

# Cloud computing: Opportunities and challenges



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We live and operate in the world of computing and computers. The Internet has drastically changed the computing world from the concept of parallel computing to distributed computing to grid computing and now to cloud computing. Cloud computing is a new wave in the field of information technology. Some see it as an emerging field in computer science. It consists of a set of resources and services offered through the Internet. Hence, "cloud computing" is also called "Internet computing." The word "cloud" is a metaphor for describing the Web as a space where computing has been preinstalled and exists as a service. Operating systems, applications, storage, data, and

processing capacity all exist on the Web, ready to be shared among users. Figure 1 shows a conceptual diagram of cloud computing.

The main objective of cloud computing is to make better use of distributed resources and solve large-scale computation problems. For example, cloud computing can focus the power of thousands of computers on one problem, enabling researchers to do their work faster than ever. Thus, cloud computing may be regarded as a distributed system that offers computing services via a computer communication network, usually the Internet (TCP/IP). Resources in the cloud are transparent to the users, and the users need not know the exact location(s) of the resources. They can be shared among a large number of users, who should be able to access applications and data from anywhere at anytime.

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Several corporations and institutions have shown an interest in cloud computing, and many platforms have been proposed. An example of cloud service is Google Apps, which is provided by Google and Microsoft SharePoint. Services are also being provided by IBM, HP, Amazon, Apple, Oracle, and Salesforce. These companies own millions of servers and have invested an enormous effort to support cloud computing. At the moment, Google is the largest provider of cloud computing service; it has its own cloud computing platform.

## Architecture

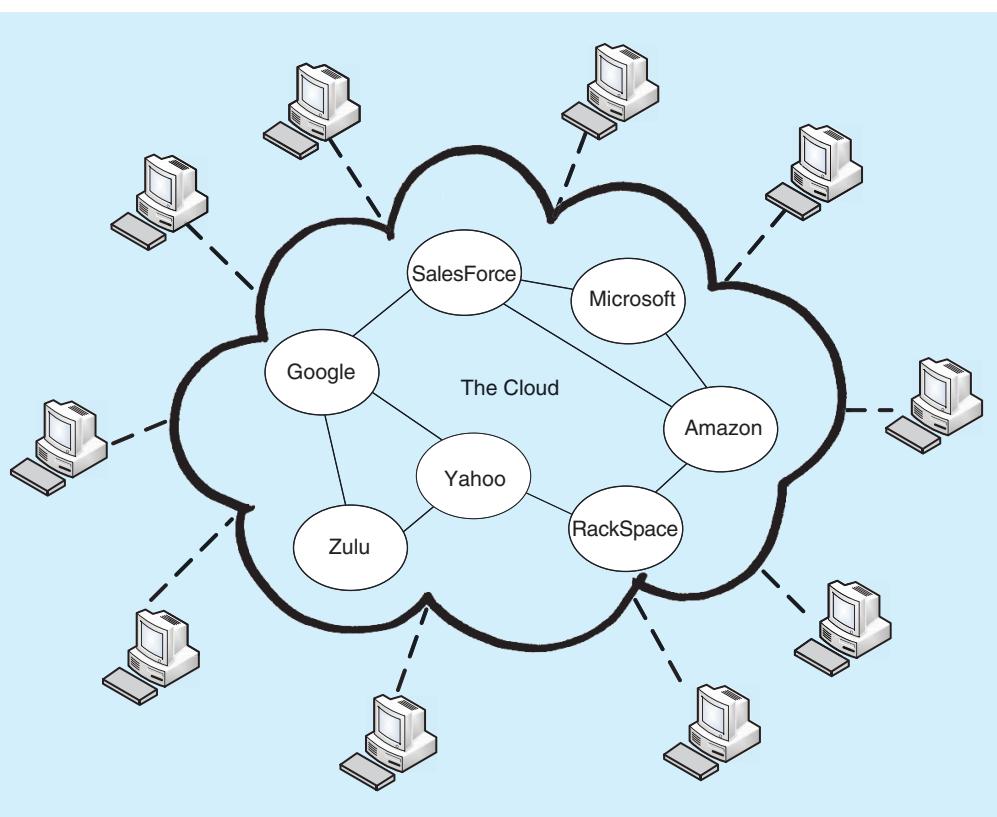
Figure 2 shows the cloud computing architecture. The services provided by cloud computing can be divided into three categories.

