



# Identification of a company's suitability for the adoption of cloud computing and modelling its corresponding Return on Investment

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## ARTICLE INFO

### Article history:

Received 1 November 2009

Received in revised form 15 March 2010

Accepted 16 March 2010

### Keywords:

Cloud computing

Return on Investment (ROI)

Benefits of cloud computing

Cost of cloud computing

## ABSTRACT

Internet has become pervasive in our daily life and cloud computing is the newest offering as service over the ubiquitous Web. Cloud computing has been considered as a much hyped phenomenon in the IT and business world promising to deliver a host of benefits. Companies need to look beyond this hype and seriously consider the real value of incorporating the Cloud in their own businesses. This paper is aimed at helping companies analyze several characteristics of their own business as well as pre-existing IT resources to identify their favorability in the migration to the Cloud Architecture. A general Return on Investment (ROI) model has also been developed here taking into consideration various intangible impacts of Cloud Computing, apart from the cost. The analysis presented herein provides a much broader perspective and insight into Cloud Computing to its prospective adopters.

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## 1. Introduction

Cloud computing (CC) [1] is a paradigm shift in computing with the potential of changing the whole perspective with which we look at computing today. Currently, desktops, laptops and numerous such devices have penetrated into our daily lives and have become indispensable [2]. It will not be too long from now that all we will need to know is that there is one huge computer at a remote location (without even knowing where it is) which has the potential to provide all the computational power and resources that we ever really need.

CC can be defined as collection disembodied services accessible from anywhere using any mobile device with an Internet connection, provided by a type of parallel and distributed system of virtualized computers that are interconnected and that can be dynamically provisioned and presented as one or more unified computing resources based on Service-Level Agreements (SLAs) established between the service provider and the user [3–5].

In this paper, we analyze some of the economic aspects of migration to cloud architecture. Specifically, we attempt to model ROI in using CC in organizations. Studies of the economic aspects, in general, and ROI, in particular, are important organizational considerations in the adoption of any new technology. In the context of Grid Computing [6,7], for example, works (e.g., [8–16]) relating to these aspects exist. As CC is an important technological trend, it is also important to study these economic aspects of CC.

There are different cloud delivery models (e.g., [3,17,18]) based on pay-per-use models, viz., Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS). Software-as-a-Service (SaaS) may be described as a process by which different software applications are provided by the Application Service Provider (ASP) as a rental over the Internet leveraging cloud infrastructure. This eliminates the necessity for installing and running the application on the customer's own computer. It also diminishes the tremendous load of software maintenance, ongoing operation and

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support [3]. Platform-as-a-Service (PaaS) is an entire virtualized platform. It includes one or more servers, operating systems, specific applications and development platforms provided as a service over the Internet for developers to build applications on Infrastructure-as-a-Service (IaaS) is the delivery of computer infrastructure as a service. Infrastructure includes servers, processing power and storage. This helps in the elimination of upfront capital cost and is of immense benefit to companies who want to start small [17,18] and also relieves them of their need to forecast their demands of the future and provision accordingly.

There is no doubt about the paramount potential of CC, but it is yet to cross its stage of infancy, with only a limited number of takers currently, owing to some of the challenges of its widespread adoption such as security, trust, and cost-effectiveness [19,2]. It is estimated that 71% of companies believe that cloud computing is a real technology option. 70% hold that it would make their business flexible. 62% think that it would help them react quickly to market conditions and 65% feel, it would help increase focus on core business [20]. However, in reality, there are only very few companies which are actually using CC. It is because of the lack of proper understanding of the cloud architecture, its pricing model and its suitability to the different requirements and scenarios of different companies with different business environments. These form the motivation behind the work presented in this paper.

The rest of the paper is organized as follows: In Section 2, we provide the background and motivation of this work. Section 3 gives the guidelines that identify the suitability of a company for the adoption of the CC, while in Section 4, we derive our ROI model. Finally, we conclude the paper in Section 5.

## 2. Background and motivation

Considering the way adoption of CC can revolutionize the business scenario as it has revolutionized the research scenario, some work has been done in this field. In [3], Pyke has supported the potential of CC in business and explained how it is a paradigm shift from what we have known traditional computing to be, and how to tell if the application is in the cloud or not. He also dealt with the technicalities for the implementation of CC and its delivery to customers. The various layers in the cloud infrastructure and some delivery models have been exhaustively covered in [4]. The authors have also dealt with market-oriented<sup>2</sup> resource allocation of Clouds by leveraging the third generation Aneka enterprise Grid technology. Some works (such as [24,25]) have perceived the likelihood of CC becoming the fifth utility after electricity, water, gas and telephony.

Comparisons of CC to other forms of computing such as grid computing (desktop grids) and volunteer computing have been made in [26]. The benefits of CC, the challenges faced in the implementation of the cloud architecture, the opportunities in their solution and the various risks that users might have to undertake for migration to the cloud have been explained in [17]. The authors also proposed a tradeoff equation which indicates which technology can give more profit.

Different cloud services provided by the different service providers along with their costs and characteristics have been compared in [27,28].

Reports and inferences drawn from various global surveys carried out for CC have been mentioned in [20,29,18,30]. Also, various types of cost–benefit analysis of cloud have been reported in [31–34], giving direct figures of costs that are included. Currently, there also exists debates in various blog sites between primarily two groups divided on the opinion of profitability of the cloud. One group finds the cloud to be cost saving, while the other finds it to be more expensive. ROI of implementing CC has also been calculated in a few cases (viz., [27]), but pertaining only to specific companies. Even cost analysis of whether e-mail servers should be moved to the cloud is given in [34]. But none of these sources are fundamentally similar in context and scope of this paper which neither measures the suitability, nor gives a generic model for the calculation of ROI. Dargha's work [35] is based on the principle that this paper has followed for finding the suitability index. But the present work provides a much deeper insight. It defines a number of factors to be considered prior to adopting CC. In this paper, we have more criteria over and above the major criteria. This makes analysis more meaningful. The present work also provides both objective and subjective tools for the present analysis as well as for decision making.

Some previous researchers (e.g., [24,25]) have also studied the cost–benefit analysis of CC, but their works pertain to the data of single companies. Only direct costs have been included in their discussions, but as such a generic model containing variables [24,25] which should be applicable to any and all companies—big or small, well established or start-ups, has not been explored.

A contemporary survey has found out that the current pricing pattern and other factors of the cloud make it highly suitable for small and medium enterprises [18]. Currently, CC may not be very suitable for big enterprises. However, no criteria have been set forth to consider the factors which make a company big, medium or small. It is yet to be decided whether the criteria should be based only on their annual revenue or some other factors as well.

The ROI model has been limited only to the accounting of costs of the cloud, the savings made from it or the extra amount to be spent on it. No valuation has been given to the intangible benefits of CC (e.g. [24,25]). Intangible benefits have been limited only to its mention in certain sources.

