Choosing The Right Cloud

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***Abstract*- Cloud computing platform offers several advantages over the in-house application hosting on the own infrastructure of a company by itself. These advantages include hassle-free management, less investment in infrastructure, drastic reduction in operational expenditure (electricity bill, real estate costs, etc.). All of these will be provided with the cloud platforms with no or very less compromise with the security adhering to the client's standards. With the advancement in the field of cloud computing and services that one can avail, there are splendid choices available to move to a cloud platform depending upon one's organizational and business requirement. Depending on the growth rate, workload, performance of different cloud platforms and cost that can incur, we (A2 Limited) have discussed about the various options that the emerging start up - Virtual Phone Ltd, can opt for their cloud computing platform with us.**

***Keywords*: Mobile cloud computing, cost analysis, cloud infrastrucre analysis.**

I. Introduction

In this report we present a tender for Virtual phone Ltd (Starting in 2014), in which we present the available options from our side, depending upon the requirements of Virtual Phone Ltd. The firm in context is a promising start up which claims to expand tremendously over the next 3 years. Depending on the statistics provided by the client, the target goal of customers at the end of 2014 is 1 Million with +/- 10% variant. The company targets to achieve 10 Million customers in 2015 with +/- 30% variant and in 2016, it targets to achieve 30 million customers with +/-50% variant. We have speculated the calculation and providing the offer with ECU (EC2 Compute Unit) equivalent computational units, where each provides equivalent CPU capacity of 1.0 - 1.2 GHz 2007 opteron or 2007 xeon process. Also as per our speculation, 1 ECU will serve up to 10 users during the maximum load where half of computation power goes to real time computation and the other half goes to batch jobs. Depending on our research on Virtual Phone Ltd and the data provided by them, the load distribution is similar every day and the load is evenly distributed between maximum and minimum load. We also assure to minimize the Round Trip Time by keeping the data as close as possible to the customer. The evaluation period set is 3 years with interest rate of 10%. The tender provides information on four options that we can provide to Virtual Phone Ltd, which are providing cloud platform on Public cloud, Hosted Private cloud, Own Private cloud and a hybrid cloud.

II. Background

Public cloud services are mostly offered as Platform as a Service (PaaS) or Infrastructure as a Service (Iaas). PaaS systems are mostly used for hosting web based applications. The provider offers a virtual server with an operating system and a set of tools for developing applications. Access to the underlying operating system is very limited for PaaS users. PaaS developers use the provided tools to create applications. Usually, PaaS offers access to most popular programming languages such as Java or PHP. The advantages of PaaS systems are simplicity and increased productivity in creating applications. A variety of tools offered by the provider out of the box, so no need for maintaining underlying operating system[1]. Furthermore, using PaaS does not impose any costs for buying and maintaining operating system and the environment for running web applications. The cost of PaaS vendors provided software is included in virtual computing units rent price.

IaaS systems are also widely used for web applications development. The main difference between PaaS and IaaS is that IaaS does not provide an operating system in a virtual environment. It acts more as a plain server, where users can install required software and tools, used to host web applications [2]. IaaS providers do not need to consider costs for creating and maintaining operating environment tools, thus, they can offer better prices for computation units rent.

A public cloud service dynamically allocates resources which are accessible through the Internet. It is a fine grained service with which developers interact without knowledge about the exact location and exact hardware running their tasks [2].

A private cloud consists of hardware and software owned by a company. Only the company has access to development and running of web based applications on the private cloud. Owning a private cloud removes a need to lease public cloud resources but imposes relatively high costs for buying, managing and maintaining own servers.

Also when it comes to "Private cloud" services, it can be visualized as 3 different types - SaaS, PaaS, and Pure Service. In SaaS- private cloud services, Providing software to run the cloud based services (Softwares that

should be present when we host our own cloud) . Companies like VMWare and Softlayer sell such software as private cloud solutions [8].The cost of such software when hosting the private cloud can be null if the open source alternatives are used.[9]. In this case, the infrastructure is by the client, not by cloud vendor. Also Maintenance of the cloud can be by the vendor or client or both depending on the agreement. Cost of SaaS private cloud services, varies between 0(Open source alternatives) to few thousand Euros depending on cloud capacity, performance and overall architecture. In PaaS-private cloud services, the cloud vendor is expected to provide hardware (infrastructure) along with Software and maintenance. In this case everything is provided by the cloud vendor but the complete control is with the client. Here the cost is more but this is recommended if security is the major criteria for the organization (e.g. Data that they host itself is their business) , then one should go with PaaS-private cloud services. Though "Service only - private cloud computing" comes along with SaaS or PaaS private cloud computing services, there are myriad of instances, where only type/ types of cloud related services are provided by the expert group from the cloud vendors. This may include maintenance, support, along with training cost training, certification. As per my experience these costs a lot for a company with more people and less knowledge on cloud.

