

Cloud Computing, I-Service, And IT Service Provisioning

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ABSTRACT

Cloud computing is an architecture for providing computing service via the Internet. Use of the term “cloud” is a metaphor for the representation of the Internet used in most systems diagrams. In this case, the Internet is the transport mechanism between a client and a server located somewhere in cyberspace, as compared to having computer applications residing on an “on premises” computer. Adoption of cloud computing practically eliminates two ongoing problems in IT service provisioning: the upfront costs of acquiring computational resources and the time delay of building and deploying software applications. This paper covers both subjects.

Keywords: Cloud computing, I-Service, IT service provisioning, cloud platform, software as a service, software plus service.

FORWARD

The discipline of service science serves as the basis of modern computer and Internet technology encompassing the subjects of Web services, service-oriented architecture, and, most recently, cloud computing. Practically all aspects of modern information systems are derived from service science, as well as the pragmatic sides, of business and economic theory. In fact, if one replaces the principle of labor with that of service, it can be properly asserted that the science of services has its foundations in the essential work of Adam Smith [Smi76], most pointedly in his notions of “value in use” and “value in exchange.” This paper seeks to investigate the underlying principles that govern the exchangeable value of computer services. Throughout, we will attempt to show the real value of service, the different parts of which a service is constructed, and the forces that govern the dynamics of service value.

CLOUD COMPUTING CONCEPTS

Cloud computing is a means of accessing computer facilities via the Internet, where the adjective “cloud” reflects the diagrammatic use of a cloud as a metaphor for the Internet. Most of us have been using cloud-computing facilities in one form or another for years through ordinary email and the World Wide Web. Recently, the term has come to reflect the use of software and the running of computer applications via the Internet where the computer infrastructure and software are not “on premises.” Clearly, the computer facilities and software have to reside somewhere out in cyberspace but definitely not on the client’s site. The use of cloud computing as a form of IT service provisioning has given rise to several related concepts, such as hybrid computing, cloud platforms, and software plus service.

A proper, but not necessarily definitive, conceptualization of cloud computing is to use office-class applications via your web browser over the Internet instead of having those applications reside on your “on premises” computer. In this instance, the service provider supplies the network access, security, application software, and data storage from a data center located somewhere on the Internet and implemented as a form of server farm with the requisite infrastructure. A service would have ubiquitous access through a web browser. In general, the cloud computing concept is not limited to single-function applications, such as those available with typical office suites, but could include comprehensive enterprise applications pieced together from components residing in varying Internet locations.

I-SERVICE CONCEPTS

Every year, businesses spend millions of dollars on their IT infrastructure consisting of hardware, system software, applications, networks, people, and other organizational assets. With “on demand” computing, they can plug into the wall, figuratively speaking, and only pay for the IT services they use. The concept is called *utility computing* that is accessed as most public utilities. We are going to refer to the total utility computing concept as **I-Service**. When appropriate, an I-Service utility is a viable option for obtaining computing services, the essence of which is in the packaging of computer services as a metered facility without up-front costs for IT infrastructure. In the current view of things, an I-Service utility is network based and is dependant upon the Internet as a transport mechanism. In recent years, computing has become the operational medium for business, government, education, and a part of everyday life for most people, and as with electric utilities, computing utilities have evolved from being a luxury to an everyday necessity.

I-Service Characteristics

I-Service utilities are characterized by four key factors: necessity, reliability, usability, and scalability. *Necessity* refers to the idea that a preponderance of users depend on the utility to satisfy everyday needs. *Reliability* refers to the expectation that the utility will be available when the user requires it. *Usability* refers to the requirement that the utility is easy and convenient to use – regardless of the complexity of the underlying infrastructure. *Scalability* refers to the fact that the utility has sufficient capacity to allow the users to experience the benefits of an expandable utility that provides economy of scale. Certainly, modern Internet facilities for search operations that engage thousands of servers satisfy these characteristics.

