Project for an Enterprise Architecture Solution for Infrastructure Management

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Abstract

Cloud Computing has been gaining significant attention through the years. Advantages such as flexibility and scalability, attract organizations to consider the migration of their services to the cloud. However, economic requirements and organizational change impose some constraints to the adoption of cloud services. Although Cloud Service Providers have online calculators for knowing the cost of their services, migrating an organization is a long-term project and organizations can change extensively during that period. So, to compare the cost of the cloud with the cost of the data center in an ever-changing environment, this Thesis takes aid on the Enterprise Architecture which allows comparing the costs of both solutions seeing not only the current state of the organization but also future states. The goal is to present another perspective of cloud cost calculation. This analysis shows that looking at future states can change the initial decision on cloud adoption. Nevertheless, with a thoroughgoing Enterprise Architecture, the analysis is more accurate.

Keywords: Cloud Migration, Enterprise Architecture, Total Cost of Ownership, Cloud Computing

1. Introduction

This paper extends the current work on cloud migration. It presents an analysis joining the current work with the Enterprise Architecture (EA), having in mind the evolution of the organization into the future, i.e., how to compute the cloud costs not only for the current state of the organization but also having in mind the evolution of the organization (pipeline of projects), the restriction of the data and the applications, considering not only the costs but also the load of the system. It identifies and analyzes variables that should be considered when deciding to go to the cloud or maintain the use of on-premises infrastructures. The EA allows managers to handle complex environments where organizations operate [21]. It gives a comprehensive view of the organizational Information Technology (IT) components [37] allowing to perform measures in the EA model such as performance and workload calculations [21]. The EA provides the necessary tools to increase the understanding and the knowledge of the organization itself, providing an approach for planning possible changes to the organization's architecture [37]. It also supports the modulation of future transformations in the organization [38]. In recent years, Cloud Computing (CC) has acquired enormous significance in IT bringing a new model which supports flexibility and web access to the company's infrastructure [30]. However, problems such as privacy, security, efficiency, trust, legislation, and availability, impose some fall-backs to deploy cloud computing in businesses [6, 7]. Moreover, security and privacy are the most mention reasons not to go live to the cloud [8]. The need for standards and, consequently, the fear of data lock-in also play a role in the decision [2]. Thanks to the pay-per-use basis, rapid scalability, and low initial investment, the cloud manages to attract businesses [1]. For now, managers need to cope with existing technologies and come to an agreement on a fair price between their organization and the Cloud Service Provider (CSP). Businesses are demanding more from IT departments to boost their business value [18]. IT managers have to deal with the organizations' demands as well as keep track of the current technologies and developments being done that can improve the business processes [18]. These concerns sometimes arise when businesses face the decision to buy or to lease new resources [19, 43]. When deciding to go to the cloud, costs should not be the only consideration. Companies need to adapt their systems to take advantage of the real value of the cloud, i.e., adapt their systems to sup-port the scalability and flexibility which the cloud offers [20]. Cloud cost analysis has been analyzed throughout the literature [13, 23, 25, 44]. However, every analysis overlooks the changing environments in which organizations operate and, consequently, their evolution throughout time. Organizations need to look at their internal processes, their current and future projects. Technologies like cloud computing are creating a complex world where complex companies perform [22]. Moreover, businesses must be able to cope with all those changes in the environment, both internal and external, and adopt a strategy to overpower them. So, making a cloud cost analysis today without looking for changes occurring in the future can quickly become worthless. In Section 2, there is an overview of the current cloud migration models and related work. Later, Section 4 presents the research design and implementation. Section 5 and Section 6 show the results and the discussion of those results, respectively. Finally, Section 7 presents the conclusion and some final remarks.

2. Theoretical background and related work

CC has been discussed over the years on what is its meaning and purpose in the business and the IT [34]. According to the National Institute Standards and Technologies (NIST) working definition, CC is:

> a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction [26, p.2].

There are three service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS), and four deployment models of cloud services: Private, Community, Public, and Hybrid clouds [26].

2.1. Decision models for cloud migration

There has been a significant number of migration decision support articles throughout the literature. Each of them analyzes the providers and types of existing cloud services to decide which systems are best for migration [16].

[19] presents a tool-kit that aim in helping decision makers to choose if their enterprise should use CC. It gives some metrics to the decision. However, the article did not consider the migration process of applications to the cloud when performing its cost analysis.