A hybrid cloud solution includes both private and public clouds. Some of the computation work may be offloaded to a public cloud while still doing some for example security sensitive tasks on a private one. Hybrid clouds aims to combine the advantages of both private and public clouds and offer optimal price/features ratio.

III. Architecture

We chose to use private hosted and public clouds. Own private cloud was discarded due to high price. Although it would guarantee the most security, here the security requirements are not present, hence we mainly focused on the price and the round trip time. We choose to use hosted private cloud which can run both IaaS and PaaS for the first year. This would guarantee small round trip time for Finnish customers, since the servers of the provider are located in Finland. For the second and third year, we suggest to choose public cloud solutions to optimize expenses and impact on the environment. As it is explained in “Cost Analysis” section, public clouds are cheaper than private ones. Also, Carbon Footprint Analysis shows that public clouds are greener than hosted or own private clouds. However, since the growth of the customers is exponential, first year expenses only account for less than 1% of all expenses. That is why it is feasible to choose a bit more expensive solution using hosted private cloud and only later opt for public ones.

IV. Cost Analysis

In the analysis, public, private and own cloud solutions were analyzed in terms of price. Hybrid solutions were also considered. Price was calculated in terms of Amazon Elastic Compute Cloud Compute Unit (ECU), since this is used as a reference unit to measure the performance of required cloud services. The calculated price is presented in euros. Cloud providers show prices in U.S. dollars (USD), thus the divider of 1.2 is used to convert dollars to euros. Virtual Phone Ltd client growth is exponential. 1 ECU is needed to server 10 customers. The error ratio in customer growth is considered as well as 10% safety margin. The expected number of ECU’s is presented in figure 1.

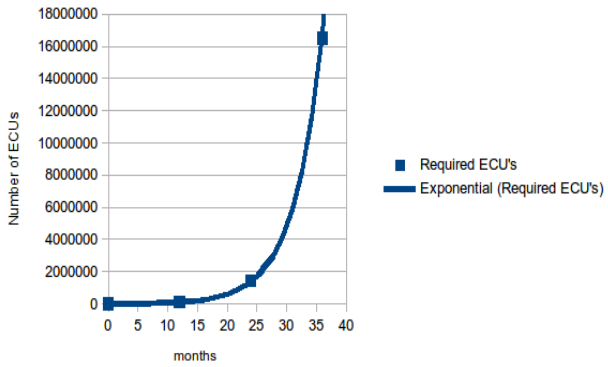

Figure 1. Expected growth of required ECUs

i. Public cloud

Three different public cloud providers were analyzed during the research, including Amazon Web Service (Amazon Elastic Compute Cloud), Google Compute Engine and Microsoft Azure. Google and Microsoft allow to pay for services on-demand. That means, a customer is only billed for the time a virtual instance is active. Customers can benefit from such flexible pricing (in compare with pricing when one needs to buy all resources in advance). Microsoft also offers fixed term and fixed resource plans for 6 or 12 months. In this case, customer can get discounts up to 30% when buying resources in advance. Amazon also has discounts for users who buy resources in advance. The disadvantage is, that it is needed to buy enough computing power in the beginning to be sure that there will be enough resources in the end of the period (when the number of clients increases). Amazon Elastic Compute Cloud (EC2) offers an instance with 8 virtual cores capable of having 88 ECUs [amazon]. The price of such instance located in Europe (Ireland) is $2.7 ~ 2.25€. Thus, 1 ECU costs 0.0256€ per hour.

Google Compute Engine is a PaaS system mostly focusing on high computation demand [3]. The “n1-highcpu-8” machine offers 8 virtual cores which are more or less equal to 22 ECUs, as 1 Google virtual core ~ 2.75 ECU. An hour rent of one of such machine which is hosted in European region costs $0.584 ~ 0.487 euro. Thus, one ECU costs ~0.022 €.

Windows Azure is also a PaaS system. However, Azure offers discounts on long term rent periods of 6 and 12 months. Additional discount is added if paying instantly for the whole period. One Windows Azure computing unit is a Linux virtual machine with a Intel Xeon 1.6 GHz processor which is 1.62ECU [4]. A rent of a machine hosting 8 of Azure virtual units is $0.48 ~ 0.4 euro per hour. Also, the performance of the machine equals to 12.96 ~ 13 ECUs and thus 1 ECU costs ~0.031€.