Utility Computing Services

The notion of “paying for what one uses” is a compelling argument for using I-Service for special or all computing needs. However, the proof of the pudding may, in fact, be in the details. The key question is whether the service should be based on a metered model or a subscription model. With the *metered model*, the usage is easily measured, monitored, and verified and lends itself to managerial control on the part of the user. In addition, metering can be applied to differing levels of service. With the *subscription model*, usage is difficult to control and monitor and its adoption is favored by managers more concerned with convenience than with resource control.

For example, water and electricity service commonly use metered service while the plain ordinary telephone system “usually” provides subscription service for local service and metered service for long distance. In the area of computer networks, broadband cable and telephone digital-subscriber line (DSL) rates are normally based on the subscription model. With cable TV, on the other hand, there are usually differing levels of subscription service along with “pay per view” for special services.

One can readily conceptualize a scheme for a typical I-Service customer – nominally assumed to be a small-to-medium-sized business. Office services, such as word and spreadsheet processing, could be subscription-based service and special applications, such as integrated enterprise systems, would be metered service.

I-Service Architecture

The difference between application services and multi-tenant services may very well be the deciding factor in determining whether metered or subscriber service is the way to go. With *multi-tenant service*, several clients may share the same software with separate data – as in the case of office processing. With *application service*, the service provider supplies one instance of the software per client, thereby lending itself to a form of metered service. In the latter case, the notion of a client should be regarded as an environment comprised of several users.

Hosting and Virtualization

A common example of utility computing is *hosting* wherein an application service provides “off premises” computer services on a subscription or pay-as-you-go basis. The practice is prevalent among relatively small

software developers that require expensive computer facilities. A service provider usually supplies requisite services on a time-sharing basis through communications facilities, and the service provided is the access to and utilization of a computing platform comprised of a computer system, an operating system, and necessary utility facilities. This is the origin of the *Platform as a Service* (PaaS) concept, often sustained through virtualization.

Virtualization refers to the provisioning of a “not real but virtual” computing environment created through a software facility known as a *hypervisor* with the capability of managing several diverse computing platforms, executing concurrently, so that the client is given the operational advantage and illusion of having a unique copy of the selected platform. The hypervisor controls the underlying computer hardware and software and passes control to a specific client instance on a demand basis. [Kat86]

The Long Tail

The long tail [Cho06] is a conceptualization of the unique opportunities available through Internet access, exemplified by online book sellers and software services. A brick-and-mortar bookseller has a limited amount of self space and typically stocks only the most popular books. Online booksellers do not have the same limitation and are able to take advantage of the long tail, as suggested by Figure 1, to provide opportunities not available otherwise.

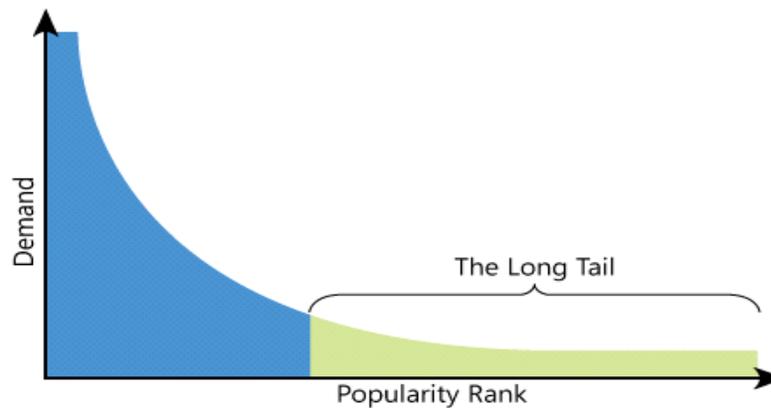


Figure 1: The Long-tail concept. [Cho06, p. 8]

The long-tail phenomenon also applies to line-of-business software, as depicted in Figure 2, and consumer-oriented services to provide a level of economy of scale not otherwise available with “on premises” software and the requisite computing platforms. The long-tail perspective provides a basis for the monetization of cloud computing.

