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Key Factors for the Adoption of Cloud Technologies by Telco Operators

Juan-Antonio Cáceres-Expósito, Juan-José Hierro-Sureda, Luis M. Vaquero-González, and Fernando de la Iglesia-Medina

Infrastructure and Platform as Service Clouds represent a major step in the evolution of hosting and the way services are published and consumed on the Internet. This paper analyzes the main aspects of the evolution of Clouds along three major development axes. The first axis has to do with the utility-like provision of ICT infrastructures. Here Clouds have still to evolve in order to achieve the desired level of abstraction as well as a convergent and flexible allocation of the computing, storage, networking and communication resources needed to comply with agreed SLAs. The second axis has to do with support from the marketplace and mashup, or hybrid, functions which will drive transformation of Clouds into true business ecosystems. The third axis address the gradual incorporation of built-in programming libraries that will ease development of applications deployed on the Cloud. This paper will also elaborate on existing technologies and the role standards and open source may play in evolution along each of these three axes. Last but not least, opportunities for telco operators in the Cloud Market will be analysed as they could have an advantageous position to offer integrated ICT solutions.

Keywords: API, Cloud, Context, IaaP, Infrastructure, Mashup, PaaS, Telco.

1 Introduction

Current Clouds[1] represent a major step in the evolution of hosting. They enable the provision of ICT Infrastructures and/or basic Platforms "as a Service", exhibiting many of the features provided by classic utilities, namely:

1. Self-provisioning and monitoring of resources, hiding underlying complexity;
2. services are accessible from almost anywhere;
3. on-demand allocation of resources; and
4. advanced billing models.

Relying on the utility-like features that Clouds provide for hosting, application providers can minimize their

[1] Note from the Editor: "Clouds", or "Cloud", refer to "Cloud Computing", that, according to the Wikipedia, is "*Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid*".

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CAPEX and OPEX on ICT infrastructure required to run their applications, without dealing with all the burdens of managing and operating that infrastructure [5].

As of today, Clouds usage can be classified into the three following categories [1][2][3][6]:

- **Infrastructure as a Service (IaaS) Cloud**. In this type of Cloud, application providers may rent infrastructure services such as virtual machines (e.g., Linux Virtual Machines or VMs), storage, networking and auto-scaling. Achieving flexibilty and maintaining and managing these components is the duty of the application provider. Billing is done based on the size multiplied by usage time of each service.
- **Platform as a Service (PaaS) Cloud**. In this type of Cloud, a flexible programming environment is provided, typically linked to some sort of programming language and software development model. Application Providers sign up for a contained environment and are charged by CPU cycles actually consumed, stored and sent data, etc. Infrastructure components are not visible to the application provider; usually the flexible programming environment sacrifices functionality for flexibility and thus scalability.
- **Software as a Service (SaaS)**. Applications running on top of Clouds are referred to as Cloud Applications.

Telecom operators are beginning to adopt these technologies and it promises to be relentless in the mid-term. The Cloud promises reduced CAPEX and OPEX to these operators based on several factors.

2 Utility-like Provision of ICT Infrastructures

IaaS Cloud is widely available and heterogeneous and has acquired a decent level of maturity. The wealth of players may represent a problem for Telecoms: relying on a single vendor is dangerous and creates tricky technological dependencies that one may want to remove at some point in the future. Telecoms need to take a step further, striving for the commoditization of the deployment mechanisms of the services/applications on top of the aforementioned infrastructure. The use of low cost computing equipment in conjunction with the use of machine virtualization make it possible to offer clients low cost, on demand, computing infrastructure as a service. Now, in addition to this commodity computing infrastructure and the existing networking commodities traditionally offered by Telecoms providers, there is commodity storage, where cheap internal server disks are used to build the low cost storage, using technologies such as Google File System, Hadoop or XtreemFS (other commercial solutions using similar technologies have been introduced in the market). The idea behind this commoditization is that you can use whatever computer you want (or can afford to pay) because all are basically the same. All are based on a common technology, x86 processors, on top of which you can run whatever virtualization technology you want (another commodity these days).

The next step is the commoditization of the deployment mechanisms for the services/applications on top of the previously mentioned infrastructure. That is, use whatever deployment system you want for your application, because it implements the appropriate standard. Several standards are likely to achieve this commoditization of the Cloud. OVF (Open Virtualization Format), released in 2009 February by the DMTF (Distributed Management Task Force) and the Open Cloud Computing Interface (OCCI) by OGF (Open Grid Forum) are two clear examples. Telefónica I+D is an active contributor to both initiatives. Also, some commercial alternatives are struggling in the race to become the "de facto" standard (e.g. Amazon's AWS and VMWare's vCloud).

