



Technology Diffusion of Cloud Computing

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Abstract: This paper (1) presents background and technical framework of cloud computing; (2) introduces innovations, technology diffusion and reasons that intensifies diffusion; (3) represents the technology diffusion enablers in relation cloud computing; (4) defines opportunities; (5) address challenges and finally sets out (6) conclusions.

Keywords: Cloud Computing, Technology Diffusion, Innovations

Paper received: 30/10/2013

Paper accepted for Publication: 20/01/2014

INTRODUCTION

Cloud computing has become one of the most discussed topics in today's IT organizations. Rather than having massive server farms, companies look for cost savings, cost avoidance and effectiveness by utilizing services based on cloud computing. Especially SaaS (software as a service) solutions have increased greatly and they are in many companies replacing the traditional on premises application environments.

When analyzing how technologies are being adapted, technology diffusion is one of the key elements. From technology diffusion perspective cloud computing is well adopted on the market but not yet a dominant design. Various technical and especially privacy related challenges need to be still addressed. Additionally, there are lots of legacy systems and legacy installations which may stay live still for several years. The cloud services become tempting often when selecting a new solution or when the support for the existing hardware or software elapses.

BACKGROUND AND TECHNICAL FRAMEWORK

Development towards cloud computing

Roots of cloud computing are back in 1960s when computer sharing was discussed for the first times. Discussion intensified again when dotcom bubble was burst in early 2000 and investments got scarce. On mean to reduce costs was to reconsider sharing computing capacity as servers had overcapacity. Systems were prepared for usage peaks which seldom occurred. Hence leasing extra capacity out became tempting. Amazon's Web Services (AWS) start up in 2002 is considered the beginning of cloud services. [1]

What is cloud computing?

Reese sets out three criteria which defines if a particular service is a cloud service: [2]

1. The service can be accessed via a web browser or web services API.
2. No capital expenditure is required to get started.
3. You pay only for what you use as you use it.

In cloud computing the software and hardware resources are delivered as a service over a network, typically the Internet. The name comes from the use of cloud-shaped symbol as an abstraction.

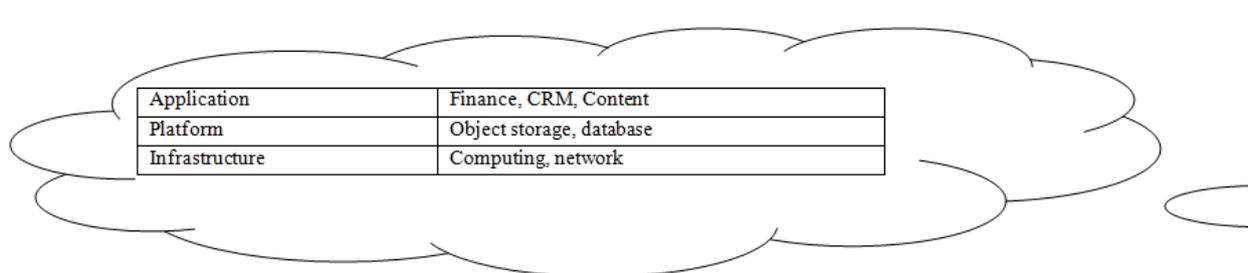


Figure 1 Cloud computing

Figure 1 shows the layers of cloud computing. Software has an important role as the application layer provides the biggest value to the end user. The business logic resides on the application layer.

Service provisioning

Cloud services can be defined into three categories in relation to service provisioning: [1]

Platform as a Service (PaaS) means the service provider has virtual servers from which the customer gets services as needed. In this model the customer can build his own applications by using predefined APIs. The computing comes from the cloud. An example of a PaaS is Google's development environment which enables development for applications to be run on Google's AppEngine service.

In Infrastructure as a Service (IaaS) the service hosts a virtual server base and gives predefined amount of computing power to customers. The customer installs his own operating systems and applications into these predefined segments. Well known IaaS service is Amazon Web Services.

Software as Service (SaaS) means the customer uses only the application, everything else from computing to the data storages is managed by the service provider. There are lots of SaaS providers. One of the most known is Salesforce.com who provides several cloud based solutions for CRM (customer relationship management) usage. SaaS is the biggest growing area in cloud computing era as it enables quick application deployment without one time deployment costs coming along with server and connectivity equipment purchases which would be required for stand-alone in-house systems.