CLOUD COMPUTING CHARACTERISTICS

The defining characteristic of cloud computing is that services are accessible through a web browser. In general, the cloud computing concept is not limited to single-function applications, such as those available as office suites, but could include comprehensive enterprise applications pieced together from components residing in varying Internet locations. Because the application software with cloud computing is not executed on a local computer, it is useful for connecting people and organizations in various combinations across the Web and supporting mobile computing. Cloud computing should not be confused with outsourcing. With outsourcing, an existing function is moved out of the department, enterprise, or geographic jurisdiction. With cloud computing service, the home of an application originates in the cloud.

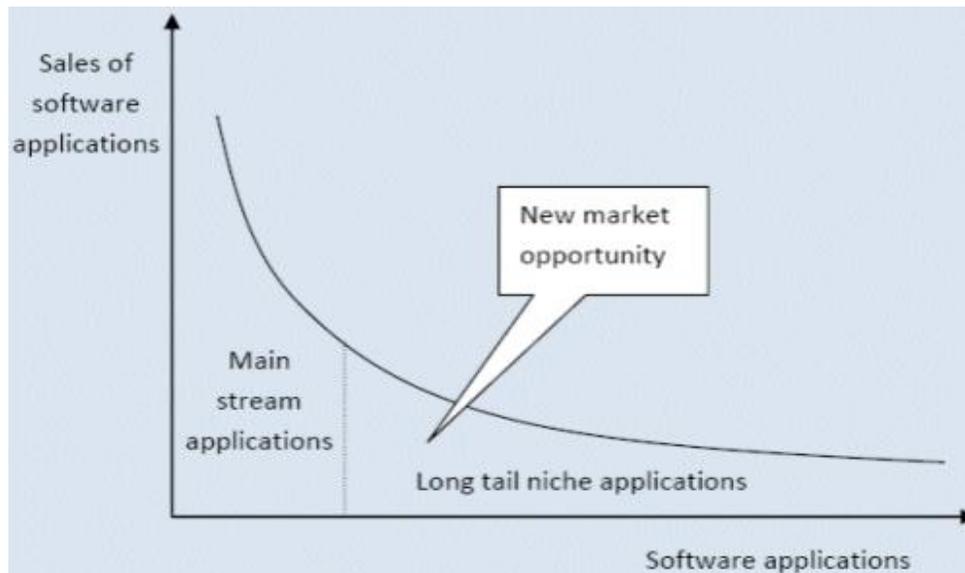


Figure 2: Long-tail software opportunities. [Cho08, p. 2]

Cloud Computing Versus Utility Computing

It is difficult to state the difference between cloud computing and utility computing, because they both appear to refer to the same phenomena. Digging a little deeper, however, it would appear that utility computing is more of a business concept – perhaps a business model – providing “pay for what you get” services, where the operational framework could be traditional batch processing, local networks, enterprise networks, or the Internet. In fact, utility computing has the flavor of a “spin off” of a non-core service to another organizational entity – either internally or externally. In general, utility computing could use the Internet, but that is not a defining characteristic.

Cloud computing, on the other hand, is by definition an Internet-based facility – hence the “cloud” metaphor referring to the usual depiction of the Internet. With the Internet providing the accessibility component, service clients do not typically own the hardware and software infrastructure. So the chief advantage of cloud computing from the client’s perspective is the availability of software, storage, and computing resources without up-front infrastructure costs.

Advantages Of Cloud Computing

With cloud computing, the client can be up and running with a new or needed application in a very short period of time, especially for functional applications with all of the I-Service advantages referred to in the previous section. Effectively, the client is renting the cloud computing service.

Cloud Terminology

As with other forms of I-Service, cloud computing has its own terminology, reflecting the underlying concepts and components, such as the following: [Wik08a]

Cloud application – the software service being offered.

Cloud client – the service participant using the cloud functionality.

Cloud platform – the computer infrastructure that supports the cloud computing service.

Cloud service – the application facilities provided by the cloud environment.

Cloud storage – the online storage for files and databases supported by the cloud platform.

Cloud architecture – the overall design of the cloud computing environment.

