

## Chapter 2

# Basic Cloud Computing Types

**Abstract** Cloud computing's marquee feature is the availability of all required software on the web. The principal service that provides this feature is Software as a Service (SaaS) and this is the leading type of service on the cloud. Medium sized businesses that have the ability to have computing expertise amongst its work force have the option of selecting Platform as a Service (PaaS). PaaS gives the business the ability to choose applications that fit their needs most by selecting multiple platforms from the cloud provider. Large and niche businesses have the option of selecting only the infrastructure from the cloud provider, thus benefiting from the Infrastructure as a Service (IaaS) option. In this chapter we will highlight the major benefits and certain drawbacks of these three important services in the cloud. Moreover, the cloud provides different modes in which an organization could benefit. The four basic modes are: public cloud, private cloud, hybrid cloud and community cloud. Public clouds are the most widely deployed and used by all small and medium sized businesses. Private clouds are predominantly used by large businesses that need to supplement their data centers in a reliable way. Hybrid clouds provide a way for a business to manage certain services in-house and use the cloud for some of their customer facing applications. The community cloud serves a vertical market such as health care or automotive where the users have some common features in their applications. This chapter will address the strengths and weaknesses of these four modes of cloud computing. We will conclude this chapter with a survey of Storage as a Service that is gaining ground as an important cloud service.

**Keywords** SaaS · PaaS · IaaS · Public cloud · Private cloud · Hybrid cloud · Community cloud · Storage

## 2.1 Introduction

Cloud computing is a global technology that is offering businesses of all types an alternative way to have an information system for their business. Businesses are good at what they do and it is a fact that in today's competitive world they need a reliable computing system to achieve their goals. Traditionally businesses of all types developed their own in-house computing system, with or without help from

external partners. For small and medium sized businesses it is a distraction to have to concentrate on having their computing system functional. It costs both time and money to manage an information system. When cloud computing system became a viable option many businesses decided to use the service. In doing so the business has to give up control of the computing hardware that they will be using as well as their data. This resulted in natural concern both from security and privacy aspects for many businesses.

Cloud computing evolved from the traditional outsourcing model. In this model the necessary service is provided by an organization that specializes in that field. The contracting organization chooses a specific period for which the service is provided. Many small and medium-sized businesses, instead of outsourcing their Information Systems, contracted with specialists to manage their Information Systems. In either case the Information System was under the control of a third party. Often the third party handled all associated data as well. Businesses did not have a problem with this arrangement because of the detailed stipulations spelled out in their customized contract with the third party.

The primary attraction with cloud computing for businesses is the ability to have a fully functional computing system within a few hours or a few days depending on the level of complexity in the chosen system. The cloud computing platform makes available all the options such as the type of hardware needed, the service type, applications needed, and amount of storage, etc. for the customers to select and launch their system (Hurwitz et al. 2012). The access to the system for the customer is through the internet. Cloud customers who need higher level of protection for their communication with the cloud may choose a Virtual Private Network (VPN) connection which is offered by the Internet Service Provider (ISP). The ISP connection speed determines their communication speed with the cloud service. Speeds such as 10 Mbps and higher are quite affordable for many individuals and businesses and so accessing the cloud computing service via their internet service will not be cost prohibitive. Some of the other benefits for a business in using the cloud service are the ability to increase or decrease the use of computing resources, access to a wide variety of applications without any licensing requirement, pay only for the service used, and the ability to have access to high-end computing resources. The most important attraction with the cloud service for a business is that the service is available without the need to maintain and manage the service, which takes significant resource and attention away from the business.

Customers can select from a variety of cloud service providers and so there is better pricing available and the cloud customer could be located anywhere in the world. Many niche services such as payroll processing, human resource management and Customer Relations Management (CRM) that are usually outsourced can be subscribed to as a service through the cloud. Major cloud service providers have invested billions of dollars in their infrastructure with plenty of redundancy built-in for higher reliability. Moreover, the service provider is able to provide a 99.9% service uptime guarantee. Cloud computing service comes in a variety of service types and deployment models. The most common service types are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The

most common service deployment models are Public cloud, Private cloud, Hybrid cloud and Community cloud. The major cloud service providers are Amazon Web Services (AWS), Microsoft Office 365 and Windows Azure, Google Apps, Rackspace and Salesforce. AWS is the largest cloud service provider globally and it offers services such as Elastic Compute Cloud (EC2) and Simple Storage Service (S3). Office 365 provides all the office productivity software that many people are accustomed to such as Word, Excel and PowerPoint and the Outlook email service. Azure provides high-end database and search engine services as well as the Skydrive storage service for the consumer and businesses. Google Apps includes all the popular software such as Gmail, Google Docs and Google Drive, plus several more niche services. Rackspace provides all the basic cloud services, including web hosting and the Fanatical Support service for all its cloud offerings. Salesforce is the global leader in offering Customer Relations Management (CRM) software over the cloud. In this chapter we will discuss the details of each service type and each deployment model in detail. We will also introduce additional service types for cloud use that are sought after by businesses.

