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# Cloud Computing

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# 1. What is Cloud Computing?

Cloud computing can be described as delivery of computing services such as storage, servers, software, databases, networking, analytics and intelligence over the internet. Users can pay for only the cloud services they use (pay-as-you-go pricing), which helps them reduce costs and operate with more flexibility. [azu]

Thanks to cloud computing, clients can achieve economies of scale, which occur when average costs start falling as output increases. [wik1]

## 1.1 Advantages of Cloud computing

### Cost reduction

Large companies that are already established often hesitate to switch to cloud computing. It may seem unnecessary for them to do so. However, according to statistics, cloud computing brings a lot of financial benefits.

A study from Ruckspace conducted in 2013 shows that 88% of cloud users experienced cost savings and 56% mentioned an increase in profits.

There are different kind of ways cloud computing can save money:

### Hardware

With cloud computing costs of repairing and replacing hardware are avoided. Off-site hardware also cuts electricity costs and saves space

### Labor/Maintenance

With off-site hardware companies can free their IT-staff to focus on important developments. Upgrades and repairs are done by the vendor. [kyle]

### Strategic edge

Cloud computing helps you to always have access to the latest versions of applications which is very good for competition in the market.

### High speed

With cloud computing services even large amounts of computing resources can be provisioned and transferred in minutes.

### Backup and restore data

It is easier to recover data once we've stored it in cloud, this makes cloud computing reliable and flexible.

### Unlimited storage capacity and mobility

Cloud users can expand their storage any time, it also helps employees to access their data no matter where they are. [guru]

## 1.2 History of cloud computing

The history of cloud computing begins in 1950s. Organizations were already using complex system of mainframe computers to process their data. Organizations purchased one or two machines and implemented "time-sharing", with it, several users could access a mainframe computer. This became the premise of cloud computing.

in 1960's an american computer scientist named J.C.R. Licklider came up with an idea for an interconnected system of computers. In 1969 this idea helped Bob Taylor and Larry Roberts to develop something known as ARPANET (Advanced Research Projects Agency Network). ARPANET is also known as "Predecessor of the Internet". It allowed digital sources to be shared among computers from different locations.

In 1972 IBM released an operating system called the VM (Virtual Machine) . The concept of virtualization has evolved with the internet. The usage of virtual computers became popular in 1990's, which led to the development of modern cloud computing infrastructure.

In 1999 Salesforce used cloud computing for delivering software programs to the end users. Businesses could purchase software without leaving the office which was very flexible and saved a lot of time.

In 2006, Amazon launched Amazon Web Services, which offers online services to other websites or clients.

In 2012 Oracle introduced Oracle Cloud, offering three basics for business: IaaS, PaaS, SaaS. Cloud computing is growing every year, demand for professionals who can manage these networks properly is also growing rapidly. [ecpi] [keith]

## 1.3 Examples of cloud computing

Scalable usage - Customers only need to pay for the resources that they use. This helps in managing spikes in demand, for example, Netflix uses cloud technology to handle server load at peak times.

Chatbots - The ever-growing storage of cloud gives us the ability to store user preferences. This provides customized solutions, messages and products based on users behavior. Most common examples of chatbots are Siri, Alexa and Google assistant.

Communication - Tools like Email, skype, Whatsapp, Calendars are all based on cloud infrastructure. Information is stored in service provider's hardware, we can access them at any time via internet.

Big data analytics-Scientists use cloud computing to analyze data for patterns, find correlations, make predictions and so on. With cloud services they can work with massive amounts of data, Examples for big data tools are Hadoop, Cassandra, HPC and more.

