# *Cloud Computing in Mobile Networks – Case MVNO*

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*Abstract*—**Cloud computing is one of the most widely used terms in IT today. Some experts regard cloud computing as hype, but others believe that clouds will have a longer future. Although web 2.0 companies have warmly welcomed clouds, mobile operators have taken a more cautious approach to this new phenomenon. However, new opportunities are opening up to operators, and a number of steps can be followed to take advantage of this development. First of all, the Open Telco concept underlines the power of open APIs that are important prerequisites for the clouds. Secondly, operators can start to utilize clouds in their own infrastructure. However, the operators that have most to gain from cloud computing are the Mobile Virtual Network Operators (MVNO), and this paper focuses on them in particular. The research methodology is based on an action research and data analysis. MVNO experts were interviewed twice according to the Delphi method. The main findings were verified with a proof of concept. Finally, the results are critically evaluated, the next research topics are proposed and conclusions are drawn.**

***Keywords-MVNO; BSS/OSS, CRM; Telecom Cloud; Hybrid Cloud***

## I. INTRODUCTION

Mobile operators are facing fierce competition from the internet players. Google and Apple have been most successful with their Android and iPhone platforms and ecosystems, leaving operators less space for new strategies. On the other hand, web 2.0 companies, such as Skype and lately also Facebook, are changing consumers' communication behavior, by substituting mobile calls and messages with internet services. One important factor for the success of the internet challengers can be found in cloud computing. Cloud platforms enable scalability and global presence without major technical obstacles. Parallel to this, the pay as you go –principle has lowered the investment barrier to new service launches within a short time.

With this background one might to start wonder why operators do not follow the web 2.0 companies and utilize cloud computing services. Basically, the main reasons are to be found in the history of such companies. Operators have a large installed base, while web 2.0 enterprises have built their business and infrastructure from inception. In spite of this, there are several opportunities for operators. Firstly, operators can consider the Open Telco [1] or Networking as a Service (NaaS) concepts [2]. This means that operators will open up APIs to provide network assets to developers, for accelerating application development and creating a new application ecosystem. Secondly, operators can start to use clouds in their own infrastructures. Several players already sell cloud capacity to their own customers, but still very few of them apply cloud technologies in their own networks [3]. Furthermore, mobile operators are moving towards a flat network architecture, due to introduction of Long Term Evolution (LTE) and 4G standards. Flat network architecture will lower the barrier to network sharing initiatives, enabling the introduction of cloud principles.

This paper focuses on the Mobile Virtual Network Operator (MVNO) case, which provides a natural and low risk entry to the cloud business. The paper consists of the following sections. First of all, the Service Level Agreement (SLA) requirements are presented, followed by the introduction of a telecom cloud. Then, the operator and MVNO types, possible cloud applications and mapping of applications are discussed. The next chapter presents the main research questions and the research methodology used in the paper. The results of the MVNO analysis are summarized, and the architecture of the proof of concept is illustrated. Finally, the results are critically reviewed, the next research ideas are proposed and conclusions are presented.

## II. BACKGROUND

### *A. Service Level Agreement*

Telecom vendors and operators often claim that clouds cannot yet meet the telecom SLA requirements. For that reason a cautious approach is recommended. According to a vendor presentation [4], a three step roadmap, depending on the carrier grade requirements, is proposed. Firstly, operators can utilize clouds in their support systems, then move onto tactical systems and finally to strategic ones. The approach is shown in Fig. 1.

On the other hand, according to the latest results [5], public clouds, such as the Amazon Elastic Compute Cloud (EC2), are already in a position to support the strictest telecom SLA conditions. SLA factors can be compared, for example, in availability, latency and throughput. EC2 promises an availability value of 99.95 percent compared with the usual telecom requirement of 99.999 percent. However, the EC2

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availability value can be easily upgraded by using two independent cloud domains or hybrid clouds. Latency results can also be optimized by using a nearby cloud zone and good quality transmission links. Finally, the throughput result concatenated by six Amazon Large EC2 virtual machines (VM) already equals the requirements set by, for example, Home Location Register (HLR) [5].

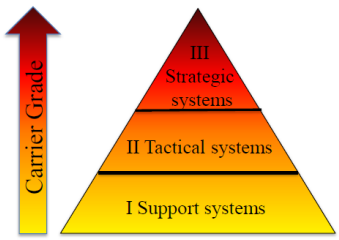


Figure 1. Telecom cloud roadmap, adapted from [4].