CC has so far been viewed primarily from the perspective of cost. This paper tries to broaden that outlook with a model that helps not just identify the suitability of a company for the cloud by clearly spelling out all the factors that need to be considered for the same, but also tries to give a certain profitability valuation of the benefits associated with CC.

<sup>2</sup> It is worth noting that similar works in the context of Grid Computing also exist in the literature. Examples include [21–23].

The CC architecture consists of three main players—Cloud Providers, Cloud Users or Customers and Cloud Vendors [36]. In this paper we would be primarily looking from the cloud user point of view. Two types of business models can be drawn for the enterprises (cloud users) willing to adopt CC services. They are:

- i. Business model for companies with existing IT infrastructure.
- ii. Business model for startup companies.

Startup companies are the most eligible candidates for the adoption of CC [18] because of the starkly visible benefits that CC offers in the form of no upfront capital investment in having to buy servers, buildings and floor space to build datacenters, no electricity, cooling costs, no purchase of software licenses, etc. thus there are no barriers to entry. These companies can start small and can invest in the increase of hardware resources as their business flourishes or only when there is an increase in their needs [17].

The challenge comes when making a decision for companies with an already existing and working datacenter (IT infrastructure) on whether CC would be appropriate for the organization and they should embark on the cloud or they should stick to their own in-house infrastructure and invest in their expansion and consolidation [37]. It is expected that this present paper will find use in this regard.

### 3. Identification of a company's suitability for the adoption of CC

Some of the key characteristics of the resources possessed by a company to be considered before hopping onto the cloud “bandwagon” are:

- I. Size of the IT resources.
- II. The utilization pattern of the resources.
- III. Sensitivity of the data they are handling.
- IV. Criticality of work done by the company.

#### 3.1. Size of IT resources

Largeness of the resources already present in a company plays a very vital role in the cost factor. The larger the volume of the resources, the lesser is the per capita cost of operating these resources, owing to the *economics of scale* [17,38–40]. This economics of scale causes TCO of datacenters to reduce their size increases. It then becomes much cheaper and more beneficial in the long run than using the cloud services. Thus, it may not be economically viable, or for that matter profitable, for companies with sufficiently large datacenters to drop their own infrastructure and head towards the cloud. Considering all relevant factors, however, cloud computing has been found to be more suitable for small and medium size business enterprises [18].

Some of the factors that are taken into account, while determining the size of the IT resources of a company are:

1. The number of servers the company maintains in its datacenters.
2. The size of the customer base of the company.
3. The annual revenue from IT.
4. The number of countries across which the company is spread over [35].

##### 3.1.1. Number of servers

- a. Less than 100 servers ... (small).
- b. From 101 to 2000 servers ... (medium).
- c. From 2001 to 10,000 servers ... (large).
- d. 10,001 to 50,000 servers ... (very large).
- e. 50,001 to 100,000 servers ... (super large).
- f. Above 100,000 servers ... (IT giants).

Categories ‘e’ and ‘f’ do not count. Category ‘e’ belongs to companies like Akamai Technologies, 1&1 Internet, Rackspace [20], etc. which maintain or rather host huge ‘server farms’.

It may so happen that in their servers a large part of the Internet resides. If it is so, it would not be meaningful for them to go for the clouds because they make their money by maintaining servers for other companies. Category ‘f’ belongs to huge hulking IT giants such as Google, Amazon, and IBM [41]. They too do not count because they themselves are as such some of the key players providing CC services.

##### 3.1.2. Size of customer base

The size of the customer base or the number of users of the services offered by a company is a very good yardstick in estimating the size of the internal resources maintained by an organization for its smooth functioning and service delivery. It also gives a picture of the utilization pattern of the in-house datacenter resources. A wide geographical distribution of the customer base of a company would give a more or less constant workload pattern [35].

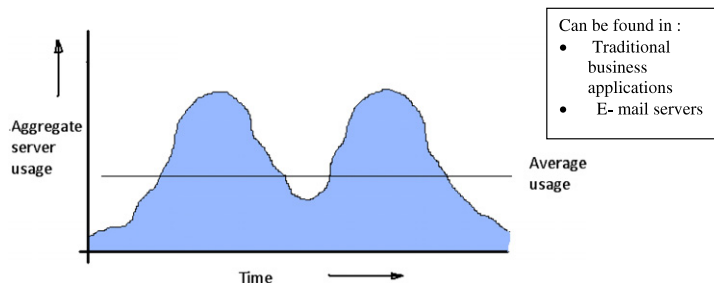


Fig. 1. Moderately variable workload with no surges.

### 3.1.3. Annual revenue from IT offerings

The amount of revenue generated from the IT resources of a company goes a long way in deciding whether it should still maintain the expensive yet convenient datacenters or should it adopt seamless switch over to the cloud.

- a. Less than \$ 100 million ... (small).
- b. Between \$ ( 100–500) million ... (medium).
- c. Above \$ 500 million ... (large).

### 3.1.4. Number of countries IT is spread across

The greater the number of countries [35] a company and its datacenters are spread in, the greater the pool of its internal resources facilitating larger benefit from economies of scale and thus reducing its operational cost. Also, if the company has its presence felt in a number of countries, then its workload can be assumed to be quite constant which might reduce its suitability for the adoption of cloud services [17,35].

Some categories we can break them up into:

- a. One country.
- b. More than one but less than four countries.
- c. Less than or equal to six countries.
- d. Less than ten countries.
- e. Above 10 countries.

## 3.2. Utilization pattern of the resources

Merely having large or small resources does not make it beneficial for a company to respectively abstain from or embark on the cloud services. Profitability also depends on the amount of utilization of the existing resources. A large number of very underutilized (too much over provisioning) server resources leads to a large amount of wastage and hence makes it suitable for using cloud services, whereas small yet perennially well utilized servers would not be economical if taken to the clouds. McKinsey report states that the global average server usage tops at 5%–10% only. This happens as a result of provisioning for the peaks, the sudden spikes & surges. It is a very daunting task to accurately forecast workload requirements. This task gets even more aggravated in businesses which depends on web applications and whose workload varies a lot more than traditional business applications [18]. CC is beneficial for companies especially if there are highly variable spikes in resource demand [17].

We can determine the utilization pattern by:

- a. Average usage.
  - i. The type of services offered by the company.
  - ii. The number of users using the services, i.e., same as customer base.
  - iii. The number of projects undertaken.
- b. Peak usage.
  - i. The duration of peak usage/year.
  - ii. The number of times the peak value is of the average value.
- c. Amount of data handling/transactions done.

Average and peak usage patterns.

Let us look into some of the normal workload variability patterns found in enterprise installations:

- Profile 1: Moderately variable workload with no surges [42] (Fig. 1).
- Profile 2: Highly variable workload with spikes [42] (Fig. 2).
- Profile 3: No variability constant workload (Fig. 3).
- Profile 4: Moderately variable workload with occasional surges (Fig. 4).