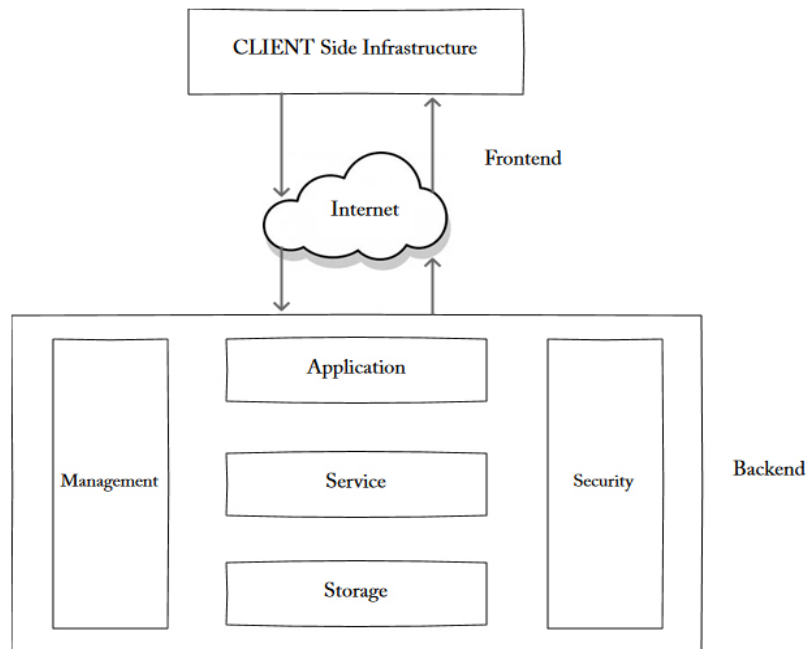
Social Networking - Social media is the most common example of cloud computing. Examples are Facebook, Twitter, LinkedIn and many other social media platforms. Users share their information on social media which means that developers need cloud technology to manage and store this data in real-time. [anu]

## 2. Architecture

Cloud architecture consists of four elements:

- Front-end platform (fat client, thin client, mobile device)
- Back-end platform (servers, storage)
- A cloud based delivery
- Network (internet) [wik2]

Picture 1.1 illustrates the relationship between different parts of cloud architecture.



Picture 1.1: Cloud architecture [w3s]

Fat client is a typical PC that has the memory, storage and computing power to run applications and perform computing tasks on its own. Fat client can be described as having a rich user interaction. [wik3]

Thin client is a simple computer that is connected with a server-based computing environment. The server launches software programs, performs calculations and stores data. With this combination resources can be centralized which reduces software maintenance and improves security. [wik4]

Back-ends responsibility is to provide security of data and control traffic. The server also provides middleware which helps to connect devices and communicate with each other. [w3s]

### 3. Service models

There are three cloud service models:

- Infrastructure as a service (IaaS)
- Platform as a service (PaaS)
- Software as a service (SaaS)

#### 3.1 SaaS

Software as a service is software that is deployed over the internet. Users do not have to install applications on their local devices. SaaS runs a single instance of the software and makes it available for multiple end users. This service model is aimed at end users.

Some of the main features:

- SaaS provider does all the upgrades for software
- It's based on "Pay-as-you-go" model
- Data is secure in the cloud, if the equipment fails the data will not be lost
- Applications are accessible from anywhere in the world via internet [ibm]

Most famous SaaS vendors are Salesforce, Microsoft Office 365, Google Apps. [epla]

#### 3.2 PaaS

PaaS is made up of a programming language execution environment, an operating system, a web server and a database.

Platform as a service offers users a cloud environment in which they can develop, manage and deliver applications. It is aimed at application developers who are limited to providers languages and tools.

Some of the main features:

- Provides a platform for testing developing and hosting applications in the same environment
- Organizations do not have to worry about underlying infrastructure [ibm]

Examples of PaaS providers are Microsoft Azure, OrangeSpace, WorkXpress. [epla]

### 3.3 IaaS

Infrastructure as a service offers servers, storage and other hardware resources over the Internet. Organizations use their own platforms and applications within a service provider's infrastructure. IaaS is mostly for infrastructure and network architects.

Main features:

- Users pay for IaaS on demand
- Infrastructure is scalable
- Enterprises don't have to buy and maintain hardware
- Administrative tasks are virtualized [ibm]

Some IaaS providers are: Amazon web services, GoGrid, CloudSigma. [epla]

## 4. Deployment models

There are four types of public deployment models: public, private, hybrid and community clouds. Deployment model types depend on who controls the infrastructure and where it's located. These four models have different types of accessibility and storage.

In order to maximize income, a company should use the model that suits it the best. [sam]

### 4.1 Public cloud

Public clouds are available to general public. It is based on pay-per-use model and users can get more resources if they need to. Service provider owns all the hardware.

Public cloud model is suited for companies who lack security concerns. Examples are Amazon EC2, Microsoft Azure, Google app engine and others.

Advantages of Public cloud:

- hassle-free infrastructure management (third party runs cloud infrastructure, users do not have to buy and maintain hardware),
- high scalability (users can easily increase storage when they need to),
- 24/7 uptime (infrastructure is constantly available).

Disadvantages of a public cloud:

- compromised reliability (clouds often experience outages and malfunction),
- the lack of bespoke services (unusual requirements will not be satisfied because providers offer standard service options).