### B. *Telecom Cloud*

Telecom networks have various functions and network elements that could be implemented in clouds, called a Telecom Cloud [2]. Operators can utilize all kinds of cloud computing services, including Infrastructure (IaaS), Platform (PaaS) and Software as a Service (SaaS). The IaaS layer offers networking, computation and storage services provided by the clouds. The PaaS layer has close links to the Business and Operations Support Systems (BSS/OSS). The SaaS layer matches the service delivery platforms. The Telecom Cloud can be supported with private, public and hybrid or community clouds located outside of the operator domain, and separated by open APIs. Finally, cloud computing can be applied to mobiles, too. Fig. 2 shows the Telecom Cloud architecture.

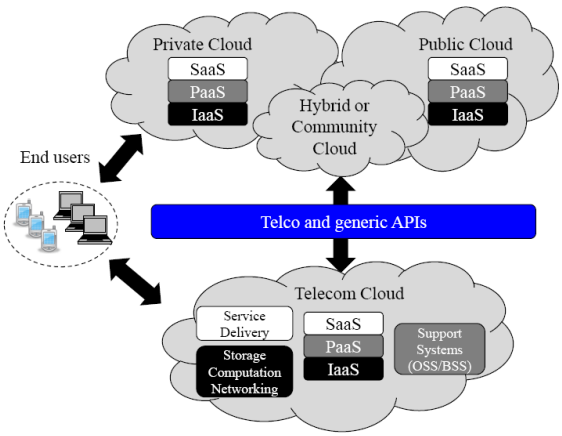


Figure 2. Telecom Cloud.

### C. *Operator types*

Mobile network operators (MNO) have classifications based upon their area of functioning across the telecom services systems and processes. MNO has the ability to control the whole value chain as it owns all or most of the systems and processes across the mobile telecom service provider value chain. MNO can rent their systems, network and services to other participants in the value chain based upon the contracts or agreements. The Mobile Virtual Network Operator (MVNO) and Enabler (MVNE) buy network capacity from the MNO [6], [7], while paying the network usage cost in a pay-as-you-go manner.

MVNO provides services to the end-users owning billing and marketing systems. MVNOs usually compete on the price differentiation rather than service differentiation [8]. They can work across multiple geographical locations, too, and thus have location based differentiation [9]. MVNE sells network capacity and services to service providers and in some cases to MVNOs. Service provider sells services to the end users and in some cases it focuses solely on marketing, branding and reselling the services, i.e. a Brand Operator. Fig. 3 shows the classification and positioning of network operator types in the mobile network service provider's value chain.

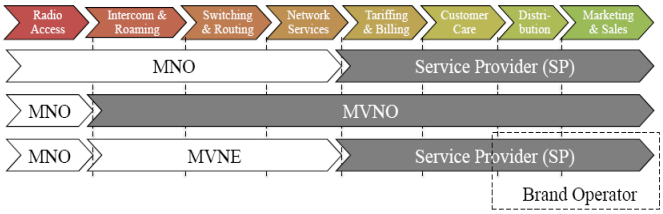


Figure 3. Operator types.

### D. *MVNO types*

A true MVNO owns HLR, switching and Intelligent Network (IN) platforms in addition to services, billing and marketing systems [10]. It has control over service and tariff design, service implementation, marketing and differentiation, as well as branding. A weak MVNO owns billing, customer care and marketing systems, while HLR, switching and service components are shared with an MNO. In this case the MVNO controls service and tariff design, service marketing, as well as branding. The reseller provides network services by implementing marketing and branding only. It sells pre-packaged services that are outsourced from MNOs. Usually resellers own just marketing, branding and, in some cases, customer management integrated with other operators. Fig. 4 summarizes different MVNO options. [11]

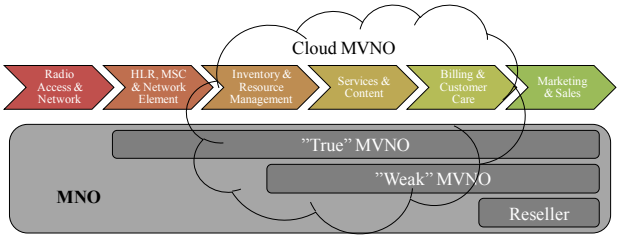


Figure 4. MVNO types.

