MAIN TYPES OF CLOUD SERVICES - EXPLAINED

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Abstract

The advent of cloud computing has revolutionized the IT industry, transforming the way organizations store, manage and process data. This paper provides a comprehensive overview of the beginnings of cloud services, tracing their evolution from early concepts to the sophisticated solutions we have today. In addition, the document highlights the main benefits and challenges associated with cloud services. This paper provides a s comparative study of IaaS, PaaS and SaaS, examining their architectures, functionalities and use cases. It explores the similarities and differences between these models, discusses their strengths and challenges, and analyzes their impact on organizations and end users. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are the three main cloud computing service models, each offering different benefits and features. The document also discusses the major players in each category and offers insight into future trends and potential synergies between the three service models.

Keywords: *cloud, cloud services, PaaS, IaaS, SaaS*

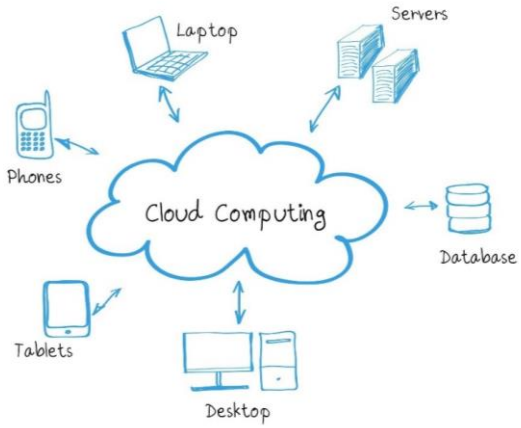
1. What is CLOUD?

There are several definitions of Cloud computing. Some define Cloud computing as virtual servers accessible over the Internet. Others believe that everything behind the firewall, from the point of view of the local network user, is in the "cloud". However, perhaps it is best to say that Cloud computing is a concept that uses the Internet as a platform to store applications, documents and information sent from any part of the world. These data are located on servers whose purpose is to store, save and process them.

Cloud computing is intended for companies as well as private users who have many services and "unlimited" resources from the service provider. When we say "unlimited" in this context, we mean that it is possible to expand the number of resources that the user can use, lease, to limits that are sufficient for even the most demanding users. This is because the companies that offer cloud services have such a large network of servers and a strong infrastructure that, from the perspective of their users, it can be said that they have unlimited resources. *Cloud computing services can offer benefits such as scalability, simplicity, expense reduction, and high resource resistance, which is why this computing model is popular among different users*[1].

Cloud Computing is still a developing term. Its definitions, examples of use, supporting technologies, problems, risks, and advantages will be constantly updated through debates in the public and private sectors.

The term "cloud computing" refers to a type of computer and communications technology that provides on-demand services[2]. These definitions, features and characteristics will change and evolve over time.



Picture 1 - Cloud computing
Source:
https://schepensinternationalsociety.com/importance-of-reliable-cloud-service-providers/, visited 13.5.2023.

2. Why CLOUD and its beginnings

Information systems consist of several components. Apart from people i.e., users of information systems, an information system is a complete infrastructure that includes computers, servers, network devices and communication devices.

Today, information systems are increasingly web-oriented, i.e., they work via the Internet, that is, they need Internet access to function. Such web-oriented information systems, which collect and process large amounts of data and that are used by many users, require high-quality hardware (servers) and strong infrastructure. That kind of infrastructure as well as servers and network devices, are very expensive, and their maintenance also requires the engagement of experts trained for this type of work. This became a big problem for companies that could not cover

[1]"Enhanced Data Security Through Deep Data Classification In the Cloud Computing". IJETER, vol. 8, no. 9, 2020, p. 6326-6333. https://doi.org/10.30534/ijeter/2020/228892020

[2]Sikka, Rishi, et al. "An Overview Of Cloud Computing". IJIRCST, 2021, p. 135-138. https://doi.org/10.55524/ijircst.2021.9.6.31

all these costs with their income, so a new approach to this problem arose.

Large companies that already had large systems implemented, and therefore infrastructure, as well as the necessary knowledge and experts in the field, saw their opportunity there.
Companies such as Amazon, Google, Microsoft, IBM began to offer part of their infrastructure, and later special services, to other companies for a small fee.
When we say a small fee, that means small costs compared to the costs that companies would have had if they had invested in the aforementioned infrastructure and hardware (servers, network equipment, data centers). *Cloud computing follows the principle of pay-as-you-go, just like when using water or electricity in a household*[3].