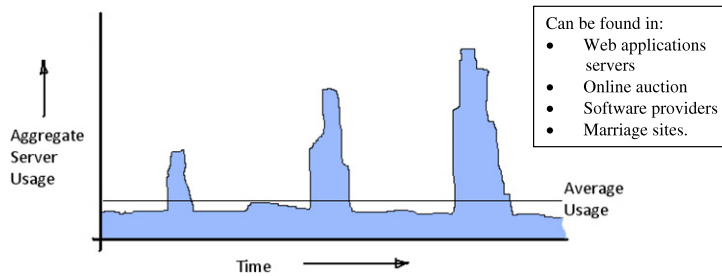


Fig. 2. Highly variable workload with spikes.

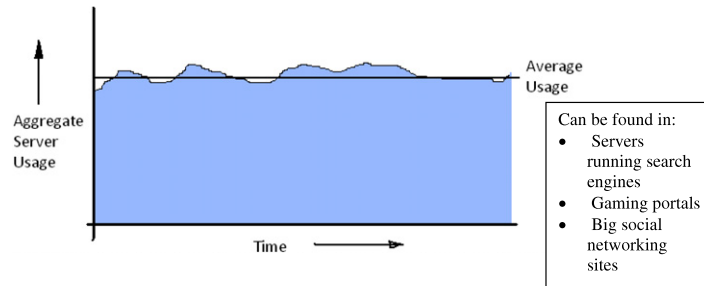


Fig. 3. No variability constant workload.

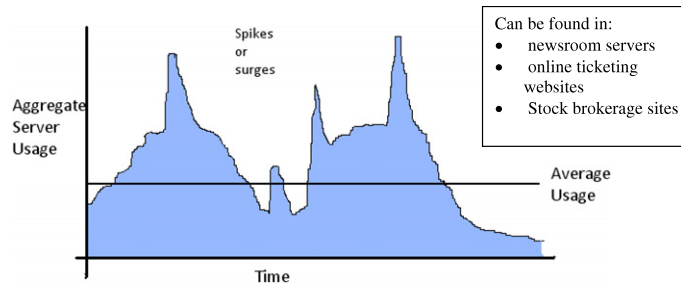


Fig. 4. Moderately variable workload with occasional surges.

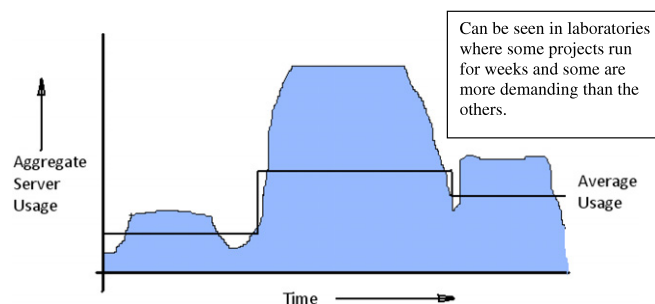


Fig. 5. Variable workload with long averages.

- Profile 5: Constant workload but workload pattern varies at different times of the year owing to different types of project undertaken (Fig. 5).

Type of services offered by a company.

Table 1 shows some examples of types of services offered by a company.

Type of projects undertaken

In this work, the type of a project refers to the degree of computationally intensive processes required to complete a task. This criterion may not be applicable for all organizations especially for those enterprises which provide web applications or internet services. These are meant for those enterprises which are involved in the various computationally intensive jobs, e.g., research laboratories involved in nuclear research, drug design, weather forecasting, etc. or companies involved in

**Table 1**

Some of the different types of online services offered by companies.

Service offered	Workload profile	Surges in workload and their duration
Social networking	3	–
Search engines	3	–
Online book store	4	New book releases. Lasts for a few days only.
E-mail	1	–
Gaming portals/arcades	3	–
Marriage sites	2	During marriage season. Usually lasts for 1 or 2 months in a year.
Banking/finance	3	–
Newsrooms	4	During sudden break of big events, disasters. Lasts from a few hours to a few weeks.
Software providers	2	New software releases. Lasts for a few weeks.
Video/music sites	3	–
Downloadable sites	–	–
Jobs site	1	–
Pornography sites	3	–
Online ticketing	4	During holiday seasons, festivals, disasters. Lasts for a few weeks.
Stock brokerage	4	Sudden fall or rise of SENSEX. Lasts for a few hours.
Photo sharing sites	2	After holiday season. Lasts for a few weeks.
Online shopping/auction	2	During lottery. Lasts for a few minutes only.

developing high-end animation and special effect movies and games or companies which are involved in the development of various softwares and applications. Thus, type of project also plays a crucial role in determining the average workload pattern of any organization.

#### Peak usage

Peak usage is the maximum utilization of the computational resources present in an organization. Peak value is reached when the demand suddenly increases and reaches its maximum value. Hence, they are often known as surges or spikes. But they may be very discrete, intermittent and sporadic. If the organization resources are provisioned for these peaks, then it leads to large wastage of idling resources. Highly variable workloads are more suitable for the clouds than constant ones [17, 18]. Peak usage can be measured in terms of:

- i. Duration of peaks. If the peaks are quite frequent, then the aggregate duration of the peaks may become worthwhile for provisioning in the organization's own datacenter. But if this duration does not accumulate to a substantial amount, then provisioning for these peaks would tantamount to large wastage of resources [42] and hence opting for CC would be a viable option.

Aggregate duration of these peaks in a year has been categorized into:

- Few hours.
  - Few days.
  - Few weeks (less than or equal to 3).
  - Few months (less than or equal to 3).
- ii. Peak by average value.

Provisioning for workload patterns with the value of peak a few multiples of the average value would draw large wastage of precious resources. If not provisioned, it would result in a large number of unsatisfied customers or delay in product delivery. Highly scalable and dynamically allocated resources of the cloud would be the best option in these scenarios.

Peak by average value has been categorized [17,43] into:

- Less than twice ... (least wastage).
- Less than five times.
- Less than ten times.
- Above ten times ... (huge wastage).

#### Amount of data handling

Amount of data handled, acted upon or generated in a day also should play a significant role in a company's decision to move for the CC services [17]. Huge amount of data acted upon would require a large bandwidth concerning data processing and storage in the cloud environment [44,45]. This would cause substantial amount of money to be spent on bandwidth charges alone, which would be detrimental for the adoption of CC in the long run. For example, CERN, the European Organization for Nuclear Research, generates terabytes of data each day from its nuclear research in its laboratories. If all these data were to be sent to the clouds for processing as well as storage and also recalled regularly for analysis, firstly it would take a huge amount of time for transfer. Also, the bandwidth charges alone would be a significant portion from their budget, apart from the charges of storage of such huge amount of data in the clouds.

In this case, the categories have been sub-divided into:

- a. Above 100 terabytes/month.
- b. 1–100 terabytes/month.

**Table 2**

Categorizing sensitivity of data.

