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Cost analysis using efficient methods and tools in cloud computing

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Abstract

Interest in cloud computing is growing, and, as a result, there is much information about it – both positive and negative. On the one hand, cloud computing saves money because it does not require IT infrastructure, servers, and it is very scalable. On the other hand, it might lead to financial loss due to security risks, possible data access problems, data privacy policies, etc. For many organizations it is difficult to determine the total costs caused by offering own services in the cloud as well as to compare them with the costs caused by an in-house datacenter. In practice, some models exist that support organizations in analyzing costs. However, these models are mostly static and do not consider the dynamics of cost development when using cloud computing. The purpose of this paper is to design and develop a simulation model that covers such dynamic aspects and supports decision makers in analyzing cost-benefits of cloud computing.

Keywords: Cloud computing, Cost analysis, Server cost, Cloud computing cost

1. Introduction

Cloud computing paradigm has evolved recently and it has taken commercial computing to a new level. The concept of cloud computing rests upon the idea that computing resources will reside somewhere other than the computer room and that the users will connect to it using the resources as and when required. In effect, it displaces the infrastructure to the network so that the overall cost with respect to the management of hardware/software resources is reduced. It appears to be highly disruptive technology hinting to the future where computation moves from local computers to centralized facilities operated by third party compute and storage utilities.

However, considering the practical implementation of cloud computing, the adoption of cloud platforms by organizations/scientific community is in its infancy. There is a paucity of research towards a model that can demonstrate the benefits of cloud computing adoption and suggest the ideal time to shift to cloud computing. This study attempts to develop a cost-benefit analysis model that can present a clear picture to the IT managers when the shifting from legacy systems to cloud computing is concerned. The computing resources and IT infrastructure of every organization is idiosyncratic. Hence, direct recommendations on profitability cannot be given until all the inputs of organizations have been considered for profitability evaluation. This paper, therefore, suggests a model that can take various parameters of an organization and provide recommendations on profitability of shifting to cloud computing.

Base Cost Estimation

Since cloud computing uses on-demand pricing, it is important to calculate the cost of maintaining IT infrastructure in house. Though many authors suggest more sophisticated cost calculation model for cloud computing, on-demand pricing would still have its ubiquitous presence in all cost calculation methods. This section explores various costs involved in in-house management of IT infrastructure which is independent of any particular project requirement. For most of the components involved in this section, the concept of total cost of ownership (TCO) is used. TCO is the means of addressing the real cost attributing to owning and managing IT infrastructure. It comprehensively considers the entire lifetime spending, capital costs, cost of operations and hence is suitable for base cost estimation.

A total of nine components have been considered in base cost estimation including amortization, cost of servers, network cost, power cost, software cost, cooling cost, real estate cost, facility cost and support & maintenance cost.

For each component, the following details are provided: a) explanation of all the variables involved and b) the method to calculate the cost of the component. The overall aim is to come up with monthly costs for all the components being considered and thus all variables are converted to monthly parameters. Unless otherwise mentioned, the currency for all calculations is United States Dollars (USD) and the computations are made on monthly basis.

Amortization

It is important to understand the contribution of IT infrastructure costs to the monthly rental structure in an organization. Hence, amortization parameter is calculated for servers and other facilities so that fair attribution of costs for various IT resources (hardware/software) can be brought about. This parameter is required to calculate the monthly depreciation cost (amortization cost) of each infrastructure item being considered. These items have initial purchase expense, the cost of which is calculated based on the duration over which the investment is amortized at assumed interest rate. Studies have revealed that the cost of CPU, storage and bandwidth roughly double when the costs are amortized over the lifetime of the infrastructure.

The interest rate is generally 5% per annum and the depreciation period of real estate is ten years whilst that of servers/other facilities is three years. Once the amortization parameter is obtained, it can be then used in the calculations of required component to obtain the monthly cost. The amortizable parameter for facility (Ap_F) is computed differently from that of server (Ap_S) owing to the different amortization periods. The interest rate is represented as Cost of Money (Com) and is kept in variable form (instead of 5%) to accommodate any changes. Ap_F is calculated as $(Com / (1 - power((1 + Com), (-1 * Time_F))))$, where $Time_F$ is the facility amortization period and measured in months. Similarly, Ap_S is calculated as $(Com / (1 - power((1 + Com), (-1 * Time_S))))$, where $Time_S$ is the server amortization period and measured in months. Therefore, Ap_S and Ap_F will be used for computation of costs in the upcoming subsections.