### E. *Cloud MVNO*

In the highly competitive MVNO market, every operator seeks opportunities to reduce the costs and to maximize the revenues. Cloud technologies produce several ways to improve

capex and opex values [12]. Because MVNOs share various network resources with MNOs, MVNOs can become the natural users of clouds. However, the mapping of MVNO architecture to the cloud has to be carefully planned. Operators must take into account, not only SLA requirements, but also security, trust and privacy aspects. PaaS and SaaS layers provide the most natural fit for the MVNO architecture, because the SLA requirements for PaaS and SaaS services are more relaxed. Fig. 4 depicts a proposed Cloud MVNO domain placed on the MVNO value chain diagram.

### *F. Business Support Systems*

MNOs already offer SaaS type of services, such as email and SMS, to their MVNO customers, but new opportunities can be sought from the PaaS layer. Both Business (BSS) and Operations Support Systems (OSS) can be provided in a shared manner. In this research the focus is dedicated to BSS, because it provides a logical path to cloud computing services. BSS layer focuses on the customer and financial transactions segments of telecom operator systems. It also manages the partner and marketing functions of operator systems. The front-end operations for the self-service portal for the end-users as well as for customer service representatives (CSR) are included as part of BSS. BSS has integrations with OSS which can be configurable.

### *G. Application mapping*

A correct application mapping to the cloud is important [13], because all applications cannot be hosted in, developed on or migrated to a cloud. It is necessary to answer to the key questions, before applications are implemented or migrated into the cloud. For example, the software architect should verify whether the application will successfully run in a cloud, or does the migration have any impact on the existing applications. It should be also checked if the complexity of the system will increase upon the cloud implementation. Also the cost factors should be evaluated. Answers to the questions given above may vary according to the application type.

Two approaches may be taken into consideration when deciding whether the application should or should not be transferred to the cloud. First of all, identify the attributes and key factors important for the application to work seamlessly in a cloud. Map these attributes to the cloud service attributes to validate if the cloud implementation for that application will be feasible or not [14]. Secondly, evaluate the cloud service providers to verify if the application or system attributes are matched. Check also that the application can be feasibly and economically hosted in the cloud.

## III. RESEARCH QUESTIONS AND FRAMEWORK

The research questions are derived from various options for mapping the MVNO applications to the cloud computing architecture. The main research question can be broken down to sub-questions that narrow down the higher level question. The main research question asks how and which BSS functions MVNOs can and should deploy in a cloud to offer a high performance, cross-location and cost-effective system to share resources among other operators. The sub-questions verify, for example, whether the current architecture will be affected, what the impacts are on the performance and security, and also whether there are any cost-benefits or changes to the business models.

Action research [15] was employed as the main research method, involving researchers and practitioners from among MNOs, MVNOs, infrastructure vendors, BSS providers and academia. Interviews with experts were conducted based upon their area of expertise using a pre-formatted and validated questionnaire. The Delphi method [16] was used for the interview format. This setup includes two interview rounds where the first round is done with the broader questions and scenarios, while in the second round questions are narrowed down by the use of research specific data gathering scenarios only. Fig. 5 describes the process flow of the expert interview setup derived from the Delphi method. In addition to expert interviews, the whole research methodology includes a literature review, feasibility study, architectural study, financial analysis, and empirical data analysis.

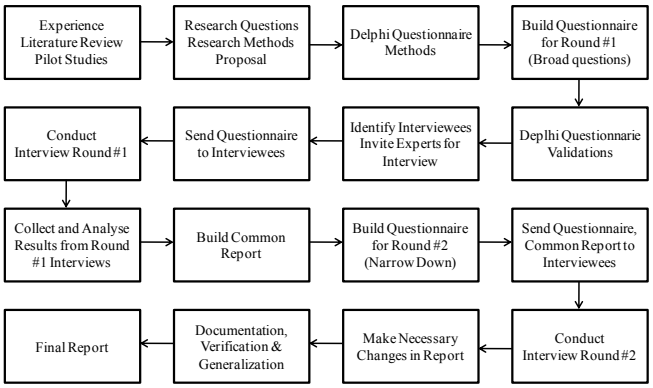


Figure 5. Delphi method.