Cloud provider – the enterprise that owns and operates the cloud computing service.

Collectively, the cloud concept engenders two related topics: Software as a Service (SaaS) and Platform as a Service (PaaS).

Software As A Service Definition

The availability of software accessibility via cloud computing is a means of deploying software without the inherent costs of purchase, installation, and computer hosting. With SaaS, the burden of software installation, maintenance, and support is eliminated from the client's viewpoint. From the vendor's viewpoint, SaaS provides enhanced protection for intellectual property and establishes an ongoing revenue stream for the software developer.

Platform As A Service Definition

A cloud platform, together with associated software, provides an "on demand" form of application availability without the inherent costs of infrastructure deployment and ongoing maintenance and support. Most cloud services are based on service-level agreements (SLA) essentially resulting in the leveraging of infrastructure costs among multiple cloud clients.

PaaS provisioning reflects a business model wherein one enterprise supplies PaaS hosting to one or more SaaS enterprises. In the provisioning package, the PaaS provider would supply advanced security measures and other necessary infrastructure facilities never actually seen, per se, by the cloud client. In this scenario, the SaaS enterprise is then solely responsible for cloud software development.

SOFTWARE SERVICE

Chong and Carraro [Cho06] define software as a service (SaaS) as software deployed as a hosted service and accessed over the Internet. The key features of SaaS are where the programs reside and how they are accessed. The two kinds of software in this category are business software and consumer software. Business software provides business services and emphasizes business solutions, such as CRM, SCM, ERP, and human resources. Consumer software provides publicly oriented personal solutions, such as office applications and are often provided at no cost – that is, in their cloud versions.

SaaS Architecture

The die has been cast, and cloud computing is destined to be a major topic in IT services provisioning, primarily because it takes good advantage of available technology and best practices for effective service economics. A major aspect of cloud computing is Software as a Service (SaaS) that will have a profound influence on the software industry. The subject of SaaS will determine how software is developed, sold, purchased, and deployed.

With business services, the most important consideration is whether the process is executed in-house or as a cloud service. When the process is handled in-house, total control over the operation is obtained along with limited opportunity for achieving economy-of-scale. As processes are distributed outward on the cloud, control is decreased but opportunities for achieving economy-of-scale are increased.

The considerations are different with consumer services. Pure service, as with office applications, provides practically no control over the application to the client and a reasonably high-level of economy-of-scale to the provider. In many cases, consumer services are advertising-supported and are complimentary to the client, as covered below.

Business Services

Business applications that reside “on premises” are governed by the traditional considerations of application acquisition and deployment. If an application resides on and is deployed from the cloud, then two options exist:

- (1) Build the software yourself (or have it built for you) and run it on the cloud as a hosted service – perhaps using a cloud platform.
- (2) Obtain the application software from an independent software vendor (ISV) and run it on the cloud in a standard or modified mode.

In the former case, all clients access the same version of the software. In the latter case, a client gets a customized version achieved with a separate code base, or its equivalent, configuration options, or operational metadata. The subject of business services is covered in more detail in a subsequent section.

Consumer Services

The primary advantage of a cloud consumer service is that it is typically free to the client, as well as being accessible from any location via the Internet, and it yields advertising-supported revenue for the provider. Consumer services have a near-zero marginal cost of distribution to clients, because of the long tail, and requires only a fraction of the number of clients to respond to advertising. This is the well-known *Freemium Business Model* [And04], characterized as follows: In the free sample product model, you give away 1% of your product to sell the additional 99%, whereas in the freemium model, you give away 99% to sell 1%. Because of the scale of the Internet with millions of users, you can reach a large market, so that the 1% is a huge amount.

Software Plus Service

Software plus Service (S+S) refers to a user-centric approach to service deployment by combining “on premises” computing (fat client) with enhanced services on the cloud. The enhanced services combine advanced functionality with the capability to scale up to meet peak computing demands for both business and consumer services. A related feature of S+S involves the distribution of service pack software updates for both system and application software and the provisioning of automatic software downloading.