Since the growth of Virtual Phone Ltd clients is exponential, it is unfeasible to buy all the required computing power at once. That is, buy around 165M ECUs in the first year and keep the same number for the whole period. Even 6 months term is too long and would cause a lot of price overhead. Much better approach is to pay per usage and increase the number of ECUs on demand. Best results are achieved if resources are allocated every day (instead of every month). Therefore, the options to buy fixed contracts form the cloud providers will not be considered. Of course, it is not possible to buy the exact required computation power for each day, as payment is done per each virtual machine with a fixed number of ECUs (e.g. 22, 88 or 13) - you cannot buy, for example 0.5 ECU. If one needs 89 ECUs and is using instances of 88 ECUs, he or she will have to buy 2 such instances.

Even though customer growth has an exponential shape, it is not exactly exponential and is hard to express with a simple exponential function. To simplify the model, it is assumed that each year, the growth of the clients is linear (see Figure 2), i.e. during the first year the number of customers grows linearly from 0 to 1M, during the second year from 1M to 10M and during the last year from 10M to 100M. Thus, only three linear functions need to be analyzed to find a close to optimal solution. It also gives a safe margin, regarding that having too much computing resources is better than having too less. To offer a better price, resources consumption is calculated for the each day (see Appendix spreadsheet "Public cloud"). The amounts of each day of virtual instances were considered and the results obtained after calculation are presented in table 1. Table shows, that cheapest option is to choose Google Compute Engine services.

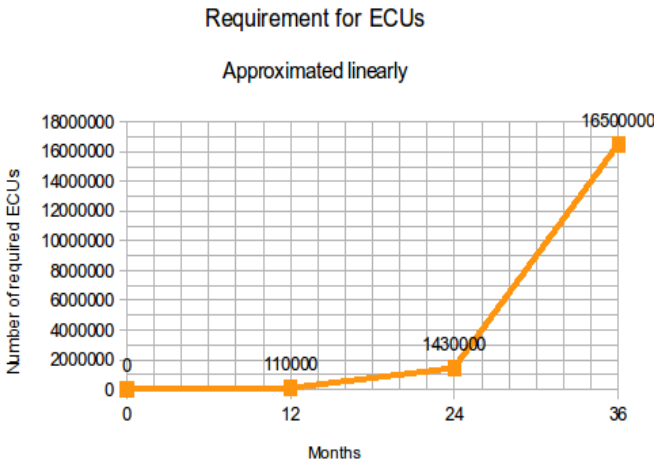

Figure 2. Linearly approximated model

Table 1. Expenses for public cloud providers over 3 year period - Cost in Euros (€)

	1st year	2nd year	3rd year	3 years period
Amazon	12,362,220	172,877,220	2,012,589,720	2,197,829,160
Google	10,689,302	149,564,502	1,741,256,502	1,901,510,307
Microsoft	14,866,992	208,035,437	2,421,981,840	2,644,884,269

However, since 50% of computations need to be done on PaaS and 50% on IaaS it is not possible to rent services only from Google since we also need services from Amazon. The solution is to buy half of the services from Google and half from the Amazon. Table 2 shows the price for such combined solution.

Table 2. Solution and prices using 50% IaaS (Amazon) and 50% PaaS (Google) - Cost in Euros (€)

	1st year	2nd year	3rd year	3 years period
Amazon	6,181,110	86,438,610	1,006,294,860	1,098,914,580
Google	5,344,651	74,782,251	870,628,251	950,755,154
			Total:	2,049,669,734

ii. Hosted Private Cloud

For a private cloud company we chose Finnish company Nebula. Since it is located in Finland, it guarantees smallest round trip time for Finnish customers. This is important in the first year, when Virtual Phone Ltd. starts its business and most of the clients are Finnish. Nebula offers virtual CPUs with performance of 2.3GHz. Comparing with Amazon ECU where a Xeon processor has a speed of 1.7GHz, it can be said that virtual CPUs of Nebula are 1.3 times faster than an ECU. The cheapest Nebula virtual machine with 1 virtual core[6] is capable of processing 1.3 ECU.The price of such machine is 0.04€ per hour. Putting these numbers into calculations spreadsheet gives the results presented in table 3. However, expenses are just a bit less than public cloud option of Microsoft which was the most expensive public cloud provider.

Table 3. Three year expenses using private Nebula cloud - Cost in Euros (€)

	1st year	2nd year	3rd year	3 years period
Expense	14,865,405	208,032,391	2,421,977,139	2,644,874,935

iii. Own Private Cloud

From the table 3, it is clearly visible, that hosting an own private cloud costs substantially more (about 10 times) than using a public cloud alternative.