## IV. RESULTS

The action research was carried through using Delphi method during spring 2011. In the first interview round, nine experts from the MVNO area, including vendors and operators, were interviewed face to face. In the second round a web form with more detailed questions was utilized. All results were reported anonymously. The research included various aspects, and only the main findings are presented here. As a summary, the experts highlighted the importance of the following factors in the MVNO context: simple and lightweight billing and customer relationship management (CRM) systems, lean and agile business operations, price differentiation, outsourced BSS, rented OSS and networks, branding and marketing as core competences, and finally cost-benefits.

### *A. Parameters*

MVNO must drive customer satisfaction and price differentiation by using lean and agile business processes to compete with incumbent operators. Before MVNO systems are mapped to the cloud, it is essential to know how critical parameters behave in an MVNO context. For that reason the

importance of four parameters, performance, carrier-grade SLA, cost-benefits and cross-location architecture, were reviewed [17]. The results of the interview are shown in Fig. 6. Cost-benefits received the highest ranking in the review, but cross-location architecture was also regarded as important, enabling flexible operations across different markets.

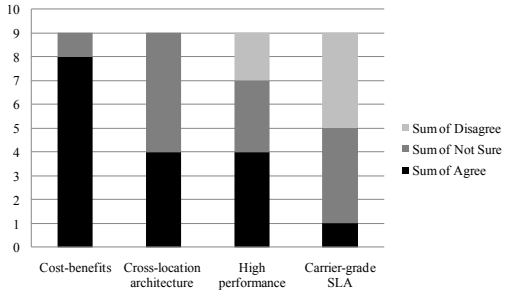


Figure 6. Parameter evaluation in MVNO context.

In the next phase more parameters were brought into the discussion. Participants interviewed were asked how the specific parameters would be affected in an MVNO and cloud context. All results are shown in Fig. 7. It represents the first round answers, and the second round, more specific questions, did not change the picture. Data security was given the highest ranking in the evaluation, which fact underlines responders' concern over cloud security [18]. The performance was ranked almost equally with the security, but on the other hand, the SLA parameter received mixed responses. This indicates that almost half of the reviewers had doubts about the service guarantee of cloud computing.

As a positive development the experts thought that cloud computing can reduce the carbon footprint by improving the power efficiency of the servers. Moreover, the clouds surely ease cross-location configurations. Cloud computing may have an impact on business models, if the cost-benefits materialize. At the same time, several responders said that business models will not change due to cloud computing. Finally, it was estimated that service delivery will not be affected too much if the service machinery moved to the cloud.

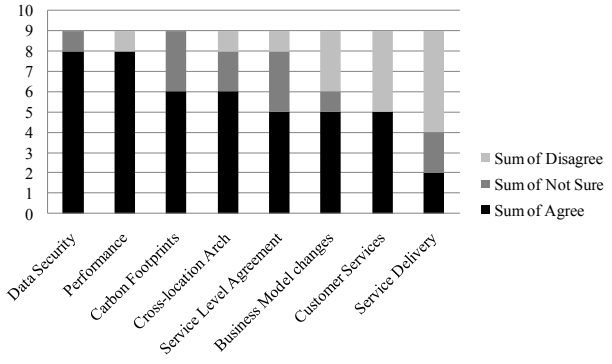


Figure 7. Parameter evaluation for MVNO in cloud.

### B. *MVNO mapping to cloud*

The next question asked which BSS and OSS systems could be deployed in the cloud. Fig. 8 includes the answers summarized in one picture. Consideration could be given to implementing almost all BSS functions, with the partial exception of Mediation, in the cloud. However, OSS or prepaid and network systems were not recommended for the clouds. The results are logical and according to expectations. Cloud computing is estimated to succeed well in both web based services and offline computation tasks. Moreover, the experts thought that carrier grade services are beyond the capabilities of cloud computing.

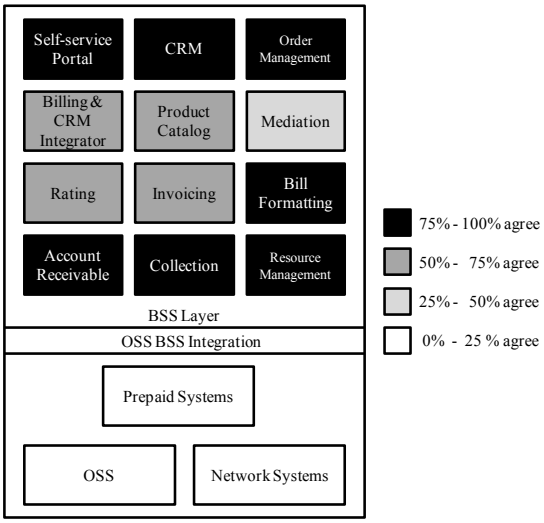


Figure 8. MVNO systems in cloud.