[42] analyses the cost of a Central Processing Unit (CPU) per hour. It presents a comparison of leasing or purchasing having in consideration the Moore's Law. Later on, it presents the comparison between leasing and purchasing storage in another article [43]. It should be considered the bandwidth used for data transfer to the cloud [2]. So, it may be preferable to keep the data on the cloud for computing purposes instead of keeping it on-premises, for example, when dealing with big data.

Another approach for cost analysis is the solution proposed by [5] which gives a method for company managers to use when deciding to lease or to use the on-premises resources. The article follows the Total Cost of Ownership (TCO) concept and empowers entrepreneurs with a cloud computing cost-effectiveness (CCCE) method that analyzes which applications should migrate to the cloud or be on-premises. They conclude that due to the total cost for high complexity applications, it may be preferable to keep on-premises, unlike low complexity applications that are encouraging to migrate. This result goes in align with the conclusions of [36] which concludes that cloud is appealing for small and medium enterprise (SME) that have small complex applications in contrast with large enterprises which mainly have high complex applications. So, their migration to the cloud can be overwhelming.

[12] shows four primary costs of the data center (servers, infrastructure, power draw, and network). They are decomposed and dissected to understand where their costs can be reduced. The article also connects the data center environment with the cloud environment and gives advantages of the cloud environments to reduce those costs. However, as noted by [20], further research is needed in this field for observing the real benefits of the proposed solutions.

There are some online calculators for computing cloud costs in the CSP, but they lack the connection between the on-premises data centers and do not show how many resources are necessary to migrate an application to the cloud and be able to handle its workload [5]. Moreover, CSPs do not share the same configurations, hardware or policies [11] which make correlating on-line calculators puzzling. Also, the absence of cloud standards makes it difficult for businesses to choose from CSPs due to fear of technology lock-in [8, 10].

[10] mentions some considerations that cloud users must have in mind when deciding to migrate. It is decisive for them to develop applications that have cloud requirements in their foundations. For example, resource elasticity, interoperability, and legal concerns. So, the article presents five approaches for migrating applications depending on the depth of the integration. It alerts for applications which can be costly and time-consuming to implement all requirements to use the full potential of the cloud. Therefore, the article provides organizations with solutions from more straightforward to

more complex environments for migrating business components. However, as [4] mentioned, not all applications can be migrated to the cloud. Compatibility, licensing, latency, impose barriers for their transfer.

Besides different architectures and solutions, payment also differs between CSPs. Pay-per-use or subscription need to be analyzed separately because depending on the use, one can be preferable over the other. For example, high resource consumption businesses usually prefer subscription models in contrast with the others that prefer pay-per-use [6].

[9] proposes the creation of models of existing cloud infrastructures using Feature Models (FMs). FMs embodies the entire possibilities of constructions of a system. Creating FMs provide a standardize-like view of the different components that each CSP hold. By analyzing the model together with Automated Analysis of Feature Models (AAFM), it is possible to compare automatically various FMs with the requirements of the business.

To conclude, [23] says that in a cloud migration analysis, it is imperative to consider both the TCO and the utilization costs.

2.2. Decision variables

Deciding to migrate to the cloud or use on-premises infrastructure is just a matter of understanding the variables involved. They will impact the managers' final choice tremendously. First of all, when mentioning CC, this Thesis will only be addressed to public clouds. Private clouds will not be considered since they have the advantages of CC and may lead to misunderstandings regarding the differences with on-premises solutions [1]. Only a small number of IT companies, such as Google and Amazon, have the capacity to use their data centers and turn them into private clouds with the advantages of economies of scale [27], and consequently, becoming CSPs. As for hybrid clouds, they will not be examined thoroughly but will be discussed later.

Since CSPs use CPU cost per hour in their pay-per-use model, it is crucial to consider it locally. [42] presents an extensive analysis of the CPU cost. It could be interesting to include the deprecation of the CPU over time (relating to Moore's Law) in the data center analysis because it is assumed that CSPs have the latest CPU of the market. However, as [42] also concludes, always having the latest CPU installed is not beneficial when comparing cloud versus on-premises.

[13]'s article gives only a small set of variables for this cost computing. It only considers hardware and operation costs. This last one includes the system administrator, space and electricity costs. It makes assumptions that restrict the scope of the solution. It does not include costs related to either software, training, licensing and maintenance [44], or network, security and privacy.

