Chapter 2:

Cloud Service Models

Cloud Service Models

2.1 Learning Objectives

After completing this chapter, learners will be able to:

1. Identify cloud service models.
2. Distinguish characteristics of SaaS, PaaS and IaaS models.
3. Use service models as potential solutions for project implementation.
4. Explain solution stacks and the decisions that need to be made to implement them.

2.2 Overview

A cloud service model (e.g., cloud delivery model) specifies the capabilities offered to users and the applications supported. Many questions must be asked and answered to determine which delivery model is right for the enterprise, including:

- Are the data to be stored/processed in the cloud sensitive?
- Are the data to be stored/processed in the cloud critical?
- Is anything other than data to be stored/processed in the cloud?
- Are business processes to be performed in the cloud critical?
- Is the infrastructure offered by the cloud adequate for the purpose? Is it predictable?
- Are there any legal/compliance or regulatory impediments to hosting the data in the cloud?
- Are data ownership issues clearly defined and agreed upon?
- What jurisdictions preside over the location of the data?
- Is an adequate and appropriate service level agreement (SLA) being offered?
- Is the cloud solution cost-efficient?
- Does the CSP have a disaster recovery plan (DRP)/business continuity plan (BCP)?
- Are upgrades in service available?

There are three basic cloud delivery models that are examined in this publication (see **figure 2.1**), each offering a distinct computing service to the enterprise that uses it:

- **Software as a Service (SaaS)**—Provides a business application that is used by many individuals or enterprises concurrently
- **Platform as a Service (PaaS)**—Provides an application development sandbox in the cloud
- **Infrastructure as a Service (IaaS)**—Provides online processing or data storage capacity

Figure 2.1—Cloud Delivery Methods

Service Model	Description	Considerations
SaaS	Capability to use the provider's applications running on cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email).	SaaS provides applications that are complete and available on demand to the end customer. Traditional licensing and asset management are changed.
PaaS	Capability to deploy onto the cloud infrastructure customer-created or customer-acquired applications developed using programming languages and tools supported by the provider.	PaaS provides an application development sandbox and is specifically designed for developers.
IaaS	Capability to provision processing, storage, networks and other fundamental computing resources, offering the customer the ability to deploy and run arbitrary software, which can include OSs and applications. IaaS puts these IT operations into the hands of a third party.	IaaS can provide infrastructure services such as servers, disk space, network devices and memory and is designed for users wanting complete freedom with regard to the OS and applications they use.

Source: ISACA, *Controls and Assurance in the Cloud: Using COBIT® 5*, USA, 2014, https://www.isaca.org/bookstore/cobit-5/cb5ca

Before examining these three in further detail, it is worth noting that they are not the only delivery models available. Cloud service offerings are constantly undergoing major changes and evolving into new and better service offerings. Within these three "traditional" service deliveries, a variety of new services are emerging that are closely related. Most of the new services focus on replacing traditional in-house IT services with cloud variants and on the activities with which internal IT departments frequently struggle. These services benefit an enterprise in multiple ways:

- Easier access to new technologies; smaller enterprises gain access to a wide range of solutions that were previously beyond their financial reach
- Technical knowledge of the CSP and access to newer technology that can provide a competitive edge through the services delivered
- Correct and structured implementation of the targeted services

The adoption of cloud technologies should always be subject to careful study and should be aligned and integrated with the internal processes and procedures of an enterprise. The following "niche" services are increasingly used in the marketplace:

- **Security as a service (SecaaS)**[3]—SecaaS comes in two major forms:
  - The CSP provides standalone managed security services ranging from antivirus scanning and mail security to full deployments of end-point security.
  - The CSP offloads appliance utilization for the client, and CPU- and memory-intensive activities are moved to cloud services.
- **Disaster recovery as a service (DRaaS)**—The CSP offers its cloud infrastructure to provide an enterprise with a disaster recovery (DR) solution. In most cases, the CSP not only provides backup equipment and storage, but also provides services for a BCP, if it is not yet available. This significantly reduces the cost for an in-house DR infrastructure. In addition, offsite storage means that the DR environment is less likely to fail in the case of a major disaster.
- **Identity as a service (IDaaS)**—IDaaS currently has two interpretations:
  - The management of identities in the cloud that is separated from the users and applications that use the identities. This can be either managed identity services, including provisioning, or management for both onsite and offsite services. Delivering a single sign-on (SSO) solution can also be part of the cloud service offering.
  - The delivery of an Identity and Access Management (IAM) solution. IDaaS is often a hybrid solution (a federated model) in which access and roles are configured by the CSP and users are authorized by enterprise internal solutions.
- **Data storage and data analytics as a service (big data)**—Big data makes it possible to analyze all types of data by taking away the constraints on volume, variety, velocity and veracity. These