## 2.2 SaaS

Today's cloud computing has three basic types: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). In the simplest of terms 'cloud computing' has come to embody SaaS. Similar to the IT time-share model mentioned in Chap. 1, SaaS provides both the server hardware and software to an organization without any of the complications of managing an IT system. The simplest example of SaaS service would be email for an organization. The first such service was Hotmail from Microsoft in 1996. Prior to Hotmail the email services from providers such as America Online and Compuserve were server based. The cloud provider benefits from the economies of scale in managing a large infrastructure because of their strength in that area and is able to provide the necessary computing resources to the user, majority of who are small and medium sized enterprises (SMEs), at an affordable cost. SaaS leaves the full control of the computing system with the provider. SaaS is also known as the On-Demand software because organizations choose the software that they need from a whole host of software offered by cloud service providers. The early leader in offering SaaS service was IBM in 2003. At that time this service was known as On-Demand software. The term SaaS evolved over a period of time and came into vogue in 2005 when Amazon launched the Elastic Compute Cloud (EC2). Today, some of the major commercial SaaS providers are Amazon, Google, Microsoft and Salesforce.

Managing software such as an office productivity suite of applications requires keeping current on the software, the necessary licenses for all users, patch management and upgrade on the software. Each of these aspects requires the management to devote time and energy. For small and medium sized businesses it is a necessity to have a dependable IT resource but at the same time it detracts them from

their core strengths. For example, a small business focusing on manufacturing an automotive part will have to keep up their quality in manufacturing, move the products in the supply chain to the automotive manufacturer and maintain or grow their business. For them, to divert their attention from their core strengths to managing the necessary IT infrastructure would take a toll. This is where SaaS comes handy for small and medium sized businesses. In fact, a service oriented IT department in an organization would immensely benefit from changing their focus from deploying the various software and maintaining them to managing the results of the various applications that SaaS vendors provide.

SaaS evolved as a natural extension on the cloud of the traditional software delivery to businesses. In this early approach, SaaS was essentially a single-tenant service from the service provider. This shifted the maintenance of the software to the cloud provider but did not give the user the benefits of integration from running multiple applications on the cloud. With the growth of technology today SaaS enables the user to work in a multi-tenant environment where the user is able to integrate the results from multiple applications on the cloud.

Businesses see the potential of SaaS as a strategic decision that they have to take to embrace given the risks involved in losing direct control over their applications. In the traditional model vendors sold the software applications to users for a onetime fee and the users were responsible for the upkeep of the software patches provided by the vendor. However, under the SaaS model, the vendor or a third party known as the aggregator provides the software application over the cloud. In this model the user pays an ongoing fee for use of the software on a per user basis without the hassle of maintaining the software. SaaS benefit extends to large enterprises as well. However, in this case the enterprise should have a software management structure whereby all SaaS applications usage in the organization must be cleared by a single group so that the organization could plan for integrating data from all SaaS applications. In many businesses there is a greater need to use both on-premise software and some SaaS applications. Until recently businesses were concerned about the security issues associated with the cloud and there was some resistance to using SaaS applications. With the widespread use of SAS 70 audit features by the cloud service providers many businesses now seem to consider SaaS applications because they will have the necessary audit data to comply with any requirements.

Organizations find another benefit when it comes to using SaaS. Typically the budgeting process in companies requires extensive lead time in order to invest in capital expenditure and also requires significant time for IT to implement the new application. A reasonable estimate of this time frame is 18 months. On the other hand when using SaaS, businesses usually spend less than two months to implement the new application and the budgeting process moves into a different area other than capital expenditure and speeds up the approval process. This ease of implementation also has a potential downside. Many units within a business would find specialized applications that they need and find it in the cloud and deploy quickly. This could lead to mushrooming of applications that a business uses and may have difficulty integrating the outputs from these various applications. That is why busi-

nesses should have a strategic vision when it comes to using SaaS as a fast solution to deploy their plan.