Cost of Servers

Servers are generally mounted on racks and it is assumed that all the servers have similar configurations. This assumption is made to ease the computation for cost of the server (without amortization). Hence, $Cost_S$ can be computed as $(N_S * Cost_{PS})$, where N_S is the number of servers in a firm and $Cost_{PS}$ is the cost per server in Dollars. The amortizable parameter for server calculated in the previous part will be used to determine the amortized server cost- $Cost_{Am_S}$. It can be calculated as $Cost_{Am_S} = (Cost_S * Ap_S)$, where Ap_S is Amortizable Parameter for Server from previous subsection. The costs other than base cost associated with the purchase of the server have been calculated separately.

Network Cost

The components that contribute to the networking costs are NIC, switches, ports, cables, software and maintenance. The cost of NIC is already attributed in the server cost while that of the software will be taken up in the software cost section. Maintenance activities have also been taken up separately in form of Support and Maintenance Cost. Hence, this section would only deal with the cost of switches, ports, cables and the implementation costs. Since cost associated with

networking again has an initial expense, it is amortized to come up with the monthly cost.

However, networking costs should be amortized to calculated the amortized networking cost represented by $Cost_{Am_Net}$ and given by $Cost_{Am_Net} = Cost_{Net} * Ap_S$ (Ap_S is Amortizable Parameter for Server).

Power Cost

Few studies have quoted that power is the single largest cost in high scale data centers. Though the validity of the statement is debatable, power is clearly one of the fastest growing costs. Green Grid has coined a very useful term named power usage effectiveness (PUE) which represents the ratio of total power to IT Equipment power. Inefficient enterprise facilities are often as low as 2.0 to 3.0 while that of the efficient ones being better than 1.2 (Google, 2010). The IT infrastructure that contributes to the power consumption in an organization includes computing infrastructure (server, switches etc.), network critical physical infrastructure, transformers, uninterruptable power supplies, fans, air conditioners, pumps, lighting etc.

Software Cost

In order to manage the data centers, it is required to install the operating system patches and resources for load balancing. The cost of software associated with the base cost estimation is due to license payment. There are two classes of software considered for cost analysis based on the license structure. Class A software includes operating system while Class B deals with other base software (Application Server, VM Software etc). Class B does not include the project specific software as it will be dealt in the layer addressing the project costs. The details of exact pricing based in total cost of ownership (TCO) for Class A software is provided in Cybersource (2002).

Cooling Cost

Past research has shown that power consumed in data center is equivalent to the heat generation in it indicating the the power rating and thermal output equivalency. This cost estimation method uses the term 'Cooling Load Factor' coined by Li et al. (2009). It represents amount of power consumed by the cooling equipment for 1W of heat dissipated. The other related parameters like Airflow Redundancy constant and Inefficiency constant has been derived from McFarlane (2005). The former represents the redundant airflow required to cool the data center while latter represents the redundant airflow to account for burden of humidification.

Real Estate Cost

This part follows the methodology of Li et al. (2009) in order to come up with monthly cost of real estate being used by IT infrastructure. Data centers take up considerable space and account for the real estate cost. Studies have shown that a 40W per square foot rated data center typically costs 400 Dollars per square foot. However, there is a huge variation in prices based on various geographic locations and hence it has been taken as a generalized variable where area specific values can be captured by the organizations.

Facility Cost

These represent both tangible and intangible components that are essential for the normal functioning of the equipment. These facilities are wrapped into racks which hold the servers. Hence, the TCO of facilities can be computed by segregating

them into racks, so that the prices of facilities per rack can be taken as an input for cost computation. These facilities may include components like PDU, KVM (keyboard/video/mouse), cables etc.

Support and Maintenance Cost

Operational staff being the major category in an enterprise, the staff involved in maintenance of data centers is very small. The ratio of IT staff members to server is 1:100 in an established enterprise, automation is partial and performance indicating problems are largely caused by the human error. After understanding the nature of support and maintenance cost in various organizations, it was found that majority of them outsource this job and the nature of job is documented in the contract. Hence, the computation of this cost incorporates the outsourcing part by taking into account the number of contract visits made in a year and the charges incurred during each visit. Thus, both internal personnel and contract human resources for preventive maintenance are included.

3. Literature Review

In this section we give an overview of literature in the cloud computing and own datacenter.

3.1 Cloud Computing

3.1.1 Costs associated with cloud computing

For many organizations it is relative complicated to determine the exact total costs caused by offering own services in the cloud as well as to compare them with the costs caused by an own datacenter. For instance, the average cost per year to operate a large datacenter is usually between \$10 million to \$25 million, while according to Alford and Morton, an organization with 1,000 file servers faces average costs in the cloud between \$22.5 million and \$31.1 million. According to Durkee, while running into the arguments regarding cloud economics, the first controversy to solve is “OpEx vs. CapEx”. This refers that running an application (or a service) with own resources at the own datacenter requires capital expenditure (“CapEx”), while using external cloud computing resources and paying just for its use means having operating expenditure (“OpEx”). In other words, the question arises whether converting capital expenses to operating expenses (CapEx to OpEx) is a cost advantage or not. For instance, having an own datacenter means having costs for power, cooling, building, network, storage infrastructure, etc. On the other side, running the service in the cloud produces other kind of cost factors, which will be described as follows.