Category	Data
Extremely sensitive	Information and data of government federal and intelligence agencies like CIA, FBI. Blue prints and information regarding weapon systems, artillery, aircrafts, etc. of the defense forces. Matters concerning national security [21].
Very sensitive	Bank related data like bank accounts, passwords, pin, transactions and balances, etc. Financial data of companies, quotations for various tenders, etc. Company databases. Ongoing confidential research. Trade secrets, drug formulas, early research findings [21]. Source codes. E-mail accounts.
Sensitive	Personal information such as name, contact details, e-mail-ids, profiles. Patient records, health records [21].
Less sensitive	Pictures, videos in social networking websites. Click stream data. Service usage details.
Not sensitive	Free software, music, videos, pictures, games, news, articles. Views & comments in blogs. Anything downloadable which is authorized.

c. 500 gigabytes–1 terabytes/month.

d. 100–500 gigabytes/month.

e. Below 100 gigabytes.

### 3.3. Sensitivity of data handled

One of the major apparent shortcomings of CC, which prevents it from being a runaway success is the concern for the security of data governance [46] in the cloud environment. Though there has been huge advancement in security and there are no fundamental difficulties as such in making the cloud a high security density zone with well understood encryptions, data firewalls, and packet filters [17], but it is yet to be tested exhaustively in the real life. Data security becomes more of an issue as the sensitivity of the data handled by a company increases. Concerns of data lock-in in case of outages and data availability in the long run in case a cloud provider goes out of business aggravates the problem. Data needs to be protected from unauthorized disclosure, fraud, waste or abuse at all costs [47,19].

Sensitivity of data has been categorized as in Table 2:

### 3.4. Criticality of work done by the company

Highly critical work requires the most stringent of resources, platforms, applications and security. The more critical the work gets, the more demanding gets the requirements. Thus very critical work may not find suitability to the cloud as it would require very stringent Service-Level Agreements (SLAs) [35] with the cloud provider. If the company is not very big, then the cloud service providers may not be very willing to provide the highly customized Service-Oriented-Architecture (SOA) and Application Programming Interfaces (APIs). They may not even be able to deliver the Quality-of-Service (QoS) [4, 19,48–51] in processes requiring very low latencies [17,35] owing to constraints of the system or lack of profitability and feasibility on their part.

Criticality of services can be categorized into:

Highly critical ... (may not be suitable for the cloud).

Critical ... (may be suitable if company is large).

Less critical ... (suitable).

Standard ... (easily suitable).

#### Tabulation sheet

All the factors have been assigned various credits (weights) according to their relative importance in the factor which constitutes them. The credits that have been already assigned may work for certain companies, but certainly not for all companies. The credits may be customized by the companies, depending on the importance of the characteristics for them or their business. Table 3 acts as an initial guide in arriving at the decision of whether or not CC is suitable for an organization and should not be considered as the definitive and the only tool for the same.<sup>3</sup> In-depth analysis should be carried out and various other factors at the company level should be considered before taking a final leap in embarking to the clouds.

<sup>3</sup> Owing to change in market conditions the outcome of this study may differ. An in-depth (subjective as well as objective) analysis is strongly recommended and will be required when applying for personalized businesses as other factors may also arise.



**Table 3**  
Tabulation sheet.

Characteristics	Credits
Size of IT resources	7
Number of servers	8
Less than 100 servers	4
From 101 to 2000 servers	3
From 1001 to 10,000 servers	2
10,001 to 50,000 servers	1
Number of countries it is spread across	4
One country	5
More than one but less than four countries	4
More than equal to four but less than equal to six countries	3
More than six but less than ten countries	2
Above 10 countries	1
Annual revenue from IT offerings	4
Less than \$ 100 million	3
Between \$ (100–500) million	2
Above \$ 500 million	1
Workload variability	8
Peak usage	6
Duration of peak usage/year	6
Few hours	4
Few days	3
Few weeks (less than equal 3)	2
Few months (less than equal 3)	1
Peak by average	9
Less than twice	1
Less than five times	2
Less than ten times	3
Above ten times	4
Average usage	8
Type of services	5
Profile 1	2
Profile 2	4
Profile 3	1
Profile 4	3
Type of projects undertaken	5
Profile 1	2
Profile 3	1
Profile 5	3
Size of user/customer base	7
Above 10 million	1
100,000 to 10 million	2
Below 100,000	3
Amount of data handling	5
Above 100 terabytes/month	1
1–100 terabytes/month	2
500 gigabytes–1 terabytes/month	3
100–500 gigabytes/month	4
Below 100 gigabytes.	5
Sensitivity of data	6
Extremely sensitive	1
Very sensitive	2
Sensitive	3
Less sensitive	4
Not sensitive	5
Criticality of work done	4
Highly critical	1
Critical	2
Less critical	3
Standard	4



## Calculations

Various calculations can be carried out using the following formulae:

$$\text{Largeness value } (L) = \text{NoS} \times C_{\text{NoS}} + \text{NoC} \times C_{\text{NoC}} + \text{AR} \times C_{\text{AR}}.$$

$$\text{Average Usage value } (AU) = \text{ToS} \times C_{\text{ToS}} \quad (\text{or}) \quad \text{ToP} \times C_{\text{ToP}} + (4 - \text{SCB}) \times C_{\text{SCB}}.$$

$$\text{Peak Usage value } (PU) = \text{DoP} \times C_{\text{DoP}} + \text{PbA} \times C_{\text{PbA}}.$$

$$\text{Value of Workload Variability } (WV) = \text{PU} \times C_{\text{PU}} + \text{AU} \times C_{\text{AU}} + \text{ADH} \times C_{\text{ADH}}.$$

$$\text{Value of Data Sensitivity } (DS) = \text{SoD}.$$

$$\text{Value of Criticality } (C) = \text{CWD}.$$

Finally,

$$\text{Suitability index} = L \times C_L + \text{WV} \times C_{\text{WV}} + \text{DS} \times C_{\text{DS}} \times \text{ADH} + C \times C_C \times (65 - L).$$

Here,

NoS = Number of Servers

$C_{\text{NoS}}$  = Credit of Number of Servers

NoC = Number of Countries it is Spread Across

$C_{\text{NoC}}$  = Credit of Number of Countries it is Spread Across

AR = Annual Revenue

$C_{\text{AR}}$  = Credit of Annual Revenue

SCB = Size of Customer Base

$C_{\text{SCB}}$  = Credit of Size of Customer Base

ToS = Type of Service

$C_{\text{ToS}}$  = Credit of Type of Service

ToP = Type of Project

$C_{\text{ToP}}$  = Credit of Type of Project

DoP = Duration of Peak

$C_{\text{DoP}}$  = Credit of Duration of Peak

PbA = Peak by Average

$C_{\text{PbA}}$  = Credit of Peak by Average

$C_{\text{PU}}$  = Credit of Peak Usage

$C_{\text{AU}}$  = Credit of Average Usage

ADH = Amount of Data Handling

$C_{\text{ADH}}$  = Credit of Amount of Data Handling

$C_{\text{WV}}$  = Credit of Work Variability

$C_C$  = Credit of Criticality.

For calculation of the upper limit we consider values on the higher side from the table.

NoS = 3, NoC = 4 and AR = 2.5.