Contrarily to [13], [44]'s article presents a solution to broad for the context of this Thesis. It includes the strategic decision, evaluation, and selection of the CSP which are project-related costs, not cloud versus on-premises costs. Moreover, it considers all processes from the selection of the CSP to the back-sourcing or removal of the service. Also, it analyses the costs for each kind of service that the cloud supplies (IaaS, SaaS, PaaS) separately. As for this Thesis, the type of cloud considered will be SaaS, because it is the only service well understood of its advantages. Thus, simplifying the definition of CC [2]. Nonetheless, licensing and training are important factors to consider because they are present differently in the data center and the cloud.

The [12]'s article presents four components: servers, infrastructure, power draw and network. Each element has small components, such as CPU, memory, and storage for servers, power distribution and cooling for infrastructure, electrical utility costs for power draw, links, transit, and equipment for the network. Every component is interesting to consider in the analysis since they are responsible for the most data center costs. Data centers use generators for dealing with electrical failures from the power distribution network. However, due to the geo-distribution of the servers, and consequently, redundancy of resources, the article proposes that the analysis of the costs should not include the expenses of the generators. They only increase the TCO of a data center without significant advantage.

[40] presents the cost parameters both for data center and cloud. For the data center, there are server hardware, network hardware, hardware maintenance, software, power and cooling, space, administration, storage, bandwidth, resource management software and support costs. For the cloud, there are server hardware, software, administration, storage, bandwidth, support, and resource management software costs. [41]'s article adds reads, writes and redundancy to both the costs presented by [40]. Furthermore, both [40] and [41] agree with previous articles mentioned here regarding data center costs and cloud costs. However, this Thesis will not consider bandwidth as a cost for the analysis, because it has the same cost for both approaches, cloud or on-premises. Moreover, data transfer costs regarding the data center are included already in the bandwidth costs. So, for the data center, neither bandwidth nor data transfer will be considered as parameters. Nevertheless, the data transfer costs regarding the cloud

are well present and certainly relevant to consider.

Businesses are worried about security issues in the cloud [18, 8]. However, [14] gives valid reasons for cloud security to be considered more reliable than those found in data centers. For example, CSPs invest mainly in security since it is their core business. Still, [32] gives a case where the flexibility of the cloud can bring problems to cloud clients. When the cloud is under a Distributed Denial of Service (DDoS), the cloud itself can still handle the extra requests leading to an Economic Denial of Sustainability (EDoS). If the attack does not converge to a DDoS, the increased workload may lead to additional costs for cloud clients.

Cooling is the main reason for expensive electricity bills [28]. Some articles even separate the costs of cooling and electricity [29, 23].

Data lock-in can become a major player in the decision. Businesses fear data lock-in when migrating to some CSPs [2]. There are some efforts to create standards and overcome this problem [31]. OpenStack and OpenNebula are two open-source solutions which can make data lock-in fears disappear. However, they are solutions for creating and managing IaaS clouds [45], which this Thesis will not consider. Nonetheless, each CSPs has its solution [31]. So, data lock-in can be an obstacle and needs deliberation.

3. Enterprise Architecture

In this ever-changing world, EA may be the key element to help enterprises for the challenges of the future. There is an entirely new set of requirements and technologies which organizations have to deal with in their daily activities. For example, CC is one of the disruptive technologies that organizations need to consider, and EA aids the management of such complex systems. It is a field which pretends to enhance management and operation, and Information Systems (IS) of complex enterprises [22]. It pretends to give a universal language of understanding between all people involved in the design of the enterprise [21].

The IEEE standard 42010 defines Architecture as

> fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution [15].

[21] defines Enterprise as "any collection of organizations that has a common set of goals and/or a single bottom line". Later, it also defines EA as

> a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure.

The most commonly used EA frameworks are The Zachman Framework and The Open Group Architecture Framework (TOGAF) [17].

Organizations have to align business strategies and IT on the same page. So, having a clear view of the organization and a strategic alignment between both processes is essential for their success [21]. The EA has only the significant functions and interfaces of a system, and capture the necessary components of a process. Ignoring the business requirements is dangerous and can lead to incompatibility between legacy systems and new systems. Finding a trade-off between moving forward and staying the same is critical in this phase [3].

[21] presents a Dutch case study showing the possibility for EAs to propagate information throughout their entities. It uses an EA metamodel which propagates the utilization times of the business layers to the technology layers of the model. This propagation allows knowing the us-age percentage of IT resources and extending the understanding of the organization.