Expensive and slow data connection: Service providers have to develop and transfer the data of the service or application they want to offer to the cloud. Due to low bandwidth and expensive connection fees, the data transfer could be slow and cause high costs to the organization.

Operation costs: Using virtual machines instead of physical machines does not necessarily mean that all the costs associated with hardware and software operations are transferred to the cloud computing provider. Depending on the level of virtualization, some (or even all) of the costs related with software and hardware management may remain (i.e. upgrades, applying patches, etc.).

Migration: Another issue is the costs caused by the software complexity and the migration of the data from a legacy enterprise application into the cloud. Although migration is a one-time task with a given cloud computing provider, the effort and money invested can be notable.

Possible failure and data loss: A temporary breakdown could cause data loss and other scenarios that may produce major damages and extra costs.

Platform costs: The application-operating environment causes generally annual maintenance costs.

Backup and archive costs: These costs depend on the backup strategy implemented.

3.1.2 Risks associated with cloud computing

Although cloud computing shows a number of benefits for many organizations, there is still a constellation of risks associated with it. According to Gartner, cloud computing has “unique attributes that require risk assessment in areas such as data integrity, recovery, and privacy, and an evaluation of legal issues in areas such as e-discovery, regulatory compliance, and auditing”. Moreover, professionals are conscious of this situation: as ENISA shows in their study, around 45% of IT professionals believe that risks involved in cloud computing outshine any benefits. ENISA identifies three main risk categories associated with cloud computing: 1) Policy and organizational risks, such as lack of standards and solutions, loss of knowhow, or lack of transparency; 2) Technical risks, such as uncontrolled backup system, data deletion, or loss of governance; 3) Legal risks, such as data protection, or copyright and software licensing risks.

3.1.3 Advantages of cloud computing

There are a number of advantages and potential benefits for organizations that run their applications and services in the cloud. One of the most known advantages is the cost reduction, which according to Zeitler, results due to low IT infrastructure and software costs. Moreover, organizations implementing cloud computing report cost reductions of 30 percent. Besides the financial factor, there are other related benefits. For instance, Erdogmus describes other advantages of cloud computing as “scalability, reliability, security, ease of deployment, and ease of management for customers, traded off against worries of trust, privacy, availability, performance, ownership, and supplier persistence”. Some of these issues are discussed as follows:

Scalability and flexible infrastructure: Cloud computing offers the possibility to scale the infrastructure with the demand for peak loads and seasonal variations, allowing greater availability for both customers and partners.

Resource management: Service providers can use more flexible and efficient resources like servers, storage and network resources by using virtualization technology in cloud computing.

Consolidation: Resources such as server, storage, databases, etc. can be used more flexible and efficient by using virtualization in cloud computing. Consequently, less physical components are needed and therefore both amount of space and costs are saved.

Energy efficiency: Cloud computing enables energy efficiency due to reduction of physical components.

Backup and Recovery: The backup and recovery options of a cloud service may be more efficient than those of an organization, since copies are maintained in different geographic locations, which makes the backup procedures more robust and faster to restore.

3.1.4 Disadvantages of cloud computing

In the last section we presented the advantages of cloud computing. Nevertheless, there are a number of drawbacks related with it. However, one of the most known and also one

of the most wicked disadvantages of cloud computing is the security and privacy concern. Therefore, in this section we summarize the drawbacks and disadvantages an organization has to face while offering its services in the cloud.

System complexity: Compared to a traditional datacenter, cloud computing environments can be very complex due to the number of components and their dispersion. Moreover, the number of possible interactions between the components increases the level of complexity.

Shared environment: Service providers that offer their services in the cloud typically share the resources and components with other unknown cloud users. Consequently, the risks and threats increase producing a drawback for the offered services.

Remote administrative access: Compared to own datacenter, where the applications and data are accessed from the organization’s Intranet, organizations with services in the cloud have to face increased risk from network threats due to remote access.

Loss of control: Migrating the data in the cloud means transferring control to the cloud provider of both information and system components that were previously under the organization’s control. Consequently, by losing control of physical as well as of logical aspects, the organization also loses the ability to set priorities, weigh alternatives and think about changes regarding security and privacy issues. For many organizations, the advantages of cloud computing far outweigh the disadvantages, for other, the disadvantages still outshine any benefits.

