalities into operators' network nodes.

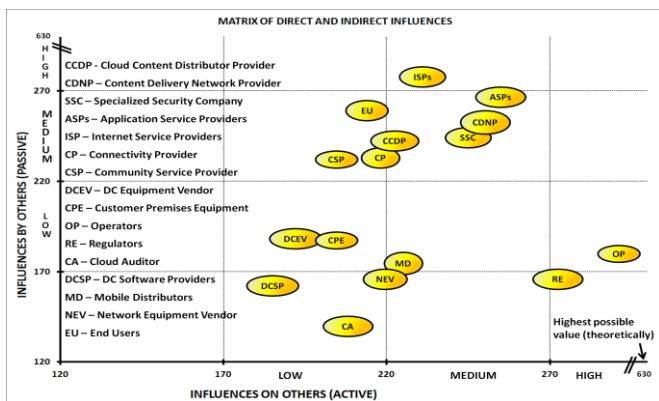


Figure 3. Matrix of direct and indirect influences among actors

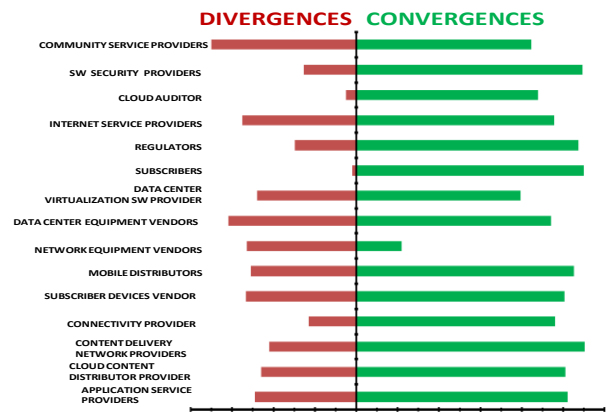


Figure 4. Convergences & divergences of operators for CSO architectures

VI. CONCLUSIONS

CSO architectures (joint planning and provisioning of network and IT resources) constitute the key for operators to deploy the increasing demand of Cloud services more cost-effectively, as CSO ensures a more efficient, flexible and reliable usage of the physical infrastructures. The MACTOR analysis shows operators as one of the most influent actors. Thus, they allying to turn divergences of strategic objectives into convergences may result fundamental to successfully drive the CSO market. Within FP7 GEYSERS project, a CSO architecture has been defined, implemented and demonstrated.

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