Following up on the theme of the previous paragraph, we look at the details of Microsoft Office 365 suite of products. This is a cloud service provided by Microsoft that makes available all their leading software products for office productivity. The main benefit to a business in using Office 365 is that it not only comes with the software that people are accustomed to using in their own computers but it also provides storage for the documents created using Office 365. This feature enables the user to access their documents from anywhere on multiple devices. Today, with the work force being so mobile, access to documents on multiple devices is a must. Moreover, some of these devices use different operating systems, such as iPhone. Instead of the business trying to manage the software on all devices that their employees use and from any location, a business stands to gain in cost and management time from letting the service provided by a cloud provider such as Microsoft using Office 365. Google also provides a similar service using Google Apps. Since many users are already familiar with Microsoft products it helps a business to use Office 365 both from the availability of the necessary software but also providing its work force full access to the documents from anywhere on multiple devices. These are important considerations for a business in evaluating a cloud service.

Typically, in evaluating cloud service businesses consider the pros and cons with regard to the software applications and the hardware maintenance. As mentioned earlier, small and medium sized businesses benefit more from SaaS. The service SaaS consists of a variety of software products that a business uses, not just office productivity software. So, for this reason a business might have to consider other aspects of SaaS when it comes to a multitude of services such as inventory control and Customer Relations Management (CRM). The leader in CRM services on the cloud is Salesforce.com. This being an independent software, businesses will have to evaluate the ease of interoperability between the many software applications that they choose on the cloud. Thus, Office 365 may not suit all businesses. In this regard one software that is worth mentioning is Zoho. Compared to its major rivals Salesforce.com and Google Apps, Zoho provides a free version that could be used by small and medium sized businesses. The approach taken by Zoho is worth mentioning as it offers significant integration of multiple types of applications such as Office products such as email, spreadsheet, inventory management and growing the business using easy tools to follow customer leads. Major software such as Salesforce.com and Google Apps also offer such integration but at a per user cost on a monthly basis which will add up quickly for a small or medium sized business.

Web based services such as SaaS should provide greater flexibility in integrating multiple applications. One such application for many businesses is web based forms through which businesses collect valuable information. Application software such as for CRM should support integration of information gathered through web based services. We emphasized the benefit of SaaS for SMEs in that the business can focus on its core strengths and rent IT services from a cloud provider. Given the need to support many mobile devices for its workforce, SMEs are faced with the

**Table 2.1** Interpretation of system uptime metric

System uptime level (%)	Downtime per day	Downtime per month	Downtime per year
99.999	00:00:00.4	00:00:26	00:05:15
99.99	00:00:08	00:04:22	00:52:35
99.9	00:01:26	00:43:49	08:45:56
99	00:14:23	07:18:17	87:39:29

problem of supporting applications on the mobile devices. Companies like Zoho have realized this need and have developed products that will help them remotely troubleshoot mobile devices for specialized applications. Besides Salesforce.com and Zoho other related CRM products are BatchBook and SugarCRM. Each of these software try to provide a niche service such as seamlessly integrating with social media in order to follow customer leads that come through email.

When a business controls its IT the benefit is the knowledge the business gains in knowing the reliability of the system and its uptime. These are two aspects a business must evaluate before deciding on a cloud service provider. In this regard the metric to watch is the system uptime. It is measured as number of 9s, for example, four 9s uptime means that the service provider guarantees that the service would be up 99.99% of the time. It should be noted that the measure is reported as four nines and not four ninths. The four 9s uptime translates to a total down time of only 52 min a year. Managing a highly available computing infrastructure is very expensive. In order to add one more 9 to the uptime level nearly doubles the cost for the cloud provider. The following table summarizes the meaning of multiple 9s uptime in terms of the respective downtimes per day, per month and per year. It is clear from this table that four 9s uptime provides that a system could be down only 8 s per day. In order to provide such a high level of reliability the cloud service provider must have plenty of redundant systems in place. Companies like Amazon Web Services and Google have the necessary resources to guarantee such a high level of reliability. If a cloud service provider lists in their promotional literature greater reliability then the potential (Table 2.1).

We have mentioned here how a customer could assess the service reliability of a cloud service provider by checking their uptime level. There are simple commands available for the end user to accomplish this. In the Unix/Linux environment the command is `$uptime` and in the Windows environment the command is `systeminfo | find "Up Time"`. Knowing that such simple tools exist based on the operating system used, the customer need not take the claims of the service provider at face value.

Another major advantage of cloud services is the ability to integrate vertical market applications. For example, in health care or automotive businesses, cloud computing can help eliminate redundancy in the deployment of application software for all businesses in the industry. Using economies of scale, a SaaS provider will be able to provide the necessary common application software to all businesses in the same field such as health care. Likewise, in horizontal market applications such as

payroll and customer relations management, cloud computing can help eliminate redundancy in the deployment of application software and their management. It might appear to be lost revenue for the software vendor because they would not be selling their software to many businesses. However, they would still reap the benefits of providing the same service to many more businesses through the cloud. In this case the software vendor would make up the difference in revenue through volume. Moreover, the cloud service would benefit the software vendor in dealing with one provider rather than numerous individual businesses.