4. Research design and development

This paper takes aid from a metamodel firstly presented by [24]. However, not all entities of the metamodel are essential for the analysis. Figure 1 shows the relevant components of the EA metamodel to this paper.

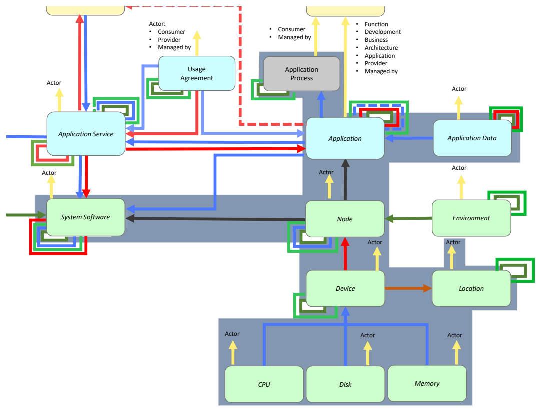


Figure 1: EA metamodel focused on the relevant entities. Source: adapted from [24]

It also uses a tool called Enterprise Architecture Management System (EAMS) which automatically generates EA models and representations on-the-fly from the textual information of different sources [33]. This tool also gives an instrument to view organizational change over time by collecting the organization states at a present position (as-is states) and future positions (to-be states). Table 1 shows the variables considered in this analysis and their relationship with the infrastructure where their cost is present.

Table 1: The relation between variables and the infrastructure where their cost exist

	Data center	CSP
Electricity	x	
Server	x	
Space	x	
Staff	x	
Network	x	
Maintenance	x	
Software	x	
System failure	x	
Data transfer		x
Support		x
Training		x
Migration		x
Licensing		x
Legal issues		x
Privacy		x
Data lock-in		x
CPU	x	x
Security	x	x
Storage	x	x
Memory	x	x
Redundancy	x	x

The variables present in Table 2 are added to their respective entity on the EA. Only variables of the data center have their representation in the metamodel.

Table 2: Variables of the data center and the corresponding EA component

Variable	EA component
Redundancy	Device
System failure	Device
Server	Device
Electricity	Device & Location
Network	Device & Location
Maintenance	Device & Location
Security	Application Data, Device & Location
Space	Location
Staff	Actor
Software	System Software
CPU	CPU
Storage	Disk
Memory	Memory

The variables Server, Space, Staff, Software, CPU, Memory, and Storage are straightforward. Each of them has a direct relationship to an EA component.

The only staff costs calculated will be from the EA elements which are managed by the CSP once in the cloud, i.e., the *Location*, the *Device*, the *CPU*, the *Disk*, and the *Memory*.

Electricity and Maintenance are also straightforward because the Server is the main reason for their existence. So, since the Server is a *Device*, then both of them are in the *Device* as well. Moreover, Space, i.e., the *Location*, needs to be powered (Electricity) and cleaned (Maintenance).

Redundancy correlates with storage and, consequently, the *Disk*. However, higher redundancy means more storage and more disks which need to be represented in the EA. So, the *Device* has a property to keep the redundancy rate associated with its disks which allows knowing how much storage is used for redundancy.

As for Network, the *Device* and the *Location* have network infrastructure. So, the cost is present in both of them.

As for System failure, the two main components that fail in a data center are the *Device* or the *Application*. However, an *Application* can fail both locally and remotely. So, it will only be considered on the *Device*.

Finally, Security measures need to be placed both on the data of an application and the device itself, because both of them can be potential targets. Furthermore, the location of the data center can be threatened as well. So, *Application Data*, *Device* and *Location* have security cost.

The variables inserted in the metamodel for Electricity are not the cost itself, but rather the amount used, i.e., the Watts used. So, depending on the current cost of the kWh, its cost is computed afterward. The System failure, the Maintenance, and the Security have their costs per month. Furthermore, the cost of maintenance is indirectly separated between different EA entities considering that every time an EA component of the *Device* is substituted during maintenance procedures (for example, a *Disk*) it is introduced in the EA. Thus, the maintenance cost in the *Device* refers to the expense of the staff maintaining it and other materials which do not have any representation in the metamodel. The cost of ownership of the *Actor* and cost of the ownership and network costs of the *Location* are costs per month. All hardware-related costs of ownership, such as *CPU*, *Memory*, *Disk*, and *Device*, and software-related costs of ownership, such as *System Software*, are costs of their one-time purchase. The network cost of the *Device* is also one-time purchase.