As provided in the table  $C_{\text{NoS}} = 8$ ,  $C_{\text{NoC}} = 4$  and  $C_{\text{AR}} = 4$ .

Now,  $L = \text{NoS} \times C_{\text{NoS}} + \text{NoC} \times C_{\text{NoC}} + \text{AR} \times C_{\text{AR}}$ .

Using these values we get,  $L = 3 \times 8 + 4 \times 4 + 2.5 \times 4 = 50$ .

Then, ToS = 3, SCB = 2.5.

As given in the table  $C_{\text{ToS}} = 5$ ,  $C_{\text{SCB}} = 7$ .

Now,  $(AU) = \text{ToS} \times C_{\text{ToS}} \quad (\text{or}) \quad \text{ToP} \times C_{\text{ToP}} + (4 - \text{SCB}) \times C_{\text{SCB}}$ .

Using these values we get,  $AU = 3 \times 5 + (4 - 2.5) \times 7 = 25.5$ .

Please note that decimal or fractional values can also be obtained from the table by breaking them into smaller groups.

Similarly, DoP = 3, PbA = 3. From chart  $C_{\text{DoP}} = 6$  and  $C_{\text{PbA}} = 9$ .

We know,  $(PU) = \text{DoP} \times C_{\text{DoP}} + \text{PbA} \times C_{\text{PbA}}$ .

Therefore,  $PU = 3 \times 6 + 3 \times 9 = 45$ .

Now,  $WV = \text{PU} \times C_{\text{PU}} + \text{AU} \times C_{\text{AU}} + \text{ADH} \times C_{\text{ADH}}$ . Here ADH = 4 and  $C_{\text{ADH}} = 5$ ,  $C_{\text{PU}} = 6$  &  $C_{\text{AU}} = 8$ .

Therefore  $WV = 45 \times 6 + 25.5 \times 8 + 4 \times 5 = 494$ .

DS = 4, C = 3;

Now, Suitability index =  $L \times C_L + \text{WV} \times C_{\text{WV}} + \text{DS} \times C_{\text{DS}} \times \text{ADH} + C \times C_C \times (65 - L)$ , where  $C_L = 7$ ,  $C_{\text{WV}} = 8$ ,  $C_{\text{DS}} = 6$  &  $C_C = 4$ .

Therefore, Suitability index =  $50 \times 7 + 494 \times 8 + 4 \times 6 \times 4 + 3 \times 4 \times (65 - 50) = 4578$ .

Leaving some margin we get the value to be around 4600.

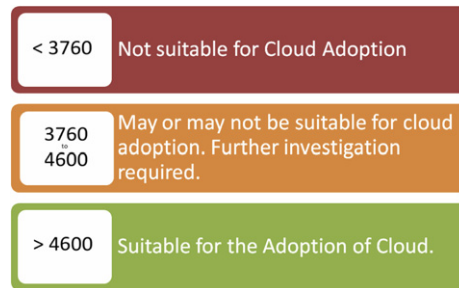


Fig. 6. Suitability of a company for adoption of cloud.

Similarly, for calculation of the lower limit we consider values on the lower side from the table.

NoS = 2, NoC = 2 and AR = 1.5.

As provided in the table  $C_{NoS} = 8$ ,  $C_{NoC} = 4$  &  $C_{AR} = 4$ .

Now,  $L = NoS \times C_{NoS} + NoC \times C_{NoC} + AR \times C_{AR}$ .

Using these values we get,  $L = 2 \times 8 + 2 \times 4 + 1.5 \times 4 = 30$ .

Then, ToS = 2, SCB = 1.5. As given in the table  $C_{ToS} = 5$ ,  $C_{SCB} = 7$ .

Now, (AU) = ToS  $\times C_{ToS}$  (or) ToP  $\times C_{ToP} + (4 - SCB) \times C_{SCB}$ .

Using these values we get,  $AU = 2 \times 5 + 2.5 \times 7 = 27.5$ .

Please note that decimal or fractional values can also be obtained from the table by breaking them into smaller groups.

Similarly, DoP = 2, PbA = 2. From chart  $C_{DoP} = 6$  &  $C_{PbA} = 9$ .

We know, (PU) = DoP  $\times C_{DoP} + PbA \times C_{PbA}$ .

Therefore,  $PU = 2 \times 6 + 2 \times 9 = 30$ .

Now, WV = PU  $\times C_{PU} + AU \times C_{AU} + ADH \times C_{ADH}$ . Here ADH = 2 and  $C_{ADH} = 5$ ,  $C_{PU} = 6$  &  $C_{AU} = 8$ .

Therefore  $WV = 30 \times 6 + 27.5 \times 8 + 2 \times 5 = 410$ .

DS = 2, C = 2;

Now, Suitability index =  $L \times C_L + WV \times C_{WV} + DS \times C_{DS} \times ADH + C \times C_C \times (65 - L)$  where  $C_L = 7$ ,  $C_{WV} = 8$ ,  $C_{DS} = 6$  &  $C_C = 4$ .

Therefore, Suitability index =  $30 \times 7 + 410 \times 8 + 2 \times 6 \times 2 + 2 \times 4 \times (65 - 30) = 3794$ .

Leaving some margin we get the value to be around 3760.

#### Interpretation of results

On doing the calculations a numerical value would be obtained. If the numerical value obtained for a particular organization is below 3760 then it would not be recommended to be suitable to adopt CC.

A result obtained between 3760 and 4600<sup>4</sup> is considered moderate i.e. it may or may not be beneficial for them to go for the cloud. Further investigation would be required and other factors at the company level should be taken into consideration in order to arrive at the decision whether the cloud services would be viable in the long run. A company could look at other options in these cases such as partial adoption of cloud services or adoption of virtualization techniques in its already existing datacenters.

A score above 4600 would indicate that the company needs to adopt CC in order to enjoy large cost savings and other benefits that come along with CC.

The above is shown pictorially in Fig. 6.

It is important to note that the cut-off scores given here are suitable for the credits given to the factors in the table and would only apply to those companies which keep the same weightage to the various factors. Customizing the credits of the various factors to suit certain needs would cause the cut-off scores to change accordingly. The lower and upper cut-off scores are obtained by taking the lower average and the upper average of the factors respectively.

It should also be noted that owing to change in market conditions the outcome of this study may differ. An in-depth (subjective as well as objective) analysis is strongly recommended and will be required when applying for personalized businesses as other factors may come into the picture.

#### 4. ROI

The discussions presented in Section 3 serves as a pointer in determining whether CC is advisable for an organization or not. A lot of time and resources are spent in calculating ROI by taking into consideration a large number of factors involved in a business. The indication given by the marker would give an image of how the ROI would look like and the pain and effort

<sup>4</sup> These scores are obtained by taking the lower and upper averages of the factors respectively.