Self-service portal, CRM, order management, account receivable and resource management can be deployed as SaaS in a cloud. All these applications need a user interface for the customer service representatives, and SaaS suits this need. The self-service portal is an end user application, and it is connected to the other functions via self-service APIs. SaaS enables quick scaling up and down depending upon the load and thus brings cost-benefits in managing these applications.

Billing and CRM integrator, product catalog, rating, invoicing and bill formatting should be implemented using PaaS, because these applications do not require end-user intervention and possess asynchronous background processing capabilities. In addition, PaaS provides a platform that can be shared among several MVNOs, bringing further cost-benefits due to load elasticity. Finally, batch job processing, such as mediation and business intelligence systems, should be deployed in IaaS, since these applications need higher computing, as well as larger storage capabilities.

### C. *Proof of concept*

A public cloud utilizes internet links for communication, thus exposing critical services and data to security threats. A private cloud is more restricted environment, guaranteeing the data and application security. On the other hand, it also loses the initial cloud computing benefits, such as elasticity, economies of scale and green computing. A hybrid cloud is a

model that can retain the advantages of both domains [19]. In the proposed system the data reserves are placed to the private cloud, while the application images are able to run in both clouds. This setup enables dynamic load balancing [20] reducing the total cost of ownership (TCO).

As an example, a CRM application called SugarCRM, was configured in a hybrid environment. See Fig. 9 for details. First of all, the private cloud system is installed with application images and a database. The load balancing script must be modified on the Apache server, to enable the usage of cloud instances for load balancing. Next, the instances are installed into the public cloud, and secure, high bandwidth access to the private cloud database is opened. The IP addresses of the public cloud instances are added to the load balancer. In addition, the load balancer logic must be modified to switch the load from private to public cloud instances, whenever the private cloud instances reach their maximum capacity, in terms of memory, processing or other attributes.

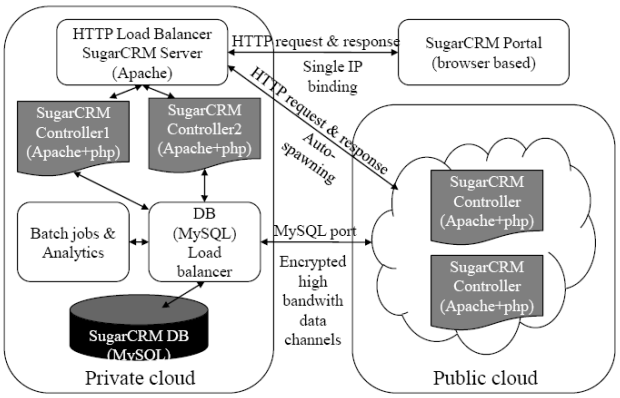


Figure 9. Hybrid cloud architecture for CRM system.

## D. *Billing-as-a-Service*

A Billing-as-a-Service can be set up in the hybrid cloud in PaaS fashion, using the proof of concept presented above. In this architecture, the database remains in the private cloud due to data security and access reasons. Real time and batch job processing can be executed on both private and public cloud instances. To handle load fluctuating the hybrid cloud provides possibility to set up private cloud processing according to the average processing need. Fig. 10 illustrates the architecture.

Network usage data comes to the system from MNO in the form of call data records (CDR) and IP data records (IPDR) via a highly secure data transfer channel. Robust mediation system converts the usage data from a different format to a common one, and places the data into the database. The rating functionality provides interface to rate the calls and data traffic for subscribers. It takes input from a reference or configuration database related to the product rates and changes, as well as it gets input from call details. Finally, the rating module converts the CDR to financial data, and forwards it to the invoicing system. A hybrid cloud fits really well with these functions, because the load can considerably fluctuate. The rest of the system operates in normal fashion.