The Business Model

Clearly, the business model for the deployment of both SaaS and S+S changes with the adoption of cloud computing. The ownership of software shifts from the client to the provider, along with the responsibility for the technology infrastructure and its management. [Cho06] The marketing targets for SaaS and S+S clients are service consumers and small to medium sized businesses and economy of scale is achieved through specialization and the development of cloud platforms.

Cloud Application Architecture

A comprehensive SaaS application structure includes a continuum of architectural levels, based on the capability of handling multiple clients and software configurability. Four levels are identified. The number of levels in any specific operational environment is based on the cloud platform and its characteristics.

Level One. At the first level, the users within a client domain address a single instance of an application running on a server. Each client/instance is totally independent of other client/instances running on the same server. This is the traditional hosted service operating in the cloud. Each software instance is individually customized for each client.

Level Two. At the second level, the server hosts a separate instance of the software for each client, but the instance is a configurable version of the same code base, reducing maintenance costs and contributing to increased economy-of-scale.

Level Three. At the third architectural level, the vendor runs a sole instance that is shared by multiple clients. The feature set for each client is determined by configurable metadata, and authorization/security policies insure the separation of user data.

Level Four. At the fourth level, the same “level three” instances are run on a server farm with fabric for load balancing.

The choice among architectural levels is determined by the provider/client’s business, architectural, and operational models.

CLOUD PLATFORMS

A *cloud platform* is an application service provider that runs in the cloud. More specifically, a cloud platform provides services to applications in the same manner that “software as a service” programs provide services to clients using the cloud as a transport medium. A cloud platform resides in a cloud data center and exists as a powerful computing facility, a storage system, an advanced operating system, support software, and the necessary fabric to sustain a server farm and scale up to support millions of Internet clients. A cloud platform is as much about operating in the cloud, as it is about developing applications for the cloud.

Application Development

A cloud platform provides the facility for an application developer to create applications that run in the cloud or use cloud platform services that are available from the cloud. Chappell [Cha08] lists three kinds of cloud services: SaaS user services, on-premises application development services (attached services), and cloud application development services. An *SaaS application* runs entirely in the cloud and is accessible through the Internet from an on-premises browser. *Attached services* provide functionality through the cloud to support service-oriented architecture (SOA) type component development that runs on-premises. *Cloud application development services* support the development of applications that typically interact while running in the cloud and on-premises.

Cloud Platform Architecture

A cloud platform can be conceptualized as being comprised of three complementary groups of services: foundations, infrastructure services, and application services. The *foundation* refers to the operating system, storage system, file system, and database system. *Infrastructure services* include authorization/authentication/security facilities, integration between infrastructure and application services, and online storage facilities. *Application services* refer to ordinary business services that expose “functional” services as SOA components.

Cloud platforms are a lot like enterprise-level platforms, except that they are designed to scale up to support Internet-level operations.

Application Services

“*Venus* is for application services and *Mars* is for infrastructure services.” Application services are designed to be used by people, and infrastructure services are designed to be used by applications. [Cha08, p. 11] The basic idea of cloud platforms is that SaaS applications will be created by developers to provide services used by people, and SaaS applications will use infrastructure services.

Software Plus Service Considerations

Software plus service (S+S) is an in-between point in the cloud service continuum, falling between the pure-play user-centric set of services and the large-scale enterprise application systems in which on-premises and cloud software interact to support comprehensive business services. In the S+S hierarchy, the cloud platform should consist of building block, attached, and finished services to complement application services, mentioned previously, and to support a flexible set of operational scenarios that include PCs, the Web, mobile devices, on-premises servers, and cloud-based services. [Fol08]

FURTHER RESEARCH

Cloud computing has evolved into a huge research topic with each major player in the IT provisioning group supplying its own version of exactly what the subject matter should incorporate. The above materials are an attempt at finding a middle ground and providing a basis for further research. Two very important areas have not been covered: authorization/authentication/security and cloud databases. Both are significant for exchanging data between applications within the cloud.

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