3. Pioneers in Cloud computing

The beginning of Cloud computing was influenced by one of the most important events in 1999, when the company Salesforce[4] presented a new concept that enabled the execution of business applications through their service in a web environment.

In 2002, the Amazon company (known to us for its online web store and sales) launched its web services Amazon Mechanical Turk[5], which made it possible to "hire" human resources and work on some tasks that a computer is not able to do. These are tasks such as recognizing some things in videos, writing product descriptions, answering questions, etc.

After that, in 2006, Amazon launched a Cloud platform called "Elastic Compute Cloud", which gave business or private users the opportunity to rent computers on which they could run private applications.
Based on Amazon's reputation, many other companies (Google, IBM, Microsoft, Digital Ocean) joined the market race, and today users have a large selection of service offers, but Amazon, or their AWS (Amazon Web Services), is considered the most complete and the most stable cloud computing platform. *AWS is best known for its on-demand computing and storage services, called Elastic Compute Cloud (EC2) and Simple Storage Service (S3)*[6].
It can be concluded that Cloud computing has been present on the market for a long time and the services offered are increasingly diverse. In order to decide which service we will use, it is necessary to familiarize ourselves with the Cloud computing models and, based on our needs and the information system we want to use in the Cloud, decide on the best and most convenient option.

4. CLOUD service models

The emergence and development of Cloud computing has led to the creation of several models of cloud services. The models differ in the principle on which they work, as well as in what they offer their users. Which model suits an individual user depends on which of the services they want to use, or at what stage of development they are.

This means at which level their internal structure of the information system is located, i.e., how much they have "in house", and what is their primary domain of business.

Companies should be considered here as end users of information systems (applications), companies that develop

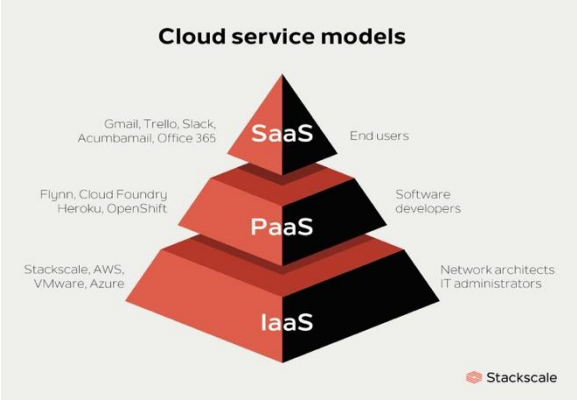
[3] Michael Kavis, "Architecting the CLOUD - Design decisions for CLOUD computing service models (SaaS, PaaS, AND IaaS)", John Wiley & Sons Inc., USA, 2014, page 2
[4]https://www.salesforce.com/news/stories/the-history-of-salesforce/, visited 7.5.2023.
[5]https://www.pewresearch.org/internet/2016/07/11/what-is-mechanical-turk/, visited 7.5.2023.
[6] Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, "Mastering cloud computing: foundations and applications programming", Morgan Kaufmann Publishers, Elsevier Inc., USA, 2013, page 24

information systems, i.e., web applications that they offer to other companies and finally companies that are engaged in providing services of a lower level than those they do not run, i.e. preparation of the infrastructure that will be the basis of the Cloud platform.

Regarding all different types of potential users mentioned above, there are three basic models of cloud computing:

- **IaaS** - Infrastructure as a service - infrastructure as a service
- **PaaS** - Platform as a service - platform as a service
- **SaaS** - Software as a service - software / applications as a service

Each of the listed models corresponds to a certain population of users because it offers completely different services and requires specialized knowledge and skills to use them.



Picture 2 - Cloud services models Source: https://www.stackscale.com/blog/cloud-service-models/, visited 16.5.2023.

We can present these three Cloud service models in the picture no. 1, and we can see that IaaS (infrastructure as a service) is at the lowest level, and that the PaaS (platform as a service) is the superstructure of the IaaS model, while SaaS (software as a service) is at the highest level. i.e., it is located above the platform as a service.

As a convenient analogy, and for easier understanding of everything that will be explained below, we can take the example of a car, that is, a transportation service. The information system, its implementation, Cloud service models will be compared with "models", that is, people's ability to move from point A to point B, i.e. , a parallel will be drawn with means of transportation in the real world.