As for the CSP variables, they are stored in an EA entity outside of the EA metamodel. The EA entity is Measure. This entity is one of the essential parts of the EAMS dashboard which behaves as a front-desk for managers to analyze data from EA models. The entity and its relationship with the previous metamodel is present in Figure 2.

One important feature of the solution is the ability to calculate the costs of the variables at different timestamps. The EA of an organization is dynamic

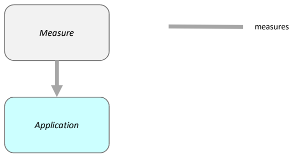


Figure 2: External EA metamodel with the CSP variables.

and uncertain, so, doing a cost analysis for separate time periods can be an advantage. It is developed a set of calculation formulas which will be solved automatically by EAMS to calculate the cost of both local and cloud solutions throughout time, not only at current but also future states of the EA model. Finally, with the metamodel uploaded and populated with the organization's data into EAMS, it is possible to run the calculation formulas and get results. First, the analysis calculates the costs for a starting date. Then, it calculates the costs for different time interval along with the workload of the system for a specific application. The IT resources and costs are propagated from the technology layer to the application in analysis. The manager provides the start date, the range and the number of time intervals of the analysis.

4.1. Scenario and setup

It is examined four applications with different sequences throughout time, i.e., with evolutions on the organization. They already have in place a prediction for their evolution during the next six months. In the next months, the business will be expanded at the beginning of each month. These expansions will mainly affect two of the four applications.

- The application A will see an increase in the number of users and, consequently, in its requests, with every new expansion. It will be deployed beforehand two new devices to handle those extra requests. One in two months' time and another in three months' time.

- The application B (Site) will also see an increase in connections during the next month and in four months' time above the average consumption, but only during those periods. So, in the next month, another device will be deployed.

- The application C continues to maintain the same effort, i.e., the number of users will stay the same during the period of analysis.

- The application D is mainly operated during the last week of the month. So, it will have a significant increase in the number of users during that period.

Each application has at least one dedicated server with a six-core CPU, 1000GB of disk space, and 16GB of memory, which consumes 450W and 93W in full and idle, respectively, for €1284 (after six months both application A and B have three and two servers, respectively). All servers are stored in the same location which costs €100 per month. The location and the servers are managed by two managers who cost €1000 per month each. Every server as an instance of an operating system which costs €2389 each. The price of kWh considered is €0.20. It is also considered a lifespan of five years for the servers and the system software. As for the cloud, it is considered only the cost of the cores per hour and GB per hour of memory and storage, which are €0.0722, €0.0059, and €0.0003, respectively. All remaining costs are omitted from the analysis.

5. Results

First, for every application, it is calculated the workload. In EA, the workload is calculated using the relations *Actor-Business Process-Application Service-Application*. For example, considering that two actors use a Business Process during one hour and the *Business Process* has an *Application Service* that uses one CPU during thirty minutes, this means that there is a workload of two CPUs during one hour. However, in practice, only the workloads calculated directly from the servers are known. So, both workload results (from the EA or the servers directly) are stored in the *Application Process* entity.

Second, it is associated the costs with the workload for each application and presented in line or bar graphs to the managers.

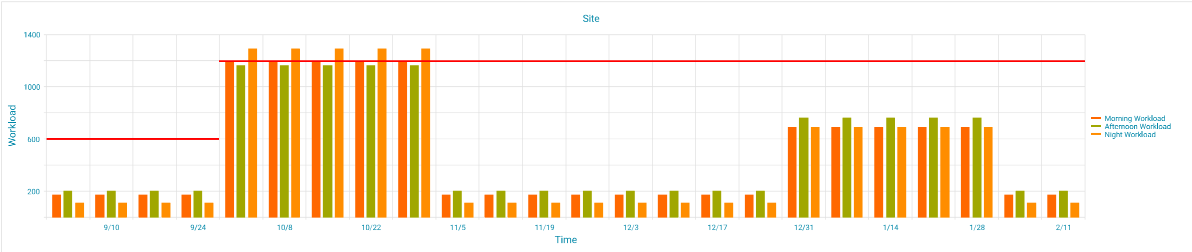
The application A starts with the local costs higher than the cloud costs. However, it the increase in the workload and the number of resources required, the cost of the cloud increases at a higher rate than the local costs. This increase leads to the overall cost of the cloud to be higher than the cost of the data center.