Accessibility

Another way to classify the cloud services can be done by the accessibility: [1]

Public cloud means that the capacity is set out freely to anyone and it is not dedicated to any customer. The payment model is subscription based on time or on capacity. Private cloud is a company specific cloud which utilizes its own LAN. It does not require an internet connection outside. The operating and maintenance costs are carried out by the customer who also maintains the operating environment.

Public and private clouds can be connected to a hybrid cloud. Hybrid cloud means that company's private cloud is connected to a public cloud via internet connection.

TECHNOLOGY INNOVATIONS

Innovations can be segmented on radical innovations and on incremental innovations. [3] Cloud computing is considered to be an incremental innovation which utilizes the existing technology elements in a new way. The cloud implementation itself may include radical innovations but to end customer the services looks mostly the same.

The rate of technology performance and the rate at which the technology is adopted in the marketplace have been shown to conform to an s-shape curve. These curves are related as improvements in technology may foster faster adoption and greater adoption fosters further investments in performance improvement. [3]

Technology diffusion means technology adaptation in the marketplace. [3] Technology diffusion can be also presented by an s-shape curve which plots cumulative number of adopters against time. In the beginning the adoption pace is slow but as the technology becomes known in the marketplace, it accelerates. Finally the pace saturates as the rate of new adopters decline. S-curves in technology diffusion are in part a function of s-curves of technology improvement:

when technologies are further developed, they become more secure and useful to users, facilitating their adoption. [3] As learning curve and scale advantages accrue to the new technology, the price of finished goods reduce which again attracts new users. [3]

Even if new technologies may be much better compared to the new ones, they often fail to attract the users and can be deployed only to a niche market. One major reason behind may be the complexity of the knowledge underlying new technologies, and the lack of complementary resources that make those technologies useful. Many potential users may not adapt new technology until the technology is available to them. [3] Cloud computing in its best is not visible to the end users but it affects application developers and IT organizations heavily. Making technology available to them is crucial.

Technology diffuses through international trade and international R&D ventures by multinational corporations. Developments in software technology and sharing of R&D investments have fostered this process. The future trend is to increase knowledge diffusion of technology. The competition for new processes and products has been intensified lately due to trade globalization and markets expansion. [4] Cloud computing itself can act as a knowledge diffuser; it eases the knowledge and knowledge sharing globally in a cost effective manner.

A change in the technology indicates a change in the production or in relation to the costs. In general technology includes all the knowledge and innovations needed to the production and distribution process. [4]

Technology generates multiple changes that affect the long term growth of an economy. In the upward shift it improves the productivity of inputs like labor or capital following by reduced unit costs. Cost reduction helps to improve the profits and decreases the costs. [4] Additionally, technologies help to expand the scale of production and enables further globalization and market expansion.

Innovation efficiency changes technology at the various points of value chain, thus challenging the companies to compete in new innovative ways. Successful companies transform their technologies to create new strategic assets which bring them more cash flows and new projects. This enables further investments and growth. [4]

Especially the latter is something cloud computing certainly helps; it enables companies better to focus their operations to competing edge rather than using capital and resources on ongoing services which in principle keep the current activities on the existing level.

TECHNOLOGY DIFFUSION ENABLERS

Adaption to the market requires the product or the service needs to be commercially attractive. In addition to commercial requirements proper technology diffusion requires the technological and functional needs to be fulfilled. Technology enablers make the commercial deployments possible.

Functional enablers [5]

There are four cornerstones which are to be fulfilled in order to reach adequate quality of service level:

1. Efficiency: Execution and coordination of services are optimized in terms of data traffic and

latency. Data traffic carries a big cost element with it, and therefore reducing that carrying cost is a long term goal. Latency can affect a lot in customer satisfaction and therefore needs to be watched carefully.

2. Scalability: Cloud platforms can be connected by massive amount of people. Ability to work during burst hours is crucial.

3. Robustness: The systems are to be designed for high availability with effective use of failover and graceful failover.

4. Security: Proper security provisions must exist for both the applications and the data to protect service providers as well as consumers for intentional misconducts or malicious actions.