One drawback in the use of cloud services either for a vertical or horizontal market is the potential for data leakage. In either type of market the common thread is the application software. When many businesses use the same software for their inventory management or customer relations management they all store data in several virtual servers that share a single data storage device. When a virtual server malfunctions and accesses an area outside of their server then chances are that data would be pulled in a readable format. Another related issue is explained in the following scenario. When data is stored in clouds by multiple banks (all using SaaS from the cloud provider) then the potential exists to search all those data for a particular customer based on the Social Security Number as the key. Why is this important? If in a major investigation the law enforcement wants to find out the financial reach of an individual then cloud facilitates it much easily.

The adoption of SaaS has been rather slow in spite of the many benefits it offers. In the 2008 Forecast survey by Computerworld, many respondents identified several reasons for not considering adoption of SaaS in their operations. The main reasons given were:

1. Security concerns over lack of control
2. Need for enhanced bandwidth to access the application and data over the cloud
3. Lack of offline access to the application
4. Lack of interoperability among multiple applications by different vendors
5. Potential for their data getting comingled with others' data
6. Costly Service Level Agreements (SLAs)

Some of these concerns still persist, especially the interoperability and security aspects.

We described above a general scenario in which cloud services benefit the software applications vendor. We now look at a special case to amplify this command further. Oracle is a major database and Enterprise Resource Planning (ERP) software vendor. They have developed Exadata servers with the specific goal of providing cloud service that combines the benefit of a single provider who is able to provide SaaS applications such as CRM and ERP using the cloud. The benefit Oracle provides in this case is their maturity in both the CRM and ERP markets and their ability to connect these applications using the Exadata servers. Since SaaS applications in the cloud require both fast processors and storage, Oracle's Exadata Database machines are able to meet the demand in terabyte level storage and peta byte level scalability of applications.



## 2.3 PaaS

Platform as a Service (PaaS) is a cloud based service that gives the subscriber more freedom in the choice of computing platform that they want to use. The PaaS user must have adequate computer specialists to manage the platform that they subscribe to as opposed to a SaaS user. PaaS brings the same level of flexibility that a cloud platform provides with regard to availability of resources and elasticity of demand. Just like SaaS, PaaS also fits the pay-as-you-go model. PaaS provides the customer a platform, such as the Windows operating system with the necessary server capacity to run the applications for the customer. The PaaS cloud service provider manages the system for its upkeep and provisioning of tools such as .NET and Java whereas the customer is responsible for the selection of applications that run on the platform of their choice using the available tools. Thus, the customer is responsible for the security challenges associated with the applications that they run. For example, a customer running a SQL Server database on the platform should be aware of the vulnerabilities of the database system. Hence, the customer should have the expertise to manage such applications on the platform used. The benefit to the customer is that if their hardware needs change or if they require a Linux/UNIX platform for some other applications, then provisioning them takes only a few days as opposed to few weeks to make the new system operational. Major PaaS cloud service providers are Google App Engine, Salesforce.com and Windows Azure.

In PaaS, the cloud service provider makes available several application “components” that the user must put together as needed. This service is somewhat akin to building an object from Lego blocks. For example, Google Apps is a PaaS service from Google where a user could have storage space, ability to work collaboratively with others on textual documents, spreadsheets, presentations and emails. Google Apps is free for those in the education domain whereas it is a paid service for businesses. With over 5 million business users Google Apps is a well known PaaS service. By its very nature PaaS is a complex service that could be managed by organizations that have an experienced IT staff. Because PaaS is available through the cloud it is highly scalable. Even though PaaS gives the user the freedom to choose the applications that run on their platform, the hardware aspect is managed by the cloud provider and so the user can expect to have continuous service with no scheduled downtime for maintenance on a weekly basis. Companies use PaaS to develop and test new applications without the constraints of acquiring the necessary hardware.