- **Data storage and data analytics as a service (big data)**—Big data makes it possible to analyze all types of data by taking away the constraints on volume, variety, velocity and veracity. These constraints are removed through a synergy between new technologies and the extended capabilities provided by cloud computing. Limitless volume availability and variety allow enterprises to reuse their "old" data for new purposes. Furthermore, big data technology facilitates the ability of enterprises to find patterns in their current data, which influences their way of doing business.
- **Information as a service (InfoaaS)**—This service builds on the big data concept. Rather than providing the raw data or algorithms that are used for trending, InfoaaS provides the required information. With this service, the result of a query is more important than the query itself.
- **Integration platform as a service (IPaaS)**—IPaaS, which is also called "cloud integrator," is defined as "a set of automated tools for connecting software applications that are deployed in different environments...often used by large business-to-business (B2B) enterprises that need to integrate on-premises applications and data with cloud applications and data."[4] Many enterprises are implementing a hybrid model in which some of their data, applications, services and infrastructure are maintained locally onsite, while others are provisioned by a cloud provider. Cloud integrators can help address the complexity of integrating these business resources without the need to constantly modify and maintain diverse and often incompatible applications.
- **Forensics as a service (FRaaS)**—FRaaS is a multi-tenant capacity framework that enables forensic analysis on digital evidence to be provided as a service in the cloud.[5]
- **Blockchain as a service (BaaS)**—BaaS utilizes cloud technology to deploy and support blockchain systems.

Because the marketplace and the cloud environment are so dynamic, other targeted deployment models are undoubtedly already in development or in actual use.

2.3 Software as a Service (SaaS)

SaaS is a method of software delivery and licensing in which software is accessed online via a subscription, rather than bought and installed on individual computers onsite, and is used by many individuals or enterprises concurrently. The applications are accessible from various client devices through a thin client interface, such as a web browser. SaaS provides the most-used cloud applications to the vast majority of online users. This model also provides the customer with the least amount of control as it is mostly managed by the CSP. Examples of consumer-directed SaaS applications include Gmail and Netflix. Office 365 and QuickBooks are common business-directed SaaS applications.

SaaS can be modified for specific business uses and individual users. An enterprise can customize the user interface (UI) to change the look and feel of the program, and modify specific areas, such as data fields, to alter what data appear. Several business process features can also be turned off and on at will. In addition, users can often edit their own personal workspace, such as a dashboard or task list. When the workspace is edited, it shows only the information they need to see for their unique work style.

Despite SaaS's utility, it is not necessarily perfect in all situations. Two areas in which SaaS may not be the right solution are:

- Applications that require fast processing of real-time data
- Applications that are prohibited from hosting data externally because of legislation or other regulations[6]

2.4 Platform as a Service (PaaS)

A computing platform or digital platform is the environment in which a piece of software is executed (run). PaaS provides the capability to deploy customer-created, or -acquired, applications that are developed using programming languages and tools that are offered by the provider. Stated briefly, it provides an application development sandbox in the cloud. Examples of PaaS include Microsoft Azure and the Google App Engine.

With PaaS, the CSP offers enterprise developers elemental Service-Oriented Architecture (SOA) application building blocks to configure a new business application. This may include such underlying cloud infrastructure components as servers, networking equipment, operating systems, storage services, middleware and databases.[7] In-house development requires development, testing and user acceptance platforms, all separate from the production environment. Through PaaS, enterprise developers can rent their development environment (hardware and software), complete with an SOA tool kit, and the enterprise is charged for only the time the tools and environment are in use. The CSP owns and is responsible for operating, configuring and maintaining its technology offerings.