## 4.2 Private cloud

Architectures of public and private clouds are very similar, the main difference between these two models is that public cloud is available to general public, on the other hand only one specific company owns a private one.

Private cloud infrastructures are maintained on a private network, software and hardware are meant for one specific company.

Private cloud is suited for companies that have security concerns. It also provides more customization features.

Private cloud providers are: Amazon, IBM, Cisco, Dell, Red Hat.

Benefits of a private cloud:

- high scalability and flexible development (allows companies to customize their infrastructures),
- high security and privacy (only authorized persons can access resources).

Main disadvantage of a private cloud is the fact that it's expensive, therefore it is not a choice for small companies.

## 4.3 Community cloud

This model is similar to private cloud, the only difference is the set of users. Community cloud is owned by several organizations with similar backgrounds who share infrastructure and resources.

Community model is suited for organizations that work on a joint project and have same interests.

Pros of community cloud:

- cost reduction,
- improved security,
- privacy and reliability,
- ease of data sharing and collaboration.



Disadvantages:

- high costs in comparison to public cloud,
- sharing of fixed storage,
- bandwidth capacity. [sam]

## 4.4 Hybrid cloud

Hybrid cloud has all the best features of the above-mentioned models. It allows the companies to customize resources as they please. With this model, companies can save their mission-critical data on private clouds and use public cloud for less sensitive information, that way they can save costs and still have high level of security.

Setting up private, community and hybrid clouds requires IT proficiency, public on the other hand doesn't. Data security and privacy are low on public and high on every other model, same goes for reliability. Scalability and flexibility are high in public, private and hybrid clouds. On the other hand, community cloud has fixed capacity. [sam]

## 5. Statistics

### 5.1 Facts about cloud

The global cloud computing market is growing every year as countries are willing to invest more money in cloud computing technologies.

Here are the countries that spent the most on cloud computing technologies in 2019:

- The USA-\$124.6 billion
- China-\$10.5 billion
- The UK-\$10 billion
- Germany-\$9.5 billion
- Japan-\$7.4 billion

### Facts about cloud computing

- 90% of companies use cloud, experts say 60% of workloads were running on a hosted cloud service in 2019 (in comparison on 45% of workloads were hosted on cloud in 2018)
- The global cloud computing market is predicted to reach \$623.3 billion by 2023. in 2018 the market value was at \$272 billion
- The average business runs 38% of workloads in public and 41% in private cloud. Statistics also show that public cloud spend is growing three times faster than private cloud usage.

- 89% of companies use SaaS
- main reason for cloud adoption is the benefit of accessing data from anywhere. [host]

## COVID-19 impact on the cloud computing market

Because of the corona virus, organizations are forced to adopt to cloud technology, causing surging demand for SaaS based solutions. The demand for platforms such as Zoom, Microsoft Team, Google Hangouts, Slack have skyrocketed.

A significant increase in demand can be seen for streaming services such as Netflix, Hulu, Disney+, twitch, Youtube and others. This has caused an increase in demand for IaaS. [mark]

## 6. AWS

Amazon web service is the leading provider in cloud computing. The CEO of AWS is Andy Jassy. It's revenue in 2019 amounted to \$35 billion. The service is based on pay-as-you-go model which means that fees depend on a combination of usage. It depends on how much storage, capacity, hardware or software we need.

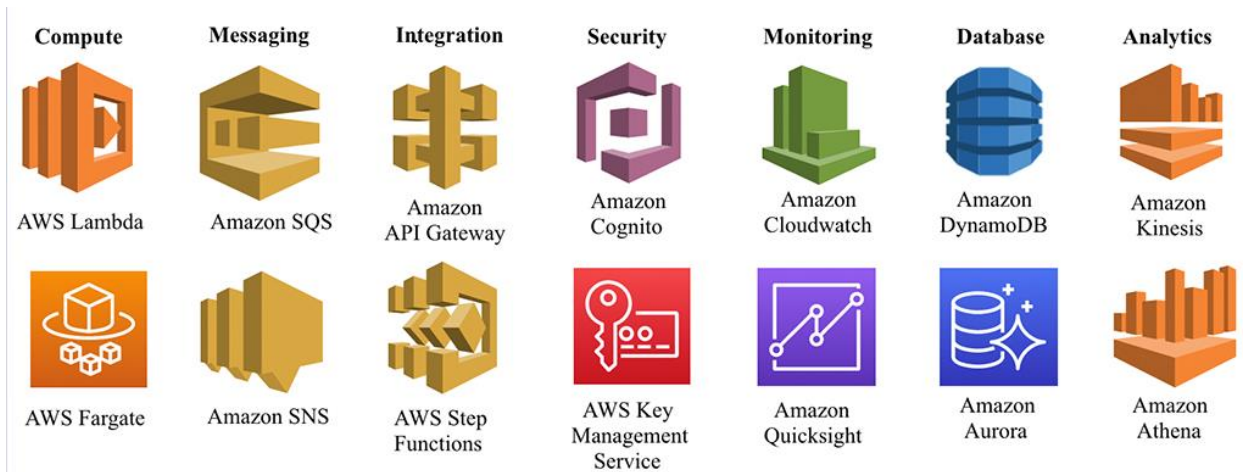
As of 2020, AWS offers more than 175 products and services including computing, storage, networking, database, analytics, management and more. The most popular services are Amazon Elastic Compute Cloud (EC2) and Amazon Simple Storage Service (Amazon S3). [wik5]