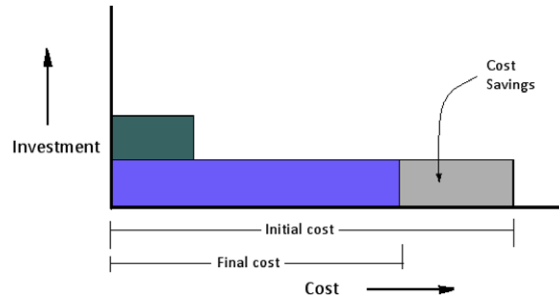


Fig. 7. Schematic diagram of traditional ROI.

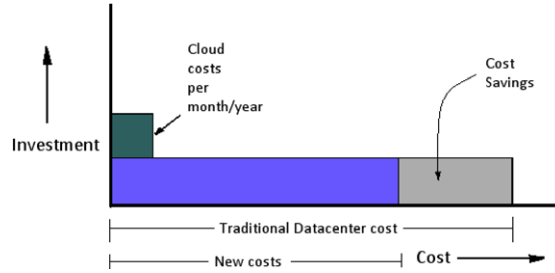


Fig. 8. Schematic diagram of costs for partial migration to cloud.

spent in calculating the ROI would be worth it. In other words, it would give an assurance that the ROI would be positive if a positive indication is given by the marker. If a negative indication is given by the table, the ROI calculated could certainly come out to be a negative one and the effort that would be spent in calculating the ROI may not pay off.

#### Calculating ROI

ROI is a tool for measuring the efficiency of any investment. For calculating ROI, as shown in Fig. 7, we need the initial cost of project, the investment made, the cost savings done owing to the new investment [52].

$$ROI = \frac{(\text{Initial cost} - \text{Final cost}) - \text{Investment}}{\text{Investment}} = \frac{\text{Costs saved} - \text{Investment}}{\text{Investment}}. \quad (1)$$

It thus turns out that for calculating the ROI of CC, we need to understand what these cost savings, the initial costs and the investments mean in the cloud model.

No initial investment is required for migration to the clouds, i.e., there is no upfront capital cost. Embarking on the cloud can be as easy as browsing through a catalogue of IT services, adding them to a shopping cart and submitting the order. As soon as the order is approved by an administrator, the rest of the things are done by cloud [53]. The cost of using the cloud services is completely operational in nature. Hence, in this case the investment is on a monthly or yearly basis using the pay-per-use cost of the cloud services. The initial project cost is the total cost of ownership (TCO) of maintaining one's own datacenter before using cloud services. Cost saved would be the entire elimination of datacenter cost (in case of complete migration) or the reduction in datacenter cost (in case of partial migration). Fig. 8 shows the schematic diagram of costs for partial migration to cloud.

However, the economics of CC does not end here. Associated benefits of CC such as massive scalability, flexibility of service, elasticity of resources, and latest technology offering add to the profitability of the enterprise cloud user. Therefore, as shown in Fig. 9,

$$ROI \text{ for cloud} = \frac{\text{Increase in profit} + \text{Reduction in cost} - \text{Cloud costs}}{\text{Cloud costs}}. \quad (2)$$

Here, the time frame can be per month or per year.

#### ROI model

Let us consider a case of a moderate value on the tabulation sheet in Section 3. For such an enterprise, the best way of using the cloud services would be to simultaneously maintain its own datacenter as well as use the cloud services for the extra resources which cannot be provisioned in its own datacenter [4,42].

Considering their average workload, they can maintain 30% above this average value in their in-house datacenter and outsource the rest of the computational needs to the cloud. Only when 80% of the in-house server capacity has exceeded,

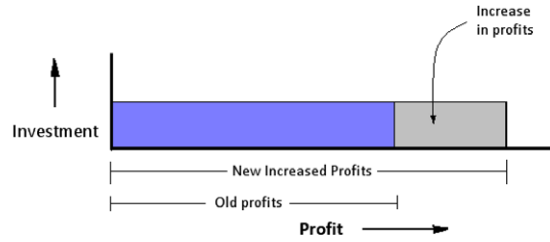


Fig. 9. View of profits.

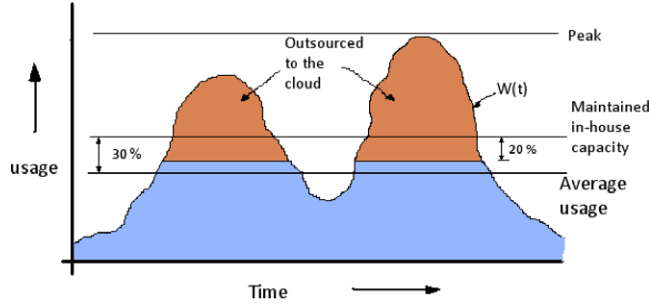


Fig. 10. Partial cloud migration model.

the excess capacity would be drawn from the cloud.

$$\begin{aligned} \text{Cost of cloud per year} = & \left( \int_0^T \left( W(t) - \frac{110}{100} \times \text{average} \right) \cdot dt \right) \\ & \times \text{cloud cost} + (\text{storage in clouds}) \times (\text{cost/month}) \times 12 \\ & + \text{bandwidth cost} + \text{cost of using applications.} \end{aligned} \quad (3)$$

$$\text{Bandwidth cost} = (\text{incoming data} + \text{outgoing data}) \text{ per year} \times \text{bandwidth charges.} \quad (4)$$

$$\text{Cost of using applications} = \sum_{n=1}^j T_n \times A_n \quad (5)$$

where,

$T_n$  = time (in hours) of usage of  $n$ th application/platform.

$A_n$  = cost of application per hour of usage as provided by the ASP.

The integral  $\int_0^T (W(t) - \frac{110}{100} \times \text{average}) \cdot dt$  takes into consideration only the positive value, i.e., the part shown in Fig. 10.

Aggregate workload can be calculated by using the formula given by Chari in [42]. Aggregate workload can be found out by calculating the area under the workload curve.

Hence,

$$\text{aggregate} = \int_0^T W(t) \cdot dt. \quad (6)$$

The average workload can be calculated as

$$\text{average} = \frac{\text{aggregate}}{T},$$

where  $T$  is time frame in which it is calculated in hours.

$$\text{Traditional cost before cloud adoption} = \text{number of servers} \times \text{cost behind each server.} \quad (7)$$

$$\begin{aligned} \text{Cost behind each server or TCO} = & \text{costs of (electricity} + \text{cooling} + \text{maintenance} \\ & + \text{manpower} + \text{software} + \text{backup power}). \end{aligned} \quad (8)$$

In-depth calculation of TCO can be done following the approach presented in [55].

### Cost savings

Since the in-house capacity is provisioned only for 30% above the average usage, and not for the peak, there is a significant reduction in the number of servers that the company has to maintain in its own datacenter. The extra servers can be decommissioned or sold. Therefore,

$$\text{Cost saved} = (\text{initial no. of servers} - \text{present no. of servers}) \times \text{TCO of each server.} \quad (9)$$

### Valuation of intangible benefits leading to increased profits:

#### Agility/flexibility

CC gives a company the ability to explore, experiment and innovate with better means such as better platforms, and application tools in a quick and cost-effective way to come up with better services and solutions. This would give a great boost to their business. Flexibility from CC adds value to an enterprise, but its value decreases with the increase in size of the enterprise, i.e., this potential to be flexible may not add so much profitability to a large organization as it may do to a small organization. Let profitability from flexibility be denoted by  $F$ .