While PaaS has many attractive features, it also is not the perfect solution for all needs. Examples where PaaS is likely to fall short include situations in which:

- Applications need to be highly portable relative to hosting
- Proprietary language would impact development or hinder later moves to another provider
- Application performance requires that the underlying hardware and software be customized[8]

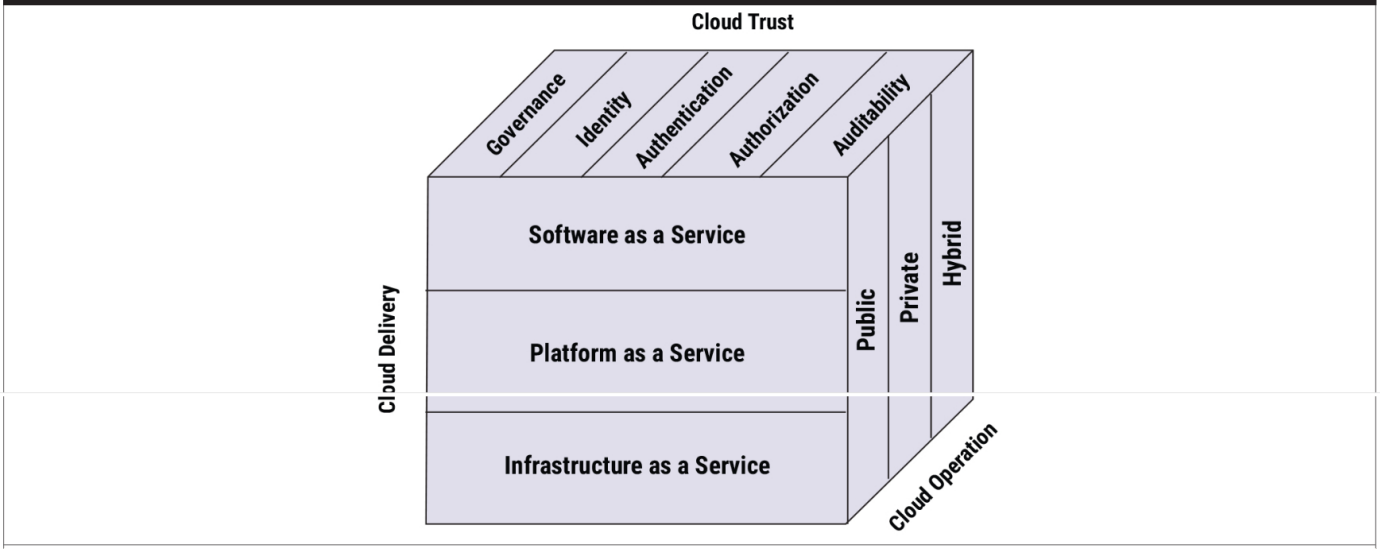
2.5 Infrastructure as a Service (IaaS)

IaaS is a cloud service that provides online processing or data storage capacity. It can be considered a virtual data center. This cloud service is ideal for enterprises considering very large, one-time processing projects or infrequent, extremely large data storage requirements, such as test environments. IaaS offers the capability to provision processing, storage, networks and other fundamental computing resources, enabling the customer to deploy and run arbitrary software, which can include OSs and applications. Other uses for IaaS are handling unpredictable demand and increasing storage needs, simplifying planning and management of backup and recovery systems, and supporting web applications. An example of IaaS is Amazon Web Services (AWS), which provides on-demand computing power, storage and networking capabilities.

Like SaaS and PaaS, IaaS is not always the ideal solution. For example, situations in which regulatory compliance would make offshoring or outsourcing data storage and processing difficult are likely to prove problematic in an IaaS environment.[9]

Figure 2.2 illustrates the three cloud delivery models and three cloud deployment models, as they address cloud trust issues.

Figure 2.2—Cloud Computing Service Delivery and Deployment Model



Source: Cloud Security Alliance®, Trusted Cloud Initiative Reference Architecture. ©Cloud Security Alliance, https://downloads.cloudsecurityalliance.org/initiatives/tci/TCI_Reference_Architecture_v2.0.pdf. Used with permission.

2.6 Solution Stacks

A solution stack is a set of different programs or application software that are bundled together to produce a desired result or solution. This may refer to any collection of unrelated applications taken from various subcomponents working in sequence to present a reliable and fully functioning software solution.[10] A widely known example of a solution stack is Microsoft Office.