Commercial enablers

IT projects or services whose mission not to go beyond helping the business “stay with the race” or on “run” mode must reduce total cost of ownership (TCO). Projects on “grow” which improve existing products and services must increase return on investment (ROI). That is to help the business make more money. “Transform” projects which enable new things or even change the game are giving the business a competitive edge. These phases are described in figure 2 which plots also an s-shape curve. [6]

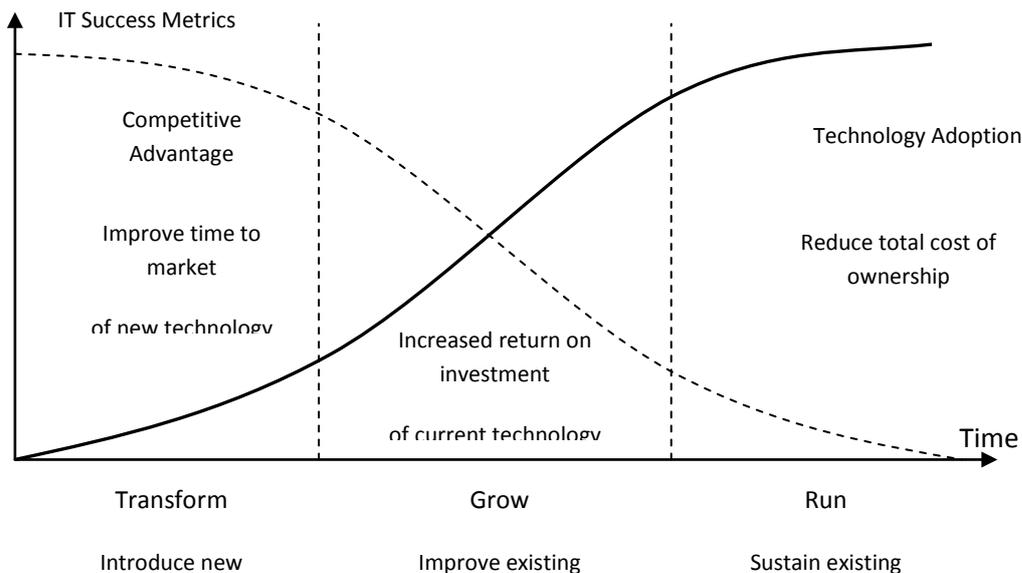


Figure 2 IT success metrics [6]

Cloud computing can reduce the IT’s involvement in “run” projects and offer possibility to shift to “grow” and “transform” projects. This enables IT to move from cost center or provider of services to a value-adding partner for the business. This is considered a big advantage cloud computing can offer. [6]

In addition to requirements for company IT cost efficiency, the cloud services themselves often meet commercial requirements such as: [1]

1. In general cloud services are reasonably priced. The absolute costs of cloud services are low.
2. By using cloud services, the company can switch fixed costs into variable costs (or operating

costs). The agreements with the cloud service providers are time limited and the company will not have any upcoming costs beyond the agreement term. Services, such as cloud services, are not usually depreciated. In addition, additional capacity can be easily acquired without any set up fees. 3. Cloud services enable the company to reduce the costs with its own efforts. The invoicing gets lower if the usage is lower, e.g. on monthly basis.

Another cost reduction or cost avoidance comes from maintenance perspective: the company does not need to worry about hardware maintenance or upgrades of the firmware or software but they are rather included e.g. in the monthly fee. If the IT environment is managed by the company itself, the environments get outdated and require bug fixes, upgrades, and configurations and related testing regularly. Finally the hardware and also software gets obsolete due to operating system upgrades or because of elapsing maintenance from hardware or software supplier. This forces the company to make new upfront investments to the IT systems which are often crucial to the businesses.

OPPORTUNITIES

Cloud computing brings great opportunities in relation to cost reduction of ongoing running costs and enables quick application and service deployment. Utilizing common computing platform is environmentally friendly but brings a business challenges to companies who traditionally have collected their revenues from server sales and from technology licensing. This applies to companies such as HP, Oracle (Sun Microsystems) and IBM. Oracle, in turn is having Big Data concept which stores and manage big amounts of data in dedicated servers effectively. Traditional IT vendors have also shift their focus on the cloud's application layer by providing SaaS services to customers who traditionally have purchased standalone database or application licenses. Utilizing similar services as SaaS will ease the learning curve and fasten the technology diffusion. The end user does not recognize any change if the performance and other technical requirements are properly fulfilled.