- **Infrastructure-as-a-service (IaaS):** the simplest of cloud computing offerings. It involves the delivery of huge computing resources such as the capacity of storage, processing, and network. It is the ability to remotely access computing resources. The major advantages of IaaS are pay per use, security, and reliability. IaaS is also known as hardware-as-a-service. An example of IaaS is the Amazon Elastic Compute Cloud (EC2).

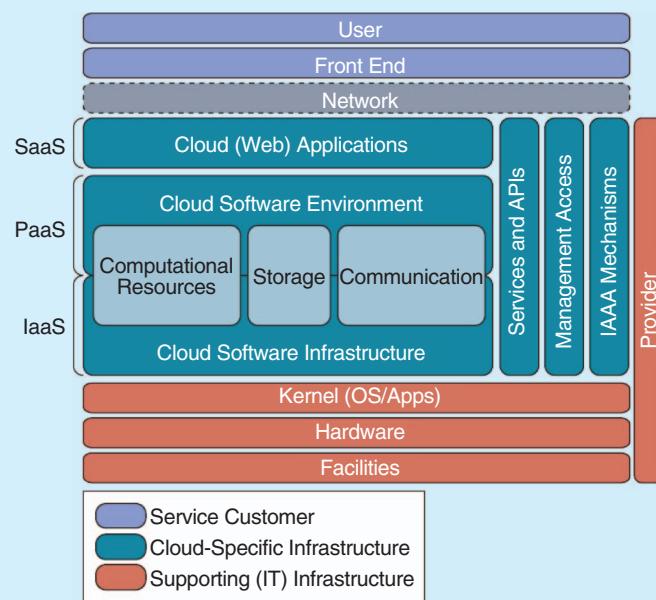
- **Platform-as-a-service (PaaS):** supports a set of application programs interface to cloud applications. It has emerged due to the suboptimal nature of IaaS for cloud computing and the development of Web applications. Many big companies are seeking to dominate the platform of cloud computing, as Microsoft dominated the personal computer (PC). Examples of PaaS are Google App Engine and Microsoft Azure.

- **Software-as-a-service (SaaS):** provides a service that is directly consumable by the end user. It is a software deployed over the Internet. This is a pay-as-you-go service. It seeks to replace the applications running on a PC. A typical example of SaaS is Salesforce.com.

These service models are useful in categorizing not only cloud computing but specific vendor offerings, products, and services. As cloud computing becomes mature, several service types are being



**Fig. 1 Cloud computing.**



**Fig. 2 Cloud computing architecture.**

introduced and overlaid on these architectures.

## Benefits and challenges

While the benefits of cloud computing are many, its disadvantages are just as numerous. If used properly, cloud computing is a technology with great

opportunity for businesses of all sizes. The major advantages of cloud computing are on-demand self-service, ubiquitous network access, location-independent resource pooling, and transference of risk. Additional advantages include lower costs, ease of utilization, quality of service, and reliability.

The greatest challenges with cloud computing are privacy and security. As data is accessed from any location, users' privacy can be compromised. Security is also a concern. Information security is about keeping data secret. Handing over confidential information to another company makes some feel unsecure. Vendors, researchers, and security professionals are working on security issues associated with cloud computing.

For some applications, latency is another issue with cloud computing. This is the delay from request for data to its ultimate delivery. There is also the problem of a lack of standards. These concerns or challenges are slowing down the adoption of cloud computing.