There are many types of stacks; web, software/application, virtualization, server and storage are the most common. Cloud computing itself, with its many "as a service" offerings, is often described as a stack, due to its wide range of services built on top of each other under the name of the cloud. Early in its development, six layers of the cloud computing stack were identified (listed from the top of the stack—in terms of visibility—to the bottom):[11]

- **Clients**—Computer hardware and/or software that rely on the cloud for application delivery or that is specifically designed for delivery of cloud services
- **Services**—Software systems designed to support machine-to-machine interaction over a network that can be accessed by other cloud computing components, software or end users
- **Applications**—Leveraging the cloud in software architecture, often enabling users to avoid installing and running the application on their own computers
- **Platform**—Delivery of a platform or solution stack (as a service); PaaS
- **Storage**—Delivery of data storage as a service
- **Infrastructure**—Delivery of computer infrastructure, often a platform virtualization environment, as a service; IaaS

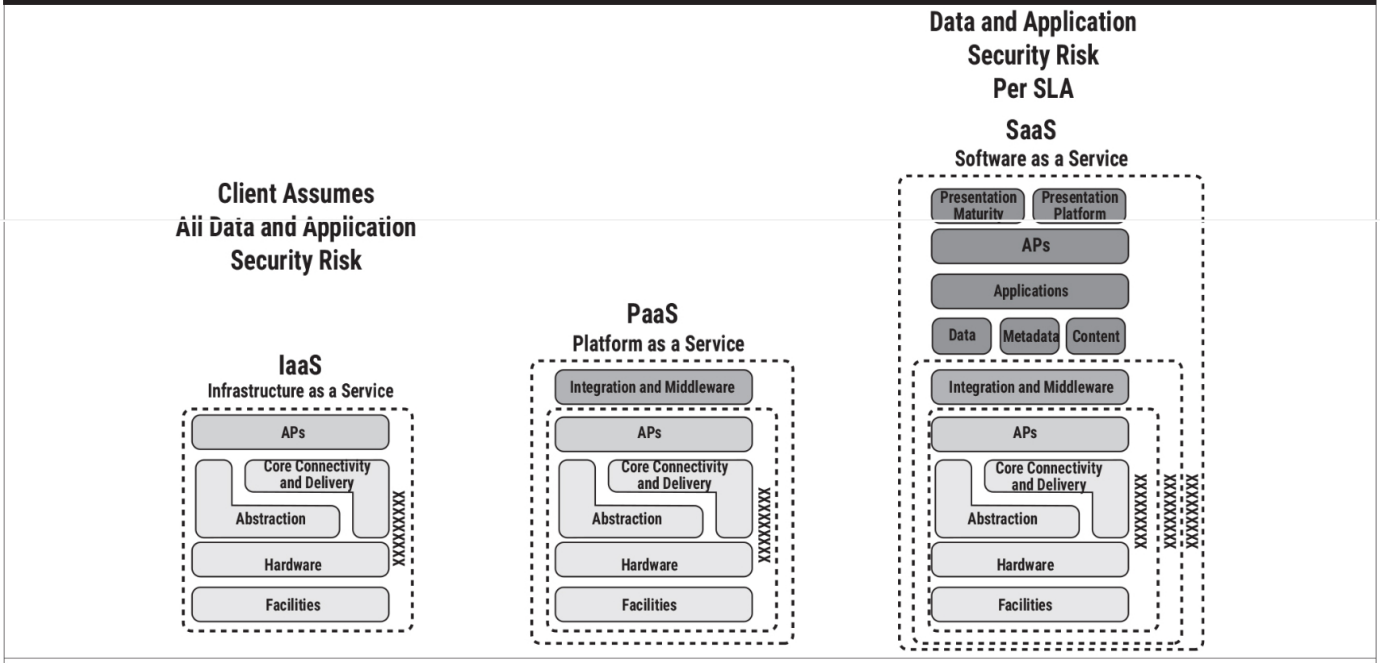
Over time, however, this six-layer view of the cloud computing stack has been streamlined and simplified, most commonly to the generally accepted three-layer view, from top to bottom: SaaS, PaaS, IaaS.

