Chapter 1

Cloud computing and Model-Driven Artchitecture

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1.1 Cloud computing

Cloud computing is gaining popularity and more companies are starting to explore the possibilities as well as the limitation to the cloud.

Some of the most essential characteristics of cloud computing [3] are:

- *On-demand self-service*: Consumers can do provisioning without any human interaction. On-demand means dynamic scalability and elasticity of resource allocation, self-service means that users does not need to manually do these allocations themselves.

- *Broad network access*: Capabilities available over standard network mechanisms. Supporting familiar protocols such as HTTP/HTTPS and SSH.

- *Resource pooling*: Physical and virtual resources are dynamically assigned and reassigned according to consumer demand. This means users do not need to be troubled with scalability as this is handled automatically.

Provider	Service	Service Model
AWS	Elastic Compute Cloud	IaaS
AWS	Elastic Beanstalk	PaaS
Google	Google App Engine	PaaS
CA	AppLogic	IaaS
Microsoft	Azure	PaaS and IaaS
Heroku	Different services	PaaS
Nodejitsu	Node.js	PaaS
Rackspace	CloudServers	IaaS

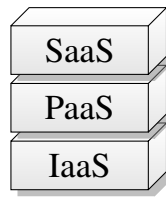Table 1.1: Common providers available services

Figure 1.1: Cloud architecture service models

- *Rapid elasticity*: Automatic capability scaling. Already allocated resources can expand to meet new demands.

- *Measured service*: Monitoring and control of resource usages. Can be used for statistics for users but also for cloud services to do on-demand self-service, resource pooling and rapid elasticity.

There are three main architectural service models in cloud computing [3] namely *Infrastructure-as-a-Service* (IaaS), *Platform-as-a-Service* (PaaS) and *Software-as-a-Service* (SaaS). IaaS is on the lowest vertical integration level closest to physical hardware and SaaS on the highest level as runnable applications. Stanoevska-Slabeva [5] emphasizes that *"infrastructure had been available as a service for quite some time"* and this *"has been referred to as utility computing"*, such as Sun Grid Compute Utility.

IaaS. The main providers are Google, Amazon with *Amazon Web Service* (AWS) [1] and Microsoft. A non-exhaustive list of common providers are visualized in TABLE. 1.1. The *National Institute of Standards and Technology* (NIST) is one of the leaders in cloud computing standardization. The NIST Definition of Cloud Computing [3] define IaaS as

> 66 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.
>
> NIST, 2011

These are capabilities found in cloud provider services, such as AWS *Elastic Compute Cloud* (EC2) and Rackspace CloudServers. NIST continue to state that

> 66 The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (*e.g.*, host firewalls).
>
> NIST, 2011

PaaS. The PaaS model is defined as an capability consumers use to deploy applications onto cloud infrastructure that provide fully partially support. For this kind of deployment consumers do not have to manage or control underlying infrastructure capabilities, and in some cases not even configuration. Examples of PaaS providers are Google with *Google App Engine* (GAE) and the company Heroku with their service with the same name. Multiple PaaS providers utilize EC2 as underlying infrastructure, examples of such providers are Heroku Nodester and Nodejitsu, this is a tendency with increasing popularity.

SaaS. The core purpose is to provide whole web applications as services, in many cases end products. Google products such as gmail, Google Apps and Google Calendar are examples of SaaS applications.

There are four different deployment models according to The NIST Definition of Cloud Computing [3]:

- *Public cloud*: Infrastructure is open to the public. Cloud providers own the hardware and rent out IaaS and PaaS solutions to users. Examples of such providers are Amazon with AWS and Google with GAE.

- *Private cloud*: Similar to classical infrastructures where hardware and operation is owned and controlled by organizations themselves. This deployment model has arisen because of security issues regarding storage of data in public clouds. With *private cloud* organization can provide data security in forms such as geographical location and existing domain specific firewalls, and help complying requirements set by the government or other offices.

- *Community cloud*: Similar as *private clouds* but run as a coalition between several organizations. When several organizations share the same aspects of a private cloud (such as security requirements, policies, and compliance considerations), and therefore share infrastructure.

- *Hybrid cloud*: Combining private cloud or community cloud with public cloud. One benefit is to distinguish data from logic for purposes such as security issues, by storing sensitive information in a private cloud while computing with public cloud.

Beside these models defined by NIST there is another arising model known as *virtual private cloud*, which is similar to *public cloud* but with some security implications such as sandboxed network.

1.2 Model-Driven Architecture approach

By combining the world of cloud computing with the one of modeling it is possible to achieve benefits such as improved communication when designing a system and better understanding of the system itself. This statement is emphasized by Booch *et al.* in one of his studies:

> 66 "Modeling is a central part of all the activities that lead up to the deployment of good software. We build models to communicate the desired structure and behavior of our system. We build models to visualize and control the system's architecture. We build models to better understand the system we are building, often exposing opportunities for simplification and reuse. We build models to manage risk."
>
> BOOCH, 2005

When it comes to cloud computing these definitions are even more important because of financial aspects since provisioned nodes instantly draw credit. The definition of "modeling" can be assessed from the previous epigraph, but it is also important to choose correct models for the task. Stanoevska-Slabeva emphasizes in one of her studies that grid computing "*is the starting point and basis for Cloud Computing.*" [5]. As grid computing bear similarities towards cloud computing in terms of vitalization and utility computing it is possible to use the same UML diagrams for IaaS as previously used in grid computing. The importance of this re-usability of models is based on the origination of grid computing, *eScience*, and the popularity of modeling in this research area. The importance of choosing correct models is emphasized by Booch [2]:

> 66 *(i)*The choice of what models to create has a profound influence on how a problem is attacked and how a solution is shaped. *(ii)*Every model may be expressed at different levels of precision. *(iii)*The best models are connected to reality. *(iv)*No single model is sufficient. Every nontrivial system is best approached through a small set of nearly independent models.
>
> BOOCH, 2005

These definition precepts state that several models (precept *(iv)*) on different levels (precept *(ii)*) of precision should be used to model the same system. From this it is concludable that several models can be used to describe one or several cloud computing perspectives. Nor are there any restraints to only use UML diagrams or even models at all. As an example AWS CloudFormation implements a lexical model of their *cloud services*, while CA AppLogic has a visual and more UML component-based diagram of their capabilities.

Model-Driven Architexture. When working with *Model-Driven Architecture* (MDA) it is common to first create a *Computation Independent Model* (CIM), then a *Platform-Independent Model* (PIM) and lastly a *Platform-Specific Model* (PSM). There are other models and steps in between these, but they render the essentials. There are five different life cycles as explained by Singh [4]:

1. Create a CIM capturing requirements.

2. Develop a PIM.

3. Convert the PIM into PSM.

4. Generate code form PSM.

5. Deploy.

Bibliography

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