What is "Cloud"?
It is time to update the NIST definition?

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IaaS, PaaS, and SaaS were formally defined in 2011. Have these definitions held up in the fast-moving world of Cloud Computing?

Back in 1985, I logged onto a Unix computer in Southern California as a guest user, while sitting in a lab in Cambridge, Mass. We all take such capabilities for granted now, but at the time it was magical. I was using ARPANET, a precursor to the Internet, and even though the only thing I could do was roam around directories using the command line, I was blown away. It was like I had teleported to a new world. ARPANET diagrams from that time (see Figure 1), show cloud-like structures and we sometimes used the word "cloud" to describe them.[1]
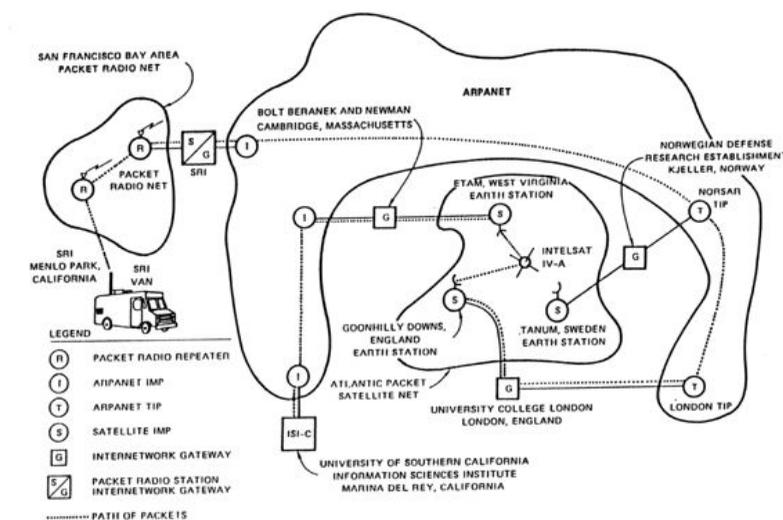

Figure 1. A diagram of ARPANET from the 1980s

Amazon Web Services (AWS) was one of the first companies to use the word "cloud" in their product advertising[2] in 2006 and then Cloud Computing showed up on the Gartner Hype Cycle and now it has its very own hype cycle.[3] And once the term was coined everybody started asking "What is cloud computing?"

DEFINITIONS

Enter the National Institute of Standards & Technology (NIST), a U.S. government entity that formally defines standards, metrics, and the like. After several years of work, industry collaboration, and multiple review cycles, they released the final version of the widely cited "The NIST Definition of Cloud Computing" in 2011.[4] In this publication, they define the now ubiquitous terms of SaaS, PaaS, and IaaS as follows:

- *"Software-as-a-Service (SaaS).* The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user specific application configuration settings.
- *Platform-as- a-Service (PaaS).* The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.
- *Infrastructure-as-a-Service (IaaS).* The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls)."
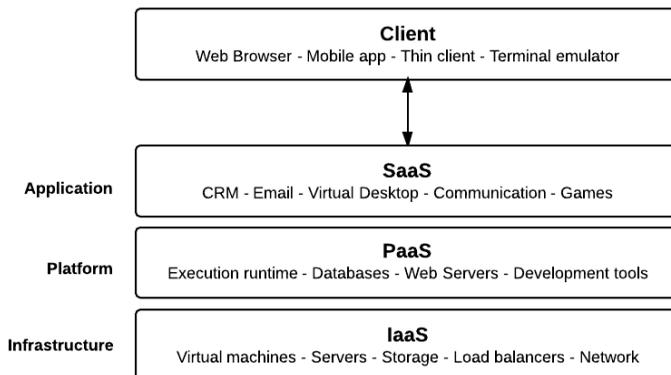
Figure 2 shows these terms.

Figure 2. Basic Cloud Computing Definitions

IaaS, PaaS, and SaaS definitions have been remarkably resilient, and most cloud computing providers still use these terms on their marketing materials. But the definition is now seven years old and the industry has evolved rapidly to include diverse technologies such as containers and serverless computing. Does it need to be updated?

ANYTHING AS A SERVICE

One evolution of Iaas/PaaS/SaaS is Anything as a Service, typically referred to as XaaS. The definition of XaaS is "any technology delivered over the Internet that used to be delivered on-site."[5] Cloud providers are able to offer other technologies as cloud services now because Internet access has become increasingly reliable and faster, and server virtualization and serverless advances make powerful computing platforms and services readily available. XaaS allows for quick response to market changes. Some of the latest on XaaS is mentioned in the Gartner Hype Cycle[3] and elsewhere[6]:

- Blockchain PaaS[7]—Microsoft, AWS, and IBM are offering platforms that include tools for creating blockchain applications.
- Business Process as a Service (BPaaS)[8]—delivery of business process outsourcing services that are sourced from the cloud and constructed for multitenancy. Services are often automated, and where human process actors are required, there is no overtly dedicated labor pool per client. The pricing models are consumption-based or subscription-based. As a cloud service, the BPaaS model is accessed via Internet-based technologies.
- Database as a Service (DBaaS)[9]—a cloud computing service model that provides users with some form of access to a database without the need for setting up physical hardware, installing software or configuring for performance. All of the administrative tasks and maintenance are taken care of by the service provider so that all the user or application owner needs to do is use the database.
- Function as a Service (FaaS)[10]—a category of cloud computing services that provides a platform allowing customers to develop, run, and manage application functionalities without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app.
- Malware as a Service[11]—a prosperous business run on the black market. Anyone can purchase code that will cause harm to computers or even hold it for ransom.
- Windows as a Service[12]—this doesn't fit the traditional definition of an XaaS. The user still has a version of the operating system (OS) running on their computer, but the OS management and updates are seamless to the user and managed in cloud. The OS is version-less in most respects because it is continuously being updated.