Then,

$$F = \frac{\text{constant } (B)}{f(L)} = \left( \frac{B}{65 - L} \right). \quad (10)$$

The constant  $B$  can be the original annual profit which the company had before the adoption of cloud services.

$f(L)$  is a function of largeness. Value of  $L^5$  found from table should be substituted. This results in about 2% to 5% increase in profit.

#### Scalability

As such, scalability can be quantified by the amount of usage of extra resources which are automatically commissioned with the increase in demand and charged on a pay-per-consumption basis. But the actual importance of scalability lies in the fact that resources are made available in minutes, which otherwise would have taken weeks or even months. Scalability also prevents dissatisfied customers as it scales the resources automatically when demand increases. Also, it leads to faster time to market.

Thus,

$$\text{Scalability} = f(\text{time value, customer satisfaction, faster time to market}). \quad (11)$$

No separate formula is given for scalability, as the benefits of scalability have been quantified separately.

#### Faster time to market

Apart from saving time in the faster provisioning of resources, companies using the technique of batch processing can complete a work much faster than what their datacenter resources permit, e.g., using 1000 EC2 machines a work can be done in one hour, which one machine would take 1000 h to complete and that too at essentially the same cost by leveraging the concept of pay-per-use [17]. Faster time to market has many advantages such as one gets to have the entire market share and thus s/he can charge a premium, as there is no other competitor in the market. Thus, one gets a lot of extra sales and for extended period of time getting the opportunity to capture the loyalties of customers earlier. It also improves the company's technological and innovative image [54].

The financial implications of faster time to market [54] can be represented graphically as shown in Fig. 11:

Let us consider the relation function to be an approximate sine curve.

We represent flow of money  $M(t) = -A \cdot \sin(t)$ , where  $A$  is the estimated break-even cost.

$$\text{Traditional cost} = \int_0^{t1} M(t)dt = \int_0^{t1} -A \cdot \sin(t) \cdot dt \quad (12)$$

$$\text{Traditional profit} = \int_{t1}^{t2} M(t)dt = \int_{t1}^{t2} -A \cdot \sin(t) \cdot dt \quad (13)$$

where,

$t1$  = original time taken to market.

$t2$  = time for which product stays in market.

Let the time saved be  $\Delta t$ .

$$\text{Now, the reference line becomes } y = -A \cdot \sin(t1 - \Delta t) \text{ (Fig. 12)).} \quad (14)$$

Therefore,

$$\text{New cost} = \int_{\Delta t}^{t1-\Delta t} (y - M(t))dt = \int_{\Delta t}^{t1'} (-A \cdot \sin(t1 - \Delta t) + A \cdot \sin(t))dt. \quad (15)$$

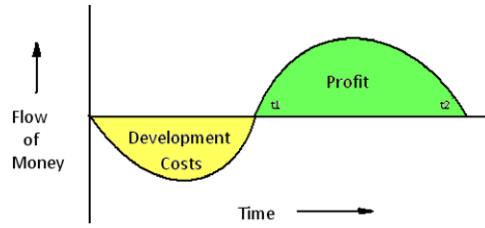


Fig. 11. Relation of cost, revenue with time [54].

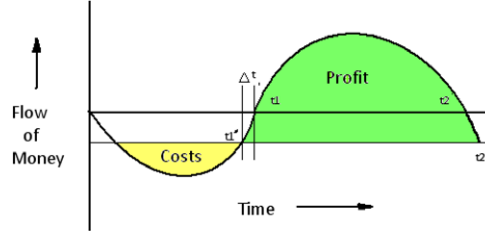


Fig. 12. Relation of new cost, revenue with early time to market [54].

Here, the time taken from  $\Delta t$  does not necessarily imply costs being considered from time  $\Delta t$  after start of project. It is just a representation for measuring costs.

Also,

$$\text{New profit} = \int_{t1-\Delta t}^{t2'} (M(t) - y)dt = \int_{t1'}^{t2'} (-A \cdot \sin(t) + A \cdot \sin(t1 - \Delta t))dt \quad (16)$$

where,

$t1'$  = new time taken to market.

$t2'$  = new time for which product stays in market.

$t2'$  may be considered equal to  $t2$ .

Therefore,

$$\text{Value of faster time to market (FTM)} = (\text{traditional cost} - \text{new cost}) + (\text{new profit} - \text{traditional profit}). \quad (17)$$

#### Customer satisfaction

Customer satisfaction is of high priority in any business. Transition to the cloud certainly add to the customer satisfaction level. Quantification of benefits of CC calls for not the level of customer satisfaction achieved, but rather the increase of it.

The increase of customer satisfaction<sup>6</sup> can be measured by any of the general traditional methods of survey.

Assuming a logarithmic<sup>7</sup> curve,

$$\text{Percentage increase in profit}^8 = B \times \log_e \left( \frac{1}{1 - \frac{\% \text{ increase}}{100}} \right) \quad (18)$$

where, % increase = (final% – initial%) of customer satisfaction.

$B$  is a constant whose value (varying from 8 to 15) depends upon the type of the services provided by the company and also directly proportional to  $L$  (largeness value).

The graph obtained by plotting various increase in customer satisfaction to increase in profit percentage is shown in Fig. 13.

#### Time value

Making IT resources available to end users becomes very time-intensive for the companies that employ traditional datacenter management practices. It includes steps, such as purchasing hardware, building floor space, adequate power supplies and cooling systems installing operating systems, middleware and software to be run in the servers, provisioning

<sup>5</sup> The value of  $L$  that we get from table is actually value of smallness. To get largeness we deduct it from  $(1 + \text{max value})$ , which is 65.

<sup>6</sup> Difference in percentage of customer satisfaction after and before adoption of cloud.

<sup>7</sup> This logarithmic function of customer satisfaction closely follows profitability when plotted.

<sup>8</sup> This is only a suggested formula and has no scientific backing behind it.

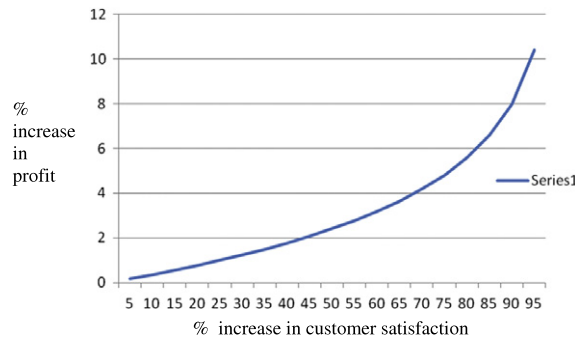


Fig. 13. Increase in profit versus increase in customer satisfaction.

the network and the securing back up power. This process may take more than 2–3 months, depending to different factors. IT organizations also take several weeks to re-provision existing hardware resources. CC dramatically alleviates this problem through automation, business workflows and resource abstraction reducing the lead time required from months to minutes [53]. This time saved in the cloud, which otherwise would have been spent provisioning for resources in the datacenter can be quantified as the expenditure of the enterprise during that time of provisioning without any profits.