Table 3. Own private cloud costs - Cost in Euros (€)

Period (months)	Server cost	Administration cost	Infrastructure cost	Total Cost
1-6	5,697,000	45,576,000	6,963,000	58,236,000
7-12	5,697,000	45,576,000	6,963,000	58,236,000
13-18	62,641,000	501,128,000	76,561,222	640,330,222
19-24	74,032,000	592,256,000 €	90,483,556	756,771,556
25-30	705,995,000	5,647,960,000	862,882,778	7,216,837,778
31-36	854,019,000	6,832,152,000	1,043,801,000	8,729,972,000
			For 3 years	**17,460,383,555**
			With 10% interest rate	**19,264,793,087**

Considering the specified prices and constraints, costs for own private cloud were calculated (see Appendix spreadsheet "Own infrastructure"). As the calculations show, costs on hardware are not the largest ones. Since all ICT costs are split into 45% hardware and 55% infrastructure, power and networking, infrastructure cost is more than just buying racks and blades. However, the main part of expenses goes to administrators of the servers. Expenses on staff salaries are 8 times more than expenses on servers.

iv. Hybrid Solution

Hybrid solution would consist of own private and public cloud solutions, since own private cloud offers best security and public cloud offers best prices. However, it is not known which part of the application requires special attention towards security. Moreover, there is an additional overhead of exchanging data between own and public clouds.

Assuming that sensitive computation takes no more than 10% of all computations, the total cost of services can be computed as [10% of own cloud total cost] + [90% of public cloud costs]. However, since we do not have exact numbers or any hints about the security, we do not consider the fact for running computations on private clouds just for security reasons.

V. Carbon Footprint Analysis

While operating, servers highly contribute to carbon footprint (CO_2) emissions. This is due to the power used for running servers. The "greennes" of each cloud solution (public, private, own) can be analyzed in terms of power usage effectiveness (PUE)[7]. PUE = [total facility energy] / [IT facility energy]. PUE of public clouds is 1.2 for PaaS and 1.1 for IaaS, whereas private clouds can have PUE of 1.7 and the ones hosted in own environment - 2.5. This is because public clouds benefits from scaling out and can fully utilize most of the available resources. Therefore, hosting applications in a public cloud is the best way of reducing CO_2 emissions.

However, not only clouds need to be considered when calculating the impact on the environment. Users will have to use phones which will communicate with the servers. Of course, such type of phone will consume less power than the ordinary one. Assuming that an ordinary phone requires a processing equivalent of 1 ECU and that PUE for a phone is 7, we can conclude that one ordinary phone consumes power equal to raw energy consumption of 7 ECUs (we refer to this as 7 power units). Cloud connected phone consumes 0.9 x 7 = 6.3 power units. However, a server uses 0.1 ECU to serve the cloud connected phone. The PUE of the server is 1.2 for PaaS and 1.1 for IaaS, therefore a cloud connected phone consumes 6.3 + 0.1 x (1.2 + 1.1) / 2 = 6.415 power units. It turns out, that a cloud connected phone is more environmentally friendly than an ordinary one.

VI. Discussion

The proposal is to choose private cloud services from Nebula for the first year, and choose Google PaaS and Amazon IaaS for the second and third year. This solution guarantees close to optimal expenses and reasonable round trip times for the customers. It is also an environmentally friendly solution in compare with having an own private cloud.

Our solution removes the need to invest a lot of money at the early stage. It also considers safe margins and evaluates required number of customers. Since prices are calculated each day instead of each month, it gives a more fine overview of expenses and allows to choose more close to optimal solution.

In order to cover the computing costs, Virtual Phone Ltd should charge their customers at least 2.22 € per month in the first year and 1.71 € per month in the second and third year.

However, Virtual Phone Ltd should consider security issues and decide whether it is secure enough to host all the data in public clouds. They should estimate which part of computations includes sensitive information and might be better computed on the own private cloud.

VII. Conclusion

This paper analyses feasibility of running a virtual phone service on different cloud platforms. We took into consideration of many cloud service providers. But We analyzed public cloud providers such as Amazon, Google and Microsoft, private hosted cloud provider Nebula and an option to host a cloud on own servers. All these options were analyzed considering costs, round trip times and impact on environment. Since security was not a criterion to be considered, we have not emphasized on that part. We have considered the expected growth rate of the company and done all the calculation based on it, so that we do not spend on unnecessary rack space.

Our proposal includes both private and public clouds. In both case we guarantee best experience for the customers with minimizing round trip times and a good price for our customer company Virtual Phone Ltd. Also, since we do not offer own private cloud, the proposal minimizes CO_2 emissions.

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