Figures 3 and 4 show the workload and the cost evolution of the application B (Site), respectively.

In this scenario, the cloud costs behave in the same way as the previous application, with every extra workload increasing the cloud costs significantly. So, again the overall cost of the cloud is higher than the local infrastructure. However, the local infrastructure is not able to handle the extra work-loads leading to an under-provisioning while the cloud with its flexibility can.

For application C, the full use of resources leads to a decrease on local costs which makes them more affordable than the cloud.

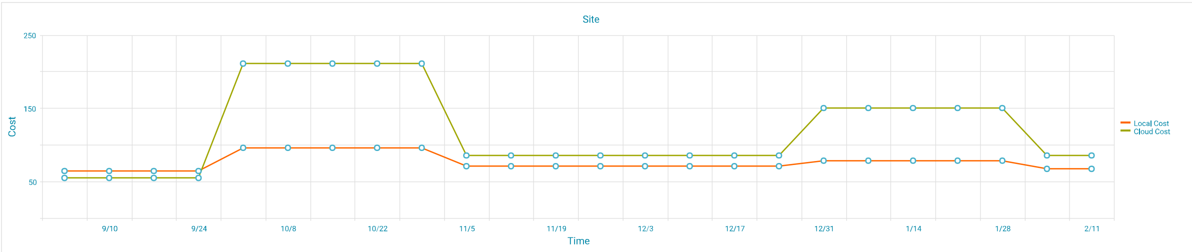
The application D is mostly unused except some



NAME	MIGRATABLE
CRM	True
Site	True
Marketing	True
Finance	True

50 items per page 1 - 4 of 4 items

Figure 3: Site: Local workload dashboard



NAME	TOTAL LOCAL COST	TOTAL CLOUD COST	MIGRATABLE
CRM	1850.80	2854.66	True
Site	1829.37	2878.38	True
Marketing	1538.62	2480.85	True
Finance	1320.97	1053.93	True

50 items per page 1 - 4 of 4 items

Figure 4: Site: Local versus Cloud Costs dashboard

specific periods. During those periods, the application is used at its full capacity. So, during idle periods, the cloud is unsurprisingly cheaper because the resources that are being paid are only those in use. During full capacity periods, as seen with application C, the local data center is cheaper than the cloud. Since the application is 80% of the time at idle, the overall cost for the cloud is cheaper than the local infrastructure.

6. Discussion

These results show that the cloud is ideal for applications that are not used frequently. Looking at the cost tag, applications which use all data center resources become almost illogical to migrate to cloud resources as they are more expensive than local resources. This conclusion goes in line with [42, 5]. However, there are other important variables which are not considered in this demonstration which can change the result of one over the other. For instance, the maintenance costs are not considered in the data center costs, and the data transfer costs are not taken into account in the cloud costs. Both of them can have a significant impact and benefit the cloud or the data center approach, respectively.

Moreover, even with the extra cost, the cloud is flexible enough to able additional requests. Thanks to its pay-as-you-go model, flexibility, and scalability, the cloud offers a solution for reducing the risk of under-provisioning and over-provisioning [2]. So, as seen in the Site, managers need to decide between keep or increase the computational power, i.e., keep the lower cost data center, but loose requests and potential clients or go for the higher cost cloud, but be capable of handling additional workloads.

[42] also shows that the cost of the hardware increases through time because of the increased cost of hardware maintenance, and buying a new hardware can be expensive. However, when upgrading the hardware of the data center, it is possible to sell existing hardware for lower prices of newer devices.

From the variables considered on the demonstration, the costs of the managers (*Actor*) had a significant impact on the local costs. However, they were not as steep as those present in [41] which represent more than 70% of the computation costs. Those results occur because the article considers a low administrator per server ratio contrarily to [2] which have higher ratios depending on the size of the data center.

Furthermore, migration costs cannot be overlooked so easily. An application needs to be redesigned to take full advantage of the cloud resources. Otherwise, the price of the cloud can be higher than the price of the data center [19]. Thus, it is essential to introduce as much data as possible in the EA to have more accurate results when comparing local versus cloud costs.