The classic approach, that is, an information system that the company would independently develop, buy licenses for its use, install on-premises, on its hardware, network, and platform, without using any Cloud services, would be like when we buy a car. We own it and maintain it ourselves. This is an expensive option, because buying a car entails large initial costs, such as an investment, and subsequently, all regular and extraordinary services are additional investments. Viewed as an information system, these are investments in hardware, network, and other system infrastructure elements.

We drive a car, which means that we must pass a driving test, which is also an investment in knowledge and skills, which is analogous to the knowledge and skills (experts) that companies must have in order to manage their infrastructure and the platform they use for their information system.

Picture 3 - On-premises solution / own car Source: https://rubygarage.org/blog/iaas-vs-paas-vs-saas, visited 18.5.2023.

In the following, we will see how this analogy can be transferred to different models of Cloud services and what are the advantages that these services bring to their users, and what are the disadvantages that users must adapt to.

5. IaaS - Infrastructure as a service

Infrastructure as a service is a Cloud service model that is at the lowest level. It can be said that it is then very similar to the models that existed before the Cloud, when it comes to certain server rental services.

Before infrastructure-as-a-service itself, there were "managed" server rental models, which meant the server was maintained by the service provider, as opposed to "unmanaged" services, where the service user had to take care of the server themselves. Now the service provider does not only care about servers, data warehouses and other hardware, but about the entire infrastructure available to the user.

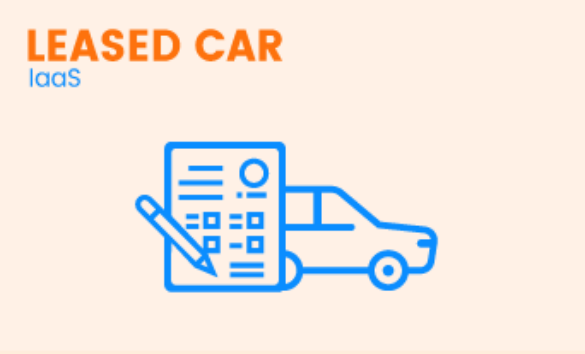
Infrastructure as a Service (IaaS) is a cloud computing service model that allows organizations to conveniently access virtualized computer resources online.
Users of such services are administrators who create the environment needed for their company on the rented infrastructure. Here, users have the most control because they, as administrators, can configure the infrastructure as desired and needed. They install the operating system they need, database management systems, etc.

The service offers various infrastructure components, such as virtual machines, storage and networking, which can be easily adapted to the current needs of the organization. IaaS is ideal for situations that require flexible, cost-effective infrastructure that can be scaled up or down based on changes in demand.

Some of its key features include self-service provisioning, pay-per-use pricing model, and reduced capital expenses. It is applied in various scenarios such as big data analytics, web hosting, disaster recovery, high-performance computing, and more.
Adoption, however, comes with potential challenges such as data security and compliance considerations that need to be addressed carefully.

Leading cloud service providers like Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform offer comprehensive IaaS solutions to meet the diverse needs of organizations.
Overall, IaaS is a cost-effective way for organizations to build and manage their computing infrastructure in the cloud, giving them greater agility, scalability, and flexibility to focus on their core business goals.

Infrastructure as a platform would be analogous to buying a car, like when we rent a car in a rent-a-car. Now we don't buy a car, we rent it.



Picture 4 - Infrastructure as a service / leased car
Source: https://rubygarage.org/blog/iaas-vs-paas-vs-saas, visited 18.5.2023.

We do not invest in infrastructure, but we use the service, and we hire it. Of course, we still must pass the driving test and drive the vehicle.

This Cloud model has helped companies that implement an information system to reduce their costs by using this Cloud

model, because they use an infrastructure that has already been built. Now the company does not need to build its own infrastructure and buy expensive hardware, servers, storage, and network equipment, and therefore hire hardware experts to maintain this infrastructure. The complete infrastructure is taken care of by the Cloud service provider, analogous to car maintenance by the rent-a-car company from which we rent the car.

6. PaaS – Platform as a Service

Platform as a Service is a service that is a level higher than IaaS. When it says "level up" it should be understood as something that comes after IaaS. Users of the platform as a service are not end users, i.e., someone who uses an information system, but they are companies, or companies that produce information systems and applications, which will eventually be SaaS.

So, Platform as a Service (PaaS) is something that facilitates and helps developers to develop applications, publish them, maintain them, and offer them as a service. In addition to companies that produce applications that they will further sell, this Cloud model is also suitable for companies that have a development team that produces applications for their internal use.