3.2 Datacenter

3.2.1 Risks associated with own datacenter

When considering the option of offering services in the cloud, a provider should not only be aware about the risks associated with cloud computing, but also with the ones related with owning a datacenter. According to Dines, the primary risk associated with having an own datacenter is the capacity bottleneck. Running out of capacity means having high costs and in extreme cases, it “requires an unexpected data center move, which is not only expensive but also potentially disruptive”. On the other side, having too much capacity could also be a risk, since IT infrastructure is most effective at peak load, making the datacenter inefficient. Moreover, besides of facilities, there are also other areas of risks while running an own datacenter, such as operations, monitoring, natural disasters and terrorism.

3.2.2 Advantages of datacenter

Although many organizations decide to move their services to the cloud due to economical issues, there are still many reasons why organizations should keep their services running in their own datacenters:

Visibility: Having direct access to all the infrastructure components like hardware, software and networking allows a better overview and the possibility to identify and mitigate any issues and systemic failures that crop up.

Control: Having the services running in the own datacenter enables greater control over the infrastructure and resources and therefore the access to the platforms can be restricted to direct or internal connections.

Less complexity: Datacenter are less complex since running the services in the own datacenter means having fewer components and therefore fewer interactions between them.

Moreover, all physical components are located in the same place.

Optimization: Having an own datacenter gives the possibility to leverage and share existing place, i.e. having the IT department working in close proximity to the data center floor for a low cost.

Usage of knowledge: Datacenters are normally run by professionals with experience and expertise.

3.2.3 Disadvantages of datacenter

Nowadays there are many organizations that still build and maintain their own datacenters even though that is not part of the core expertise of the company. As a result, there are a number of datacenters that are operated inefficiently. Absence of expertise by running own datacenters also produces a number of other disadvantages that will be described as follows:

Inefficiency: Since a service provider has to provide enough resources to deal with peak times, the average utilization rate of datacenters ranges from just five to twenty percent.

Costs: It is predicted, that the costs of datacenter facility and energy usage will become significantly larger than the actual server procurement costs.

Scalability: Running an application or service in own datacenter makes it difficult to handle a rapidly growing load.

Environment: The impact of datacenters on the environment is currently receiving negative attention.

4. Cloud Computing Costs

We present an overview of Amazon’s cloud services and pricing to be used in our calculations. Amazon has two relevant cloud computing services. First, Amazon offers the Elastic Computing Cloud service. EC2 charges each hour an instance is running, and it offers instances with different compute power and memory. The pricing for EC2 is shown in Tables 1 and 2. Second, in conjunction with EC2, Amazon offers the Elastic Block Store (EBS) service. This provides reliable and persistent storage with high IO performance. EBS charges per GB of storage and per million IO transactions. The pricing for EBS is shown in Table 3. Amazon also offers the Simple Storage Service (S3). This service provides access through web services to persistent data stored in buckets (one-level of directories) along with meta-data (key/value pairs). S3 charges per GB of storage and HTTP requests concerning it. PersistentFS offers a POSIX-compliant file system using S3 and is arguably cheaper than EBS for mainly read-only data. However, for volunteer computing projects, the cost difference between S3/PersistentFS and EBS is not significant and does not change our conclusions. Thus we assume all storage occurs on EBS. We do not consider costs of snapshots, i.e., EBS volume backups to Amazon’s S3.

Table 1. Pricing for EBS

Resource	Rate (USD)
Storage	0.10 / GB-Month
IO request	0.10 / million

Table 2. Project Costs (monthly)

Component	Project	
	SETI@home	XtremLab
Salaries	10K for sys admins	5K
Electricity	90 for 6 servers	15
Network	2K for 100 Mbit	covered by university
Hardware	18K for servers, 25K for air condi- tioner	4K
Total startup	43K	4K
Total monthly	12K	5k

5. Conclusion

This paper has addressed one of the major issues faced by many organizations on their decision to shift to cloud computing. It has attempted a three layer approach in order to incorporate maximum flexibility in the model for easy computation. A comparison across different organizations was accomplished with respect to the profitability of shifting to cloud computing. From the results obtained for thirty organizations, it was found that cloud computing is profitable for small/medium scale enterprise. Large scale enterprise did not benefit from shifting to cloud architecture. This model is being converted into a readymade tool in which the firms can directly feed in data and get recommendations on shifting to cloud computing. Further research would be to analyze the trend in profitability of organizations shifting to cloud. This model could be used to understand the relation between projected profitability and the nature of an organization. Reduction of IT infrastructure costs using cloud computing could be an effective contribution to Green IT.

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