Enterprises that use the cloud are likely to have little knowledge or "visibility" into the people, processes and technology supporting their own information assets. The lack of visibility is also known as "abstraction:" to counter the effects, the CSP should provide full details to customers on how their assets are managed. The level of abstraction or visibility provided by the CSP becomes extremely

important when evaluating risk. In fact, each service model corresponds to an abstraction level based on the number of layers in the Internet Protocol (IP) stack being replaced by the cloud. For this reason, IaaS represents the lowest abstraction level (infrastructure only) and SaaS the highest (application + middleware + infrastructure). The higher the abstraction level, the higher the risk or the number of threats to take into account because risk is cumulative (**figure 2.3**).

However, CSPs often offer only visibility into the cloud stack corresponding to the service model chosen. Security professionals must be aware of this factor when evaluating a move to the cloud. A common mistake is to assume that SaaS will not also be subject to risk related to infrastructure; however, risk and threats are there. They are on a layer that is less visible because it is no longer under the operational responsibility of the enterprise, but the CSP instead.

Figure 2.3—Stacks in Cloud Service Models



Source: Cloud Security Alliance®, *Universal Model*. ©Cloud Security Alliance. Used with permission.

2.7 Chapter 2 Knowledge Check

REVIEW QUESTIONS

1. Office 365® is an example of:
   A. IaaS
   B. PaaS
   C. OaaS
   D. SaaS

2. For which purpose might SaaS not be the **BEST** option:
   A. Specific business uses
   B. Email
   C. Fast real-time data processing
   D. Video streaming services

3. The PaaS model would be **BEST** used for implementing:
   A. Communication platforms
   B. Full virtualized infrastructure
   C. File storage
   D. Programming development environments

4. PaaS would be a great solution for a proprietary piece of software that requires massive amounts of system resources (RAM, CPU, etc.).
   A. True
   B. False

5. The IaaS model would be **BEST** used for:
   A. Subscription services
   B. Large data storage requirements
   C. Single operating system instances
   D. VPN implementation

6. AWS®, Google Cloud™ and Microsoft® Azure® are all examples of IaaS:
   A. True
   B. False

7. Which of the following is not a layer of cloud computing solution stack:
   A. Services
   B. Networks
   C. Application
   D. Storage

Answers on page 32

Chapter 2 ANSWER KEY

Review Questions

1. A. IaaS
   B. PaaS
   C. OaaS
   D. SaaS. Refer to page 24.

2. A. Specific business uses
   B. Email
   C. Fast real-time data processing. Refer to page 27.
   D. Video streaming services

3. A. Communication platforms
   B. Full virtualized infrastructure

C. File storage
D. Programming development environments. Refer to page 27.

4. A. True
B. False. Refer to page 27.

5. A. Subscription services
B. Large data storage requirements. Refer to page 27.
C. Single operating system instances
D. VPN implementation

6. **A. True. Refer to page 27.**
B. False

7. A. Services
B. Networks. Refer to page 28.
C. Application
D. Storage

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[3] The Cloud Security Alliance® (CSA), a nonprofit organization with a mission to promote best practices for providing security assurance with cloud computing, is a valuable source of information on this topic (cloudsecurityalliance.org/).
[4] TechTarget, "iPaaS (integration platform as a service)," searchcloudcomputing.techtarget.com/definition/iPaaS-integration-platform-as-a-service
[5] Soni, M.; M.K. Barti; "FraaS: A Framework for Digital Forensic Services in a Cloud-based Environment," *The International Journal of Forensic Science*, 2015, 1, p. 15-22, ijofcs.org/V10N1-PP02-FraaS.pdf
[6] Rackspace Support, "Understanding the cloud computing stack: SaaS, PaaS, and IaaS," 1 April 2020, support.rackspace.com/how-to/understanding-the-cloud-computing-stack-saas-paas-iaas/
[7] Violino, B.; "What is PaaS? Platform-as-a-service explained," *InfoWorld*, 19 July 2019, www.infoworld.com/article/3223434/what-is-paas-software-development-in-the-cloud.html
[8] *Op cit* Rackspace Support
[9] *Ibid.*
[10] Techopedia, "Solution Stack," www.techopedia.com/definition/28154/solution-stack
[11] Johnston, S.; "Taxonomy: The 6 layer Cloud Computing Stack," Sam Johnston Scribes, 17 September 2008, samj.net/2008/09/17/taxonomy-the-6-layer-cloud-computing-stack/