Chapter 1

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1.1 Cloud Computing and Cloud Economics: An Overview

Evolution is a continuous process. Structures evolve, systems evolve and so do economies. Whether we talk about genetic structures or economic structures, they evolve with time. Sometimes the changes are very superficial but sometimes they are very prominent. The past few years are witnessing rather some very prominent changes. From brick and mortar economy, the world is discussing about the virtual economy. It is not that the physical nature of the world is changing, but the effect of the virtual phenomenon is indeed great. The virtual phenomenon that is being discussed here is – ‘cloud’ i.e. cloud computing.

The advent of Information Technology took the economies around the world by storm. Cloud computing, the latest dimension of Information Technology, is further becoming the major cause of changes to these economies.

So here we will discuss – “What matters in Economics & what matters is Economics”. The point is to say, there is economics all around us. Something is consumed, it is economics; something is purchased, it is economics; something is produced, it is economics, something is distributed, it is economics. So all the activities whether related to consumption, production, distribution, trade or exchange have some or the other economic implication.

This applies in the case of cloud computing also. When some technology is adopted, rather it can be said to be fervently adopted, then, it is just not because of the technological factors but because of the economic factors
attached to it. If the technology is not economically viable, then it will wane in the long run.

There are certain revolutions which changed the very way in which the world order worked and they are more economic in nature. These revolutions are – the Industrial Revolution and the Information Technology Revolution. Now it is time for the Cloud Revolution as depicted in Figure 1.1. To substantiate this claim, some facts and figures can be referred to. The size of the overall cloud/internet economy is ranked among the top ten world economies, even surpassing the size of some developed economies. Such is the economic effect of the cloud and it is increasing day by day.

Figure 1.1: Cloud Revolution

Source: adapted from Cloud Computing (n.d.)
Economics is a discipline dealing with choices. The fundamental problems of an economy are about making a choice or decision as there is always multiplicity of ends and scarcity of means. There are alternative techniques to produce a commodity in an economy and the fundamental problem ‘how to produce’ is about making a decision regarding which technique should be used. This decision is taken by calculating the relative prices of resources and processes concerned in that economy.

This fundamental problem remains the same even today. Today the problem is about which IT technique should be given preference – traditional client-server based or the cloud based services. And the solution is also the same. The decision of migration to cloud is made only after carefully considering and analyzing the comparative price structure.

1.2 Cloud: Overview

A cloud, as described by (“Cloud”, n.d.), refers to a distinct IT environment that is designed for the purpose of remotely provisioning scalable and measured IT resources. The term originated as a metaphor for the Internet which is, in essence, a network of networks providing remote access to a set of decentralized IT resources. Prior to cloud computing becoming its own formalized IT industry segment, the symbol of a cloud was commonly used to represent the Internet in a variety of specifications and mainstream documentation of Web-based architectures.

1.3 Cloud Computing: Definitions

In 2009, a report by Gartner Inc. (Stamford, 2009) defined cloud computing as “a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies.”
National Institute of Standards and Technology (NIST) in September 2011 proposed the definition of cloud computing which gained world-wide acceptance (Mell, et al., 2011):

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models."

1.4 Cloud: Characteristics

The cloud model is based on 5-4-3 principle. There are 5 essential characteristics of the cloud. It also possesses 4 cloud deployment models and 3 core cloud service delivery models; hence the term 5-4-3. The five indispensable characteristics, as per (Mell, et al., 2011) are described as follows and are also depicted in Figure 2.3:
A. **On-demand Self Service:** This characteristic is a combination of two traits of cloud – on-demand and self-service. On-demand is related to usages like network storage and server time as per the demand and self-service indicates towards automation in such a form that most of the cloud services are provided with no or very less interaction between the user and the provider. Google, AWS, Salesforce are some of the popular instances.

B. **Broad Network Access:** Wide array of network is available and the accessing of the capabilities of the cloud is carried out by following standard protocols and via heterogeneous client platforms, which can be thick, thin or smart (laptops, desktops, PDAs, smart phones, etc.).

C. **Resource Pooling:** Resources used in the cloud are diversified in nature – storage, network, servers, middleware, applications, processing capabilities, etc. The cloud service providers bundle different resources in different packages and the service is delivered to the customer. How the resources are pooled, which ones are pooled, where are these pooled and when are they pooled, are questions that are of no concern to the customer and thus the user of the service is totally unaware about the whole procedure. Everything is shrouded inside the cloud, and unused or less used resources are thus used in an optimized way.

D. **Rapid Elasticity:** Scaling, whether up or down, is one of the most important trait of the cloud. In accordance with the demand, most of the facilities are automatically scaled outwardly or inwardly, and if not automatically, then, the option for purchase of scaling is always available in any quantity.

E. **Measured Service:** For controlled and optimized use of resources, cloud offers metering facility (pay per use), for the paid services. As other services like electricity and water are billed, similarly, cloud service
providers for ensuring transparency provide customized usage based billing facility for the type of service or resource used, i.e. network bandwidth, user accounts, storage, processing capabilities, etc.

1.5 Cloud Computing: SWOT Analysis

Rapid advancement in the field of science and technology is fuelling innovations in products, practices, processes, services, sectors and systems. But many a times it happens that some technology is much talked about and people follow in the footsteps without inquiring into the details of that technology. Resultantly some technologies are either prematurely discarded or suffer from biases.