### 6.1 Aws services

AWS provides a lot of different cloud services which are used for different requirements such as storage types, purpose-built databases, security services, big data processing, messaging, machine learning and more.

The services are intertwined with each other which gives the users ability to be flexible and creative with the creation of their applications. [rola]

On picture 1.2 we see different types of AWS services.



Picture 1.2: AWS services [rola]

- Compute provides us with execution environment. With AWS Lambda, users can run code without managing servers. The payment is based on consumed time. [aws]

Fargate is used with Amazon ECS to run containers without having to manage servers or clusters of Amazon EC2 instances. Fargate removes the need to choose server type. [aws1]
- Messaging offers tools such as AWS Simple Notification Service (SNS) and Amazon Simple Queue Service (SQS). Amazon SNS is a web service that coordinates and manages the delivery or sending of messages to subscribing endpoints or clients. There are two types of clients: clients (publishers) and subscribers (consumers). The owner of the topic can control who can access the topic. [aws2]

SQS offers a durable and secure hosted queue that lets the users integrate and decouple distributed software systems. [aws3]
- Integration allows us to integrate on-premises and cloud applications, this makes it easy to handle organization's business processes. [aws4]

Amazon Api Gateway enables users to create, maintain and monitor REST, HTTP, and WebSocket APIs. [aws5]

AWS step Functions gives users the ability to coordinate different components of the application using workflows. [aws6]
- Security tools are Amazon Cognito and AWS Key management Service (KMS).

Amazon Cognito provides authentication, authorization and user management for web and mobile apps. Main components are user pool and identity pool. User pool provides sign-up and sign-in options. Identity pool grants users access to other AWS services. [aws7]

KMS is used for creating and controlling encryption keys used to encrypt users data. [aws8]

- Monitoring resources can be done by Amazon CloudWatch and AWS Quicksight. Cloudwatch monitors AWS resources and the applications that are run on AWS in real time. With it users can create alarms that watch metrics and send notifications or automatically modify the resources that are being monitored. [aws9]  
QuickSight is used for creating visualizations based on users data. With it we can access data from multiple sources, get answers fast and tell a story with our data based on the visual representation. [aws10]
- Database tools such as DynamoDB frees users from administrative problems such as hardware provisioning, setup and configuration, replication or cluster scaling. It also offers encryption and protects sensitive data. [aws11]  
Another database tool is Amazon Aurora. It helps to remove the time-consuming administration tasks like storage autoscaling, database setup, patching and backups. [rola]
- Analytics is offered through Amazon Kinesis and Amazon Athena. Kinesis is a streaming service that collects and analyzes real-time streaming data (clickstreams, financial transactions, social media feeds etc.) [rola]

## Summary

After getting to know the common definition of cloud computing, its history and advantages, we touched on examples of cloud such as social networking, chatbox, communication and more. Email, Twitter, Whatsapp, Skype, Google docs all use cloud computing to provide service for the user.

Cloud architecture is divided in four parts which are connected to each other.

Cloud computing is offered in three different service models which satisfy a unique set of business requirements. Service models are SaaS, PaaS and IaaS.

We can categorize four cloud deployment models: public, private, community and hybrid. Each deployment model is used in different situations. They are defined according to where the infrastructure for the environment is located.

According to statistics, cloud computing is growing each year. Due to COVID-19, cloud based platforms such as Zoom have seen an increase in demand.

Amazon web service is the leading provider for cloud computing. It offers variety of services that are suited for all kinds of business situations.

In conclusion, cloud computing is rapidly growing due to its many advantages. The USA is investing the most amount of money in cloud technology for economical and perhaps political reasons as well. The market is ever-growing with possibilities.

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