6.1. Future research and limitations

There were considered a set of variables which are relevant for the analysis. However, it is possible that some variables which were omitted have a significant impact on the cost analysis for both approaches (local and cloud). Relevant cost and factors of CC are crucial pillars to decide to adopt the cloud [44]. So, overlooked costs can impair the analysis. Furthermore, the analysis uses predictive data from to-be states of the EA which is sensitive to inaccuracies, and consequently, provides inaccurate results.

This analysis also makes the assumption that the same local resources will be used in the cloud except for the CPU. For example, for CPU-intensive tasks, using more resources for a shorter period in the cloud can be cheaper than using fewer resources for a more considerable period locally. So, analyzing the time taken to perform the same task on both systems can also be relevant.

The deployment model analyzed in this Thesis was the public cloud. However, hybrid clouds are an interesting approach and the real cloud that businesses are looking for their organizations. Cloud bursting gives to enterprises the advantages of both the public and the private cloud without their disadvantages. However, it brings other barriers to its adoption, like increased complexity, latency, extra costs and security issues [4]. So, this analysis should be extended and studied the trade-off between hybrid and public clouds, and on-premises solutions.

There are also some security concerns in the cloud which do not exist in on-premises. DDoSs can occur in the cloud and understanding if the CSP covers those extra costs made by the attack or the client needs to cope will them all. This Thesis overlooks this problem but should be clear which are the insurances or protections if any concerning problems like this one when discussing the contract with the CSP.

Although this work focuses more on costs, it should be explored the cost versus the benefits of the cloud as [14] describes. Moreover, to examine the agreement between advantages of the cloud and the value of the data [39].

It is important to consider also the benefits of the cloud, not just related to its costs as this analysis does. For example, for applications in which it is not possible to determine at first-hand how much workload it will have to deal with, the data center solution will be likely under-provisioning, or over-provisioning and resources are not enough or being wasted, respectively. So, the cloud provides a way to deal with this cases thanks to its flexibility and scalability.

Furthermore, it is relevant to compare not only the benefits and the costs but also the risks involved with the migration and production on the cloud. DDoS is one potential hazard as explained before. Still, there are other risks such as legal issues, incompatibility between CSPs, and contract issues, with which organizations need to deliberate with [35].

7. Conclusions

The goal of this work is to present another perspective on cloud adoption analysis. By working on top of a structure that is always up-to-date and relevant for business managers and infrastructure managers alike, a structure not only valid for making this cloud cost analysis, but also for other purposes of the organization. It was used a solution with foundations on the EA of an organization which allows viewing both *as-is* and *to-be* states of an organization. The latter is the differentiator on the current cloud cost analyses.

Nowadays, businesses must integrate their operations and processes with IT [21], and EA provides a clear view of the processes underlying the organization. Gathering the variables for the cost analysis is the most significant challenge because there are too many conditions to take into account. For example, some of the costs associated with bandwidth data transfer of large volumes of data can be tackled by sending the physical disks with the data using a courier delivery service [2]. Thus, adding this condition to the list of cost analysis. However, considering all these variants is exhausting and time-consuming since they keep changing over time. So, this work considers those that have a significant impact on the migration and gives an approach which can be easily extended by adding additional variables to it.

One of the most significant advantages of cloud computing is its flexibility. The risk of under-provisioning or over-provisioning the resources required is a real problem [1], especially the under-provisioning because can affect possible customers who may not use any longer the service provided [2]. As a result of its flexibility, the cloud does not share these problems. A client of the cloud only pays the resources it requires to the current state of the business.

This analysis can check if a sub-system can or cannot be migrated to the cloud, considering both applications restrictions and data restrictions. As for the evolution of the organizations, thanks to the

EA, this is achieved as well.

The solution makes use of an item of the organization which it can be reused. The only piece of artifact that cannot be used again is the transformation rules and the dashboards. So, this, consequently, adds value to the organizations. By mapping the organizations' processes inside an EA, it is possible to create visualizations of them and their connections and seeing the time organizational changes when using blueprints generated from the EA.

To conclude, this work proposes a different approach to the calculation of cloud and data center costs. It offers managers a tool to analyze the costs of both approaches not only at the current time but also into the future. It analyzes the costs of the local infrastructure focusing on the elements relevant for comparing them with the cloud. Plus, since flexibility is a key selling point of the cloud, this analysis offers an explicit illustration of the total capacity of the local infrastructure to user requests, aiding managers with relevant information near their final decision.

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