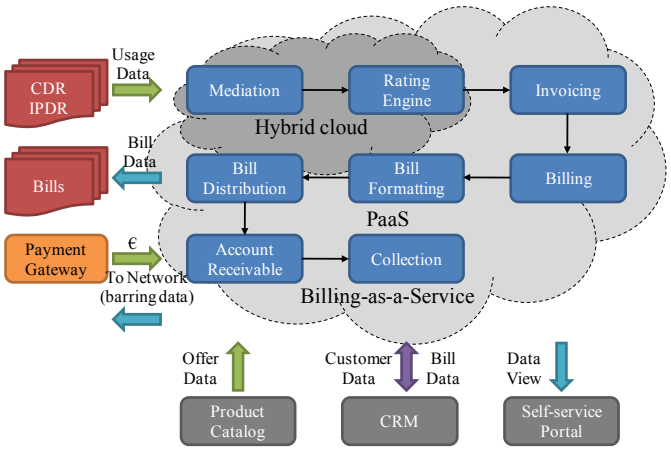


Figure 10. Billing-as-a-Service in cloud.

## E. *Cost evaluation*

Cloud computing will bring most cost-benefits due to flexibility. Capex costs can be converted into opex ones [21], which suits MVNOs well. The actual computing costs will not dramatically differ irrespective of the public cloud or dedicated hardware choice. However, cloud computing efficiently scales up and down in response to even fast load changes, which fact lowers the risks [22]. Also, administration costs are noticeable in enterprises. One statistics shows [23] that companies often spend 8$ for the administration of a hardware cost worth 1$. By utilizing clouds, this huge gap between hardware cost and its administration cost can be considerably reduced. Costs can also be decreased by shorter integration and service deployment projects that are enabled by cloud-based cross-architectures.

# V. DISCUSSION

The implications of regulatory restrictions from government related to customer data and transferring data outside the country borders were the most discussed issues in the interview sessions. If confidential data needs to be put in the cloud, then the highest level of security and availability should be in place. However, bilateral contracts formed between or among countries may help to lessen the effect of such restrictions. It was also recognized that CDRs can be transferred within EU states with customers' permission.

The other challenge for customer data relates to the data lifecycle. Data should be retained in BSS systems for a specified time frame, and ultimately it should be completely removed from the databases. Moreover, data should not be vulnerable to theft or eavesdropping because keeping customers' trust is crucial to the MVNOs. On the other hand, operators must have access to customer data any time. This encompasses the idea that data should be stored locally to enable fast response time to customer tickets and possible authority requests. Sharing BSS systems with other MVNOs puts even more pressure on the security requirements.

It is expected that cloud computing will emerge to the OSS in the near future, but applying clouds to network systems will

require changes in the network architecture. Usage of clouds will be a lot easier if the introduction of cloud computing is made from the very beginning. Updating the existing systems to clouds will otherwise be a lot more challenging. BSS and CRM functions suit clouds well, but OSS and prepaid services have more challenges ahead. In the case of MNOs, most of them have old in-house legacy IT systems, which makes cloud migration more difficult and expensive.

Cloud computing is a natural choice for the MVNOs, facing fierce price and service differentiation competition. Clouds help MVNOs to transform capex costs to optimized opex costs, simultaneously minimizing the investment risks and improving the return on investment (ROI) ratio. It can also be seen that cloud computing, due to the economy of scale, can be successfully introduced when an urgent increase is needed in computing capacity. In future flat rate business models will become more popular, and already now the flat rate data plans are in place. There will be no need for complex billing systems [24], and such a scenario will work in favor of cloud based telecom systems.

## VI. CONCLUSIONS

In this paper, a techno-economic analysis has been carried out to analyze the implementation of telecom systems in the cloud in the Business Support Systems (BSS) domain. The research focuses on architectural application mapping strategy required and financial cost-benefits gained for an MVNO if the BSS systems are implemented in the cloud. The research involves a Delphi method, in which expert interviews are conducted in two rounds to gather expert views on the subject. The results indicated that the experts believe that cloud computing and cross-network architectures will improve carbon footprint and bring cost-benefits. However, performance and security remain as the major concerns among the responders, and these questions must be solved, before major cloud deployments in the telecom side can be expected. To validate the results a proof-of-concept CRM solution, based on the hybrid cloud architecture, was proposed. In addition, the paper introduced an innovative Billing-as-a-Service solution that can be implemented in PaaS fashion, utilizing also the hybrid cloud proposal.

## ACKNOWLEDGMENT

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