Although current IaaS Clouds have proven mature enough to be released to the market, a paradigmatic example such as Amazon still leaves application providers almost alone in managing the software stack of their virtual machines and addressing flexibility of their applications. In those platforms, it is the application provider's duty to develop and arrange the developed software in an appropriate manner for a real production environment (to set up different tiers, configure load balancers, data distribution, replication, authentication, billing, etc.). While load-balancing and auto-scaling is available, it comes at the heavy cost associated with additional instances. In other words, current IaaS Clouds are too infrastructure oriented and disregard important aspects that may help operators to optimize their network usage in the same manner that datacenter operators optimize the usage and costs of their computational and storage infrastructure.

In this respect, a convergent allocation of computing and communication resources is not properly solved in current IaaS/PaaS Clouds. Flexible allocation of the necessary computing resources will not be enough to comply with established Service Level Agreements (SLAs). Thus, for example, an application may claim a higher bandwidth assigned to outbound connections in order to support some peaks in demand, or it can ask for the creation of SIP sessions among users, etc. Therefore, it is envisioned that future PaaS should be implemented on top of both IaaS and advanced NaaS (Network as a Service) capabilities.

3 PaaS Capabilities

One of the most salient features of PaaS Clouds has to do with their easing developers' lives. 4CaaSt extends this vision by providing support not only to developers, but also testers and application integraters and designers (i.e. covering the whole application lifecycle, from conception to runtime management). Algorithms and tools for **mapping application specifications**, which specify SLA/QoS constraints, into multi-tier architecture designs will be provided. These specifications may convey data regarding the network. Mechanisms for dynamic provision of network capabilities need to be offered for an actual convergence to take place since sometimes the answer to a very specific problem is not only in the amount of computational resources deployed, but also on the way they are integrated and connected via the network. Apart from easing application development and runtime management and maintenance, PaaS will improve convergence by simplifying access, publication, and commercialization of services by the inclusion of a true marketplace integrated with the development, management and maintenance capabilities (including accounting and billing). Telcos, i.e. telecommunications operators, are key facilitators to open these marketplaces since they often cross national boundaries and integrate data from millions of customers worldwide who trust the operator. In this setting, the network can be seen as glue homogenising application-domain differences. Also, telcos have a very important experience in accounting and billing that cannot be disregarded.

On the other hand, having a community of developers employing telecom-exposed APIs granting access to telecom-exclusive capabilities (e.g. NaaS) is a competitive advantage to foster the birth of a newborn generation of services that can only run on top of the Telecom capabilities. This makes telecom-enabled services unique and positions telecoms at a clear advantage over other competitors lacking their own network (such as Amazon or Google).

4 Cloud Marketplace

Very likely, the natural evolution of current PaaS Clouds will encompass the inclusion of new capacities in the "platform" on top of which applications run, related to marketplace features. Thus, the Cloud Provider would take care of billing for the usage of applications registered in the Cloud. This would typically imply that the Cloud Provider implements features such as real time rating/charging and application usage accounting [7,8], which are rather complex features to be implemented by many application providers, especially small-to-medium application providers, on their own. On the other hand, Cloud Providers would manage revenues and perform the proper settlement with application providers on a regular basis (e.g., monthly). This way, the Cloud Provider would act like a kind of "clearing house" between Application Providers and users.

What a Cloud Provider can therefore offer to Application Providers is quite appealing: if they host applications in its Cloud, they will not have to pay for the ICT infrastructure required to run the application. If the application succeeds (i.e., it has users), that would mean that the Cloud Provider can bill for using the application and, therefore, a part of the collected revenues can be used to pay for the actual usage of infrastructure/platform resources. If the application does not work, it would just make use of a minimal amount of resources and the Application Provider would not be charged. This means zero expenses for the Application Provider: an offering many people would categorize as a "killer" offering.

Finally, telco **network capabilities abstraction** and straightforward programmatic interfaces for application developers enabling a holistic view of **context** (identity, relationships, activity, location or time) and uniformly accessed and integrated via front-end **web mashup provide several convergence-boosting capabilities**. Telecoms offer open and uniform APIs for securely exposing network capabilities to application developers (MMS/SMS, IN, IMS, IPTV, …), for accessing the cloud context service including management of identity, for a cloud publish/subscribe service, and an end-user centric front-end mashup portal. Importantly, Telecoms experience in standardization with relevant bodies is also a guarantee that these interfaces and APIs will gain relevant support and help towards actual integration.

4 Conclusions

The Cloud has brought potential savings in CAPEX and OPEX that have certainly impacted on datacenter operators. Telecoms have a pivotal position in extending these benefits to the whole network and creating marketplaces for services in which developers can fully exploit the whole network potential. This way Telecoms may overcome the advantage that pure "computing" providers (e.g. Amazon and Google) possess as of today. Building network-enabled services in a trusted market (Telecoms are really trusted by users) by means of easily usable APIs exploiting NaaS capabilities would seem to be a winning approach.

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