While most of these services fit in the traditional definitions, serverless computing is hard to define. There are no virtual machines to create and the PaaS vendor figures out the best way to run your functions. Where would you put serverless computing in the current model? And Windows as a Service turns the definitions on its head by make the client the OS instead of a traditional application. Clearly the definitions we have don't always apply.

A NEW MODEL

Johan den Haan, CTO at Medix, is an expert in model-driven engineering. He has created an interactive model and a more granular framework for Cloud Computing that may be a better fit to today's range of technologies and commercial providers offer.[13] His model builds upon the pre-existing NIST definition and related ones and integrates them into a layered framework. In addition, he partitions the PaaS and other layers into further sub-layers to align with the evolution of commercial services. Amazon, Microsoft, Google, and IBM all offer sophisticated PaaS solutions for Internet of Things, Big Data, and more. This model also brings in virtualization and software-defined control of networks and storage as base services, which had been missing. I've updated this model to include Serverless computing and some of the latest PaaS offerings we have in 2018. To me, serverless fits above PaaS while others have suggested it fits closer to IaaS. Kong Yang, head geek at SolarWinds said "Serverless architecture, aka functions as a service, will eliminate and replace IaaS for some use cases, especially where a function or series of functions can provide the needed application agility, scalability and flexibility without the application life-cycle management responsibility."[14]

6	SaaS		Applications		*End User*
5	App Services	Apps in the Cloud	Communications and Social Media Apps	Data as a Service	*Any User*
4	Built-up PaaS	Business as a Process	Social Media PaaS	Data Analytics	*Rapid Developers*
3.5		Serverless Computing			*Speed Developers*
3	PaaS				*Developers*
2	Foundational PaaS	Application Containers	Routing, Messaging, Orchestration	Object Storage	*DevOps*
1	Software Defined	Virtual Machines	Software Defined Networks (SDN)	Software Defined Storage	*Infrastructure Engineers*
0	Hardware	Servicers	Switches, Routers	Storage	
		Compute	*Communicate*	*Store*	

Figure 1. An updated model of cloud computing based on Johan den Hann's model

This model is helpful not only in organizing existing services, but also in visualizing future cloud computing growth areas. Johan den Hann says "I think the popular wisdom that cloud comes in three flavors (IaaS, PaaS, SaaS) is not providing a realistic picture of the current landscape. The lines between these categories are blurring and within these categories there are numerous subcategories that describe a whole range of different approaches."[15] While Layer 2 is focused on PaaS for deployment of binaries, he says Layer 3 is for deploying code, and Layer 4 is specifically for a business engineer. Layer 2 is for DevOps where Layer 3 is for a professional developer. Layer 4 is for a non-professional developer that needs to connect applications together but doesn't actually write code. This layer contains Model-Driven Development which allows users to do their own programming via models. On the base layer of the model is Compute, Communicate, and Store—areas that have examples in all the vertical layers. IFTTT[16] (If This, Then That; a tool on the Web that allows you to connect different cloud applications and devices to each other) is an example of a Model-Driven PaaS tool in the Communicate column in Layer 4. This model clearly shows that there is more to the current cloud landscape then just SaaS, PaaS, and IaaS as originally conceptualized and documented in the "final" NIST framework.

GROWTH IN IAAS, PAAS, AND SAAS AND SERVERLESS

IaaS,[17] PaaS, and SaaS[18] are still growing at a rapid pace. Companies with aging infrastructures are replacing hardware with IaaS. And IT departments across the world are using SaaS to provide their employees with enterprise applications (such as email, storage, and word processing applications) as well as to provide customers with applications, such as package tracking for a logistics firm or catalog and shopping cart for an ecommerce firm. The number of offerings for PaaS continues to grow with companies like Amazon and Microsoft offering platforms specific to what applications and underlying infrastructure customers want.

Amazon, Google, and IBM also offer serverless computing options, also known as cloud functions. Serverless allows engineers to load code for only individual functions and have them run without worrying about machine or loading issues. For example, consider validating a credit card from a shopping cart application. In the past, you might spin up a virtual machine, load the credit card validation module, set up any network connections, call it, and then shut down the instance, perhaps being billed for an entire hour. With serverless, you just call the function and the cloud provider takes care of the rest, and you would be billed just for the resources used for a few milliseconds. If traditional enterprise computing was like buying a car, and traditional cloud computing was like renting it for the day, serverless is like taking a taxi.

CONCLUSION

In 1985, ARAPNET was about connecting computers and the original use of "clouds" to represent amorphous network constructs where the details weren't critically salient was born. As Cloud Computing emerged, the use of amorphous clouds to represent compute and storage as well as networking services was born, and NIST provided definitions for us to understand those services. Perhaps the authors at NIST will update their model as definitions from standards organizations are more widely vetted and accepted. For now, IaaS/PaaS/SaaS remained firmly perched as the best simple definitions and they are sticking because they are still largely accurate. Although newer models better portray what is happening in cloud, the simple explanation of SaaS, PaaS, and IaaS helps people get started in the complex world of cloud.

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