PaaS is well suited for large companies and entrepreneurs for developing, testing and launching new applications based on a variety of platforms. Since the infrastructure cost uses the pay-as-you-go model many entrepreneurs are able to use a variety of platforms for their applications. Given the ease of use for the end user, applications can be tested in an interactive manner for multiple concurrent users. This kind of load testing is a great benefit to developers. Since resources are all available over the cloud, the developers could create different interfaces for different types of users. Since PaaS users develop their applications on a test platform, testing could



**Table 2.2** PaaS features offered by major service providers

Provider	Architecture	ALM	API	Scalable	Log data	Programming languages
Windows Azure	Multi-tenant	Yes	.NET and REST	Yes	Yes	C#
EMC Private Cloud	Multi-tenant	N/A	Atmos	Yes	Yes	Java
Amazon Elastic Cloud	Multi-tenant	Yes	Proprietary	Yes	Yes	C++, C#, Java, Perl, Python, Ruby
Red Hat Open Shift	Special software layer	Yes	Support all major cloud service providers	N/A	Available through provider	Java, Ruby
Ubuntu Private Cloud	Open Source	N/A	Based on Amazon's	N/A	Yes	N/A

involve sharing applications by multiple users while planning for scalability and security. Another benefit of PaaS is that it allows the developer to form distributed teams that work concurrently on various aspects of their application and assign different users different levels of access and track their usage patterns during the testing phase. Thus, PaaS offers a flexible multi-tenant architecture.

One of the key benefits of PaaS is that it supports the complete life cycle of any application development. This process would involve providing features that the customer should be able to combine in the ways they want and create the necessary applications. Such users need not be traditional programmers, rather typical users in a practical environment. PaaS features support the ability to collect logs of user patterns and identify any problems that occur when a real user tries out a new application. It is important for a developer to know that the platform supports Application Lifecycle Management (ALM) since it is essential for the developer to know that future changes would be easy to implement. With this feature of PaaS in mind we recommend that a potential user should evaluate the following aspects before deciding on a particular provider:

- Does the platform support multi-tenancy in architecture and applications?
- What Application Lifecycle Management applications are supported?
- What Application Programming Interfaces (APIs) are supported?
- Does the platform facilitate scalability?
- What types of log data would be available for the user?
- What programming languages are supported by the platforms?

We conclude this section with the following table that summarizes the availability of these features with respect to some of the major PaaS services. One new concept referred to in the table below refers to REST (REpresentational State Transfer) which uses HTTP methods explicitly and is stateless. REST was introduced by Roy Fielding in his doctoral thesis at the University of California-Irvine in 2000. REST is widely used today in web services. REST uses four HTTP methods: GET,

PUT, POST, and DELETE. REST is an alternative to SOAP (Simple Object Access Protocol) based web services. For example, when the browser makes a request for GET or PUT the response could be a PDF file, an image or an XML output. For this reason REST is preferred in web services because it preserves the state of what is being transferred to the recipient (Fielding 2000) (Table 2.2).

## 2.4 IaaS

Infrastructure as a Service (IaaS) provides the customer the same features as PaaS but the customer is fully responsible for the control of the leased infrastructure. IaaS may be viewed as the computing system of the customer that is not owned by them (Combs 2012). Unlike PaaS, IaaS requires the organization to have the necessary people with extensive computing expertise. IaaS is also known as “utility computing” since the organization needs the computing resources but does not invest in it directly but acquires the resources just like it would acquire a utility such as electricity and water. The IaaS customer would be responsible for all security aspects of the system that they use except physical security, which would be handled by the cloud provider. Amazon, Rackspace, Xerox and IBM are examples of IaaS providers. Typical use for IaaS is when a developer builds an application on a virtual machine of the cloud service provider and customizes the application to the needs of various customers by running them on multiple virtual servers. In this case the large organization is able to take advantage of the availability of virtual machines and manages the VMs for running their specialized applications. Of the three services IaaS is the most expensive and it is used by large corporations. The use of IaaS could be a supplement to the in-house computing resources of the organization. As described above, IaaS could also be deployed for certain applications using a VM environment. We summarize in Table 2.3 the major providers of these three types of cloud services.

The major strength of IaaS cloud service is that it extends the capabilities of large organizations in enhancing their IT resources. Many organizations are able to modernize their IT infrastructure using IaaS without the capital outlay needed to expand their corporate IT. Since organizations pay only for the cloud resources they use, the IaaS architecture provides the traditional benefits of the cloud and yet gives the customer more control over the security aspects of the applications that run on their virtualized environment. The scope of IaaS is many-fold. Organizations could use IaaS for pure computing power, which would be hardware and software. IaaS is also used by organizations for a specific purpose such as storage, security, or networking (Gartner Magic Quadrant 2013).

The real benefit to large organizations using IaaS is in acquiring raw computing power without the capital outlay. Since the organization controls what the infrastructure is used for it has the best of both worlds—access to computing resources as well as control over the infrastructure. The main reason for acquiring such additional computing power is to find ways to integrate multiple applications. For exam-

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