Cloud based services can also act as an infrastructure to various services for mobile devices. Web surfing has expanded to emails, Facebook and Twitter. All of those are cloud applications. [1] In emerging markets lots of people would need to access ATMs and other online services. Cloud computing is a tool to enable that with inexpensive investments. As economies grow, more IT based solutions come desirable. The cloud can serve small and midsize businesses that cannot afford building massive data centers. [6]

New growth theory refers to recent modeling of economic growth which explains the rate of sustained growth of per capita income in the long run. The growth process has been affected by three dynamic forces. Firstly, technology and innovations are seen as the engine of sustained growth. Profit-seeking entrepreneurs who forward-look the state of the world make direct and intentional investments that foster technological progress. Second important factor is the dynamic externalities due to international diffusion of knowledge base and the rapid development of information technology. Knowledge spillover effect may be the most significant factor explaining the great differences in marginal productivity of capital between a less developed and a fast or developed economy when taking into account the human capital. Thirdly, trade openness and its impact on sectorial growth of output are crucial for the growth. It has been emphasized that

the diffusion of spillover research technology implies the strong connection that is foreseeable between rapid productivity growth and trade or openness.[4]

Cloud services is one element is the broad range of information technology but an important enabler in respect to providing computing capacity and easy application deployments globally. Even if security is foreseen one weakness of cloud computing, an existing cloud instance would have security provisions readily available which reduces the vulnerability of a service.

CHALLENGES

Cloud computing brings various challenges for the system and application developers, system administrators and service providers. Virtualization brings challenges for maintenance operations as multiple virtual machines need to be managed effectively so that the service level can be kept on an adequate level. [7]

Security, privacy and trust are major concerns when considering and using clouds. Important data and critical operations may be subject to cloud hosting. Hence trust to cloud providers is crucial. In addition, legal and regulatory issues need to be taken into account. Applications and data can reside anywhere in the world. Physical location of data centers and clusters determines the set of laws that are applicable in relation to data management. Some cryptography techniques may not be allowed in certain countries. Banks and insurance companies need to put extra effort to protect the confidential data of their customers. [7]

Security and privacy issues may slow down the deployment of cloud services and therefore slow down the pace of technology diffusion.

Compatibility may also slow down the deployment of cloud services. Applications that are desirable for SaaS are such that are similar in various companies. For example managing sales funnel is done similarly in many companies and is potential candidate to be used as SaaS. Applications for supply chain management differ from company to company and therefore are not so suitable for SaaS. Similarly the applications for human resource management are fragmented and as such are not the first candidates for SaaS. [1]

CONCLUSIONS

Technology diffusion of cloud services have started reasonably quickly. Dotcom burst in early 2000 intensified the use of computing power effectively. Cloud computing cannot be said yet to be domain design but it is gradually reaching that status. Cloud vendors are experiencing growth rate of 90 % per annum.[8] Especially new services are vastly build on top of cloud computing. The global recession has intensified the efficiency needs in relation to IT projects, to productivity and in relation to the running costs. New innovations in IT are required in order for the businesses to maintain their competitiveness. Cloud computing enables the expansion of IT operations to emerging markets, hence lowering the labor costs. On the other hand geographic expansion enables growth in new geographical areas. Environmental issues certainly speak on behalf of cloud computing as there is need for less hardware appliances.

Data security and privacy issues have been discussed widely in public during the last few months. The importance of them is not diminishing but rather growing as normal citizens start to

be more aware of potential underlying threats in respect to their personal and private data. Cloud computing companies and those who utilize cloud computing must address these concerns with great carefulness. Privacy issues are subject to up to privacy legislation which again is moving slowly due to national bodies and is governed by national and international legislations.

Still a sign of the importance of cloud computing is from 2008: when big real estate financiers Fannie Mae and Freddie Mac were withdrawn from the Standard and Poors 500 stock index in September, the other was replaced by Salesforce.com which is a successful CRM supplier fully relying on cloud computing. Salesforce.com has become a core holding item of many technology focused stock funds. [1]

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