Platform as a Service (PaaS) offers developers a cloud computing service model that allows them to develop, deploy, and manage applications without having to manage the underlying infrastructure. PaaS platforms provide a complete environment for development and deployment, including libraries, frameworks, databases, and other necessary tools. By removing the complexity of the underlying infrastructure's complexity, PaaS allows developers to focus on their applications while taking advantage of scalability, built-in services, collaboration capabilities, and cost-effective pricing models. *One of the biggest advantages of a PaaS service is that it abstracts the infrastructure from the developer, so the developer can focus entirely on business requirements, while the platform handles automatic scaling*[7].

PaaS is scalable and offers automatic scaling capabilities that allow applications to handle increased workloads by dynamically allocating additional resources as needed. It supports various types of application, provides built-in services and databases, messaging queues, authentication mechanisms, caching layers, and more, making deployment and management simpler.
PaaS has a pay-as-you-go pricing model, where organizations are charged based on the services and resources consumed, ensuring savings compared to investing in their infrastructure.

Well-known PaaS providers like Heroku, Google App Engine, and Microsoft Azure App Service offer extensive platforms for application development, deployment, and management. These platforms support multiple programming languages and frameworks, providing flexibility and choice for developers.

The use of PaaS services greatly reduces the costs of such companies, because they do not have to employ experts in the areas that PaaS services offer them. The platform they receive is maintained by a company that offers platform as a service, and it takes care of security, data backups, operating system upgrades, certain libraries and components that are an integral part of the platform, etc. For all these tasks, companies that do not use this type of service, must have employees who will take care of it.

[7] Michael Kavis, "Arhitecting the CLOUD - Design decisions for CLOUD computing service models (SaaS, PaaS, AND IaaS)", John Wiley & Sons Inc., USA, 2014, page 57

In the case of a means of transportation, it would be like when we hire a taxi to take us from point A to point B. Now we don't even have to have a driver's license because we do not drive the vehicle. Analogously, this Cloud model now includes operating systems, database management systems, other tools and libraries, which users of these services can use. With this, the costs of companies using this Cloud model are reduced even more. Now they don't even have to have staff to take care of the platform the developers are working on, because everything is taken care of by the PaaS service provider.

Picture 5 - Platform as a service / taxi
Source: https://rubygarage.org/blog/iaas-vs-paas-vs-saas, visited 18.5.2023.

Companies developing their web-based information systems now hire only programmers, not system administrators and network technicians. So, we still choose where we want to go and convey that to the taxi driver, who will take us there.

7. SaaS – Software as a Service

Software as a service is the highest form of cloud computing. If we look at the pyramid of the Cloud model, we will see that it is at the top of the pyramid and that it is Cloud at the highest level in the most general sense. When we return to the very definition of Cloud computing, this model is the closest to the definition itself, that is, represents the use of web applications (finished products) that are hosted in the Cloud. Users of this model are end users, that is, specific users of applications (information systems) in the cloud.

With the classic approach, the company (organization) buys a certain number of licenses, pays a one-time amount to the manufacturer and then installs the information system and its components on the local network. This one-time amount was paid in advance and was, as a rule, a large investment for the user of the information system, and great care should be taken when choosing and purchasing such a system.
With the SaaS approach, there is no purchase of licenses and installation of the system, but now there is payment for the service of using the information system, i.e., ownership is not transferred to the customer, and no one buys the entire system, but only pays to use the application.

This is a very important fact, because the price of use is incomparably lower, and, in general, is paid monthly. The user only pays for the fee during the period of use, so if he decides that he will no longer use the SaaS product, he simply stops paying the fee to the service provider. With this principle, the user does not have a big risk, as with the classic approach, because the monthly "rent" and testing of the information system does not mean serious investment.

This gives users the option to get to know and try several potential information systems, with a very small investment, and based on the gathered information and knowledge about each of them, decide which one they will continue to pay and use. Another important difference is that with classic information systems (applications), licenses are tied to a specific computer, so the use of the system is limited to one device. This is not the case with SaaS applications. This is because they are mainly web-oriented information systems (applications), so they give the user the opportunity to use it from any location or computer. This facilitates the use of the

information system and makes the upgrading or replacing of local computers "painless", because there is no need to re-install and adjust the information system as with classic information systems.