Though technical viability is significant but it is only the primary condition not the sufficient condition. The sufficient condition is economic viability. For the satisfaction of both the primary and secondary conditions it is necessary that before adoption of any technology at a large scale, a complete analysis regarding its strengths, weaknesses, opportunities and threats is carried out. For this purpose and also for providing credibility to the study SWOT analysis of cloud computing technology is carried out in this section.
Figure 1.5: Cloud Computing – SWOT Analysis
1.6 Cloud Computing & Jevons’ Paradox

Jevons’ Paradox is the proposition that technological progress that increases the efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource (Blake, 2005). In addition to reducing the amount needed for a given use, improved efficiency lowers the relative cost of using a resource, which further increases the quantity of the resource demanded, potentially counteracting any savings from increased efficiency (Blake, 2008).

Additionally, increased efficiency accelerates economic growth, further increasing the demand for resources. The Jevons’ paradox occurs when the effect from increased demand predominates, causing resource use to increase (Blake, 2008; Dave et al., 2014).

William Stanley Jevons, renowned British economist, propounded this concept regarding the consumption of coal back in 1865. In his book ‘The Coal Question’, Jevons has provided the background of this paradox. In his investigation, he found out that as the coal-burning machines were made more efficient in their processing, the consumption of coal increased at an increasing rate. As a result of the enhanced efficiency of the coal burning machinery, the consumption of coal should have shown an overall decline; but what was witnessed was just the contrary of it. The main reason was that with increased efficiency coal was put to use in several other things which were hitherto not possible because of very high cost. As a result, an overall consumption escalated.

Though the times have changed and now the economies are ICT driven instead of being coal-driven, Jevons paradox is still relevant. The explosive growth of cloud computing can be explained with the help of this paradox. As computers were invented, it was being quoted that there will not be much demand of those bulky machines but with the advancement of science and technology,
not only that perception was proved wrong but also it proved to be on the contrary. The same case is with cloud computing.

With the propagation of cloud computing technology, businesses and organisations have started taking up those tasks/projects also which were earlier not considered to be economical enough to be carried out. Thus instead of decline in expenditure, cloud technology is witnessing a hyper-growth trajectory. The reason is clear – with improvement in technology, cloud’s efficiency is augmenting and associated costs are declining. Resultantly, uses of cloud computing are expanding and diversifying; and the usage of cloud is becoming comparatively economical. This further increases the overall expenditure on cloud computing.

According to Jevons (Jevons, 1866), ‘as a rule, new modes of economy will lead to an increase of consumption according to a principle recognised in many parallel instances. The economy of labour affected by the introduction of new machinery throws labourers out of employment for the moment. But such is the increased demand for the cheapened products, that eventually the sphere of employment is greatly widened.’

It is a general perception that with improved technology, people get unemployed. With the advent of computers, it was speculated that people will become jobless in big numbers. But what happened was on the contrary. Though the number of traditional jobs decreased, but with the advancement of IT, several new employment opportunities were created – more and better than before. The same consideration lies for cloud computing. There will be displacement of some of the conventional IT jobs with new ones. Thus Jevons’ proposition works on this perspective also.
Figure 1.6: Cloud Computing – A Case of Jevons’ Paradox

1.7 Cloud Ecosystem

Cloud itself is quite a complex system; an amalgamation of varied components, actors and services. The interdependency of the cloud components, with collaborated roles of the different actors of the cloud, in order to efficiently provide the cloud services, together defines the cloud ecosystem.

1.7.1 Cloud Ecosystem: Actors

Cloud Ecosystem as per (“Part I: Introduction”, 2012), comprises of the following actors:
- **Cloud Service Users (CSU):** A cloud service user may be an individual, a group of individuals, or an institute/enterprise that can be public or private sector.

- **Cloud Service Providers (CSP):** A cloud service provider is essentially an organization that provides a single or a group of cloud resource/services, like the IaaS, SaaS or the PaaS or any other specialized sub-service to the cloud service user.

- **Cloud Service Partners (CSN):** A cloud service partner is an expert in a particular cloud domain, who provides consultation or implementation service(s) or both, regarding any particular cloud platform/product. A CSN may be
  1. a developer (application),
  2. a provider (content, equipment, software or hardware),
  3. an integrator (system), or
  4. an auditor.

### 1.7.2 Cloud Ecosystem: Services

As described by (“The Open Group”, n.d.), for efficient interoperability, various services and support services have been proposed. The major categories of the services are:

- Business Support Services
- Operational Support Services
- Cloud Security Services
- Performance Services
- Product Catalog Services
- Resource Catalog Services

These services are further classified into several other sub-services which are shown in Figure 1.4:
Figure 1.7: The Cloud Ecosystem Reference Model
Source: adapted from “The Open Group...” (n.d.)
1.8 Growth Indicators of Cloud Computing

The dramatic growth of cloud computing can be imagined through certain statistics (Larkin & Rose, 2015):

A study by Forrester shows that business spending on cloud will skyrocket to $191 billion in 2020 from just $72 billion in 2014.

The prediction of IDC says that cloud market will be worth huge $107 billion in 2017 as compared to mere $47.4 billion in 2013.

As per the report of IDC (“IDC Forecasts”, 2014), by 2018, public cloud will constitute the majority of the world’s growth in expenditure on servers, software and storage facilities.

These studies show that cloud market is going to experience bullish trends in the near future and follow what certain market experts have defined – “hyper-growth” path. This can be easily viewed in Figure 1.5:

![Figure 1.8: Global Public Cloud Market Size, 2008-2020](source: adapted from Columbus, L. (2015))