## Opportunities ahead

Cloud computing is supported by big companies that hope the investments on cloud computing see a return on investment in the near future. Some examples of emerging cloud computer technology are:

- Microsoft: Window Live Service, Window Azure
- Google: Google Docs, Google App Engine
- Amazon: Amazon Simple Storage Service, Elastic Compute Cloud
- IBM: Blue cloud
- Apple: Mobile Me.

Cloud computing will provide the dynamic resource pool, the virtualiza-

tion, and the high usability for the next generation. Successful applications of cloud computing have been implemented at educational institutions. This effort allows researchers to search, find models, and make discoveries faster than ever. The applications of cloud computing are limitless. Potentially, everything from word processing software to customized computer programs could work on a cloud computing system. Cloud computing is expected to change and increase business opportunities in the computing industry.

## Conclusions

This article presents a brief overview of cloud computing. Cloud computing is evolving as a key technology for sharing resources via the Internet. Startups and small and medium businesses are using cloud computing to great advantages. Lack of privacy and security is the main hurdle in the wide adoption of cloud computing. We are almost at the beginning of the cloud era; it is hard to predict the impact of cloud computing on society. Cloud computing is not fully mature and needs to be explored.

## Read more about it

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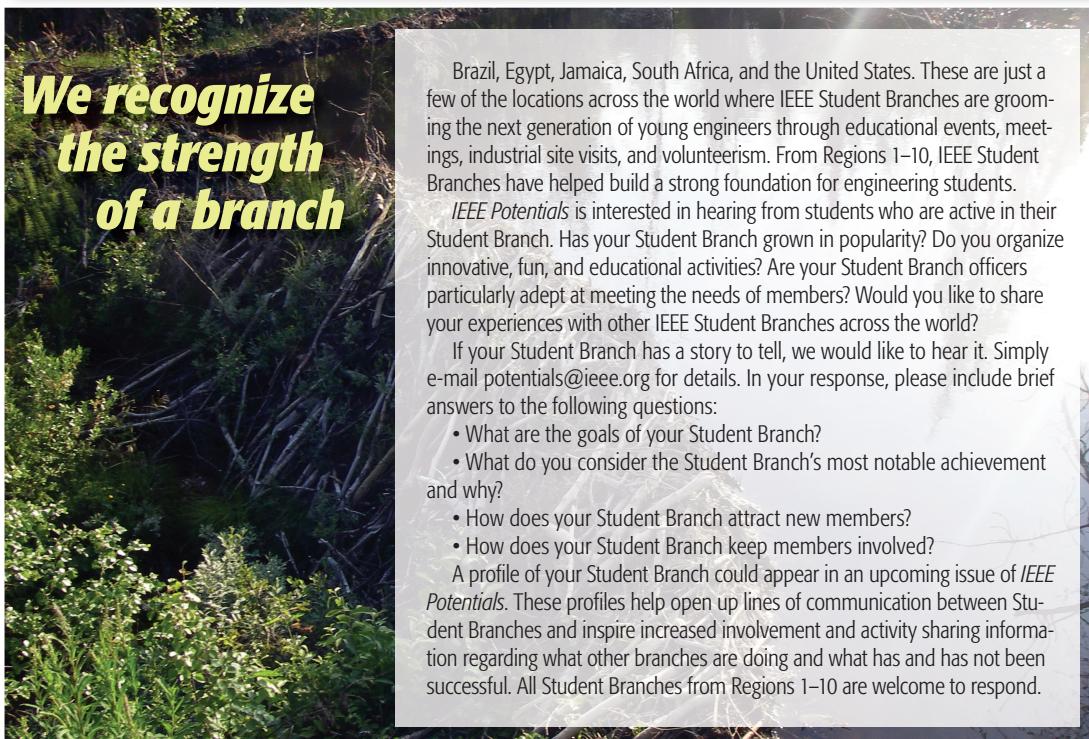
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