Another fact, which is closely related to the previous one, is that upgrades and changes to the information system are automated, that is, all upgrades are immediately available to all users, as soon as the manufacturer (service provider) places them on their servers. To use such systems, you only need to have a web browser installed. This means that there is no longer a need to download and install updates on local computers, as is the case with classic applications and information systems. This is the case when we talk about web-oriented SaaS information systems or applications. Examples are Google Docs, Trello, Zoho, etc.

There are also SaaS applications that are not web-oriented, i.e., which are not used through a web browser, so these applications need to be installed on a local computer. Examples of such applications are Office365, Adobe CC (Creative Cloud), etc.

With this Cloud model companies just need to choose the system that suits them best and use it. They pay for it monthly, and to work they only need computers that are connected to the Internet and have a web browser installed. So, they have no need to hire programmers, system and network administrators, nor technicians to take care of servers, network equipment, etc. Their only cost is the payment of a monthly subscription for the use of the information system (application), and everything will be taken care of by the SaaS service provider.

This means that users of the SaaS model use ready-made information systems (web applications) in an unknown location (in the Cloud) and an infrastructure they know almost nothing about. Users have no information, or they are not interested at all, in which technologies the information system is made, which database it uses, on which operating system it is installed, etc.
This implies that they do not have any control over the information system, except possibly for some settings, which the service provider assigned to them as part of the information system.

Picture 6 - Software as a service / bus
Source: https://rubygarage.org/blog/iaas-vs-paas-vs-saas, visited 18.5.2023.

In the analogy with a transportation, it would be like when we sit on a bus, i.e., now we no longer say where to take us, but choose the appropriate bus that goes in the direction we want.

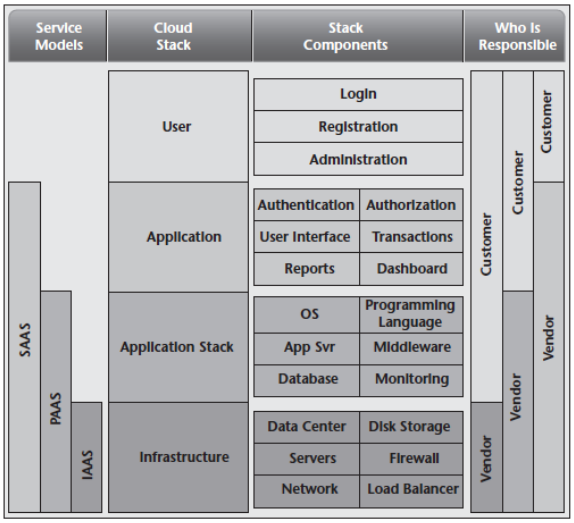
CONCLUSION

The Internet and what it brought with it was the initiator of major changes in the world of information systems, their implementation, use and maintenance. The appearance of Cloud computing, i.e., computing in the Cloud, as the last type of web-oriented information system implementation model, brought many innovations. As we have seen, there are different Cloud models, and each of them as a separate unit introduced some new approaches to the implementation of information systems that use the Internet as a medium of communication.
All of the above is presented from the aspect of the company's costs for the development, implementation, and maintenance of the information system, and it is clearly seen that the implementation of the Cloud model

is profitable and reduces costs for those who use it.

How much some companies will reduce costs depends on which Cloud computing model they will use, that is, how much control they want to have over the information structure, platform, or information system they use.

The lower the cost, the less control they have, as more things are left to the Cloud service provider. The analogy with transportation is very similar and can help in understanding the Cloud model, because also, the lower the costs and investments, the less control (own car - rented car - taxi - bus).



Picture 7 - Cloud services and division of responsibilities
Source: Michael Kavis, "Arhitecting the CLOUD - Design decisions for CLOUD computing service models (SaaS, PaaS, AND IaaS)", John Wiley & Sons Inc., USA, 2014, page 14

Companies, smaller firms, as well as individuals have recognized the advantages of the Cloud and are using it more and more, which is best shown by the numbers. Gartner's research is shown in the picture below, where you can see the revenue growth of companies offering different Cloud services, and predictions for the year 2025.

Figure 1 - Cloud revenue prediction to 2025
Source: https://www.codica.com/blog/saas-paas-iass-choosing-the-best-cloud-computing-model/, visited 25.5.2023.

Considering all the above, we can say that the use of Cloud computing is constantly increasing and that many companies have already switched to one of the models of these services, and many of them plan to do so in the near future. *Here it can be said that the paradigm is shifting from the old model of buying and controlling infrastructure and creating and buying applications to a new world where everything is consumed as a service*[8].

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