Thus,

$$\text{Time value} = (\text{time taken to provision in weeks}) \times (\text{weekly expenditure}). \quad (19)$$

#### Focus on core competencies

With no need to worry about the underlying infrastructure, their maintenance, their proper provisioning before the start of any project, more attention and care can be given towards the development and the improvement of quality of services and products of a company. Thus, better focus leads to improvement in productivity and its business propositions. Another great advantage of CC is ubiquitous access or mobility, which allows employees to be productive from wherever they are rather than confining them to their desks at the company [56].

Improvement in productivity can be quantified in terms of decrease in marginal cost ( $Mc$ ) and increase in marginal benefits ( $Mb$ ).

Thus,

$$\text{Focus} = (Mc + Mb) \times \text{number of products or services delivered/year}. \quad (20)$$

#### Disaster recovery

Disaster recovery is a very important aspect of enterprise computing. As devices, systems, and networks get increasingly complex, there are many other things that can go wrong. Disaster may occur due to several causes including natural and man-made ones. Natural sources include earthquakes, fires and anthropogenic sources that include viruses, power failure, and intrusion.

It is estimated that most large companies spend between 2%–4% of their budget and small and medium enterprises (SMEs) spend up to 25% of their IT budget on disaster recovery planning, with the aim of avoiding larger losses in the event that the business cannot continue to function due to loss of IT infrastructure and data. Of companies that had a major loss of business data, 43% never reopen, 51% close within two years, and only 6% survive long-term [57]. Hence, disaster recovery and business continuity planning are becoming increasingly important for every business organization.

Disaster recovery planning is done by replicating resources in a number of places. This fear is very much reduced in the cloud as data in the cloud is replicated thrice and stored in servers which are geographically scattered.

$$\text{Thus, savings from DR} = (\% \text{ budget}^9 \text{ invested in DR} \times \text{annual budget})$$

$$- \text{bandwidth cost of storing new data daily to cloud} - \text{storage charges}^{10} \quad (21)$$

#### Green IT

An enterprise gets a “Green IT” tag when it helps save valuable natural resources. Green tag does improve the image of a company and makes them more likely to be favored by people at the time of energy crisis. A recent survey has found that the ‘green’ tag of companies alone were able to master a 17% increase in customer acquisition, 31% increase in customer retention and a 69% raise in customer satisfaction. They have stated that the ‘Green route’ has helped improve

<sup>9</sup> This percentage is quite less than the original percentage which the company used to invest in DR as this is a model of partial migration to the cloud. For entire migration it would be whole of it.

<sup>10</sup> Bandwidth and storage charges are recurring but should not be taken into account here as it is already being paid as cost of usage of cloud.



their customer loyalty [58]. Going by the modest of values that would lead to about 5% increases<sup>11</sup> in annual profit. There are also government incentives for companies trying to 'go green'.

#### *Risks*

##### *Outage of service*

This is one of the worst nightmares of CC, and this has happened a few times in the past [17]. But since this would be an overlapping model with the cloud services being used, when datacenter capacity is exceeded, it may not adversely affect the enterprise.

## **5. Conclusion**

This paper provides an in-depth analysis of the financial perspective of CC in a very lucid and simple manner. The discussed model provides both the objective as well as the subjective decision making tool to find the suitability of a company for adopting CC. With the suitability index presented in this paper, companies need not first waste their resources and time in the calculation of ROI which is both time and effort consuming, and which may not yield a desirable result at the end. With the suitability index customized to their needs, they can easily get a pointer as to where their company stands with respect to its favorability to the adoption or migration to the cloud environment. Also depending on the score they get, they have a number of options to choose from as to which model would suit their needs better. It is then that they can start calculating ROI with the very simple yet generic model presented here which can again be customized to their specifications. Various intangible benefits have been included in the model which gives a much broader picture of CC to its potential adopters. Prospective adopters would really find it useful as it would save both their time and cost.

#### *Managerial implications*

It is highly important for a company to remain competitive in today's business scenario. To remain competitive in the market they need to embrace the latest technologies, methodologies, processes, applications, etc. to come up with the best services and products. For this managers in such organizations need to be very dynamic taking the best decisions which would accelerate changes in business processes. These changes may vary from minor adjustments in ongoing processes, to revolutionizing the entire business, systems and processes. They need tools which would assist them with proper decision making. This model is one such tool that helps them understand the different models of CC, and the potential outcomes/benefits of implementation of such models.

Management of information systems is progressively becoming more difficult. As a result senior management including CIOs and CFOs are being required to justify projects financially based on their return. Information systems have always been difficult to quantify in profitability terms because most of the derived benefits are intangible by nature, e.g. improved customer service. This paper attempts to incorporate various intangibles into traditional cost–benefit analysis and ROI. The paper also reviews the suitability of the company to CC taking into consideration various parameters. This goes a long way in assisting decision-making at the managerial level.

#### *Performance analysis and scope for further work*

We have taken up the partial migration model for showing the costs and quantifying the benefits, because with this model one can clearly showcase in good light all the various models of CC that can be adopted by companies along with their cost and how they affect the ROI calculation.

Companies which want to completely migrate to the cloud infrastructure would not have to incur any additional cost at their own datacenter, other than only operational costs of the cloud. They would be saving the entire cost of running their datacenter and whatever cost they incur from the cloud would be included as investment.

Other cases include situations when a company opts for virtualization of the IT resources in its datacenter, i.e., creating private cloud. Then, in that case, cost of virtualization that includes cost of VM middleware software license, its regular updates would be added to the TCO of the servers maintained in its own datacenter.

The expenditure of using the cloud services is completely operational in nature and that too on a pay-per-use basis. There are absolutely no up-front costs or capital expenditure at the time of adoption or migration to the cloud services. But the profits generated from the benefits of CC may not be of the same time frame as the cloud cost. The increased profits may trickle in the later. In that case, considering the operational cost of the cloud as the investment and the time frame in which increased profit is expected, Net Present Value (NPV) and Internal Rate of Return (IRR) can be calculated along with ROI.

The profits from the benefits of CC shown here may not be applicable for all companies. So companies should customize with scenarios that let them fit their model and incorporate only those costs and benefits in the calculation of their ROI.

The model presented in this paper has been developed taking into consideration a large number of factors acting in the IT industry and, hence, should work for a wide range of cases. But this model needs to be exhaustively tested with real industry data, conditions and situations. Real company data would be able to ascertain the robustness of this model. Even simulation data obtained by replicating the industry conditions on various software can be used to assess the practicality of model analyzed by us. Thus, scope for future work includes rigorous testing of this model with real and simulated data.

<sup>11</sup> Putting 69% in the customer satisfaction formula.

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