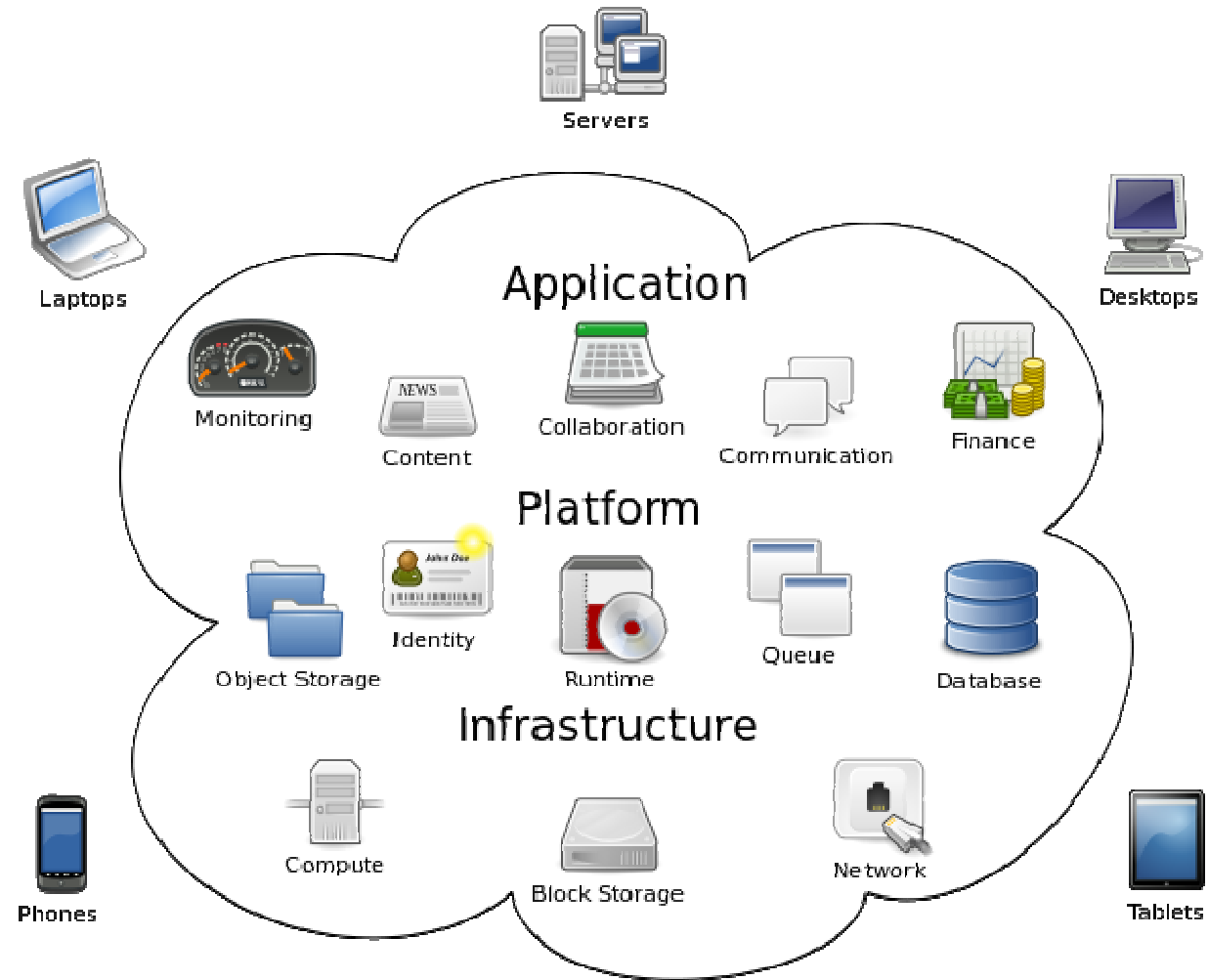# Cloud Computing

Cloud Computing

Cloud Computing

- The aim is to give an introduction to the concept of cloud computing.

- This part will be based on the following two papers (indeed they are very similar)

  - **A view of cloud computing.**

    Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy Katz, Andy Konwinski, Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica, and Matei Zaharia.

    Commun. ACM 53, 4 (April 2010), 50-58.

  - **Above the Clouds: A Berkeley View of Cloud Computing.**

    Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy Katz, Andy Konwinski, Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica, and Matei Zaharia.

    EECS Department, University of California, Berkeley

    Technical Report No. UCB/EECS-2009-28, February 10, 2009.

- For this part, you can study on the lecture notes.

1. Introduction and outline

Introduction

- Cloud Computing, the long-held dream of computing as a utility, has the potential to transform a large part of the IT industry, making software even more attractive as a service and shaping the way IT hardware is designed and purchased.

- Cloud computing is the use of computing resources (hardware and software) which are available in a remote location and accessible over a network (typically the Internet). Users are able to buy these computing resources (including storage and computing power) as a utility, on demand.

- End users access cloud-based applications through a web browser or a light-weight desktop or mobile app while the business software and user's data are stored on servers at a remote location.

- One key point is that end users can access the service <u>anytime</u> and <u>anywhere</u>, share data and collaborate more easily, and keep their data stored "safely" (hopefully) in the infrastructure.

Introduction (2)

- Developers with innovative ideas for new Internet services no longer require the large capital outlays in hardware to deploy their service or the human expense to operate it.

- They need not be concerned about overprovisioning for a service whose popularity does not meet their predictions, thus wasting costly resources, or underprovisioning for one that becomes wildly popular, thus missing potential customers and revenue.

- Companies with large batch-oriented tasks can get results as quickly as their programs can scale[*], since using 1000 servers for one hour costs no more than using one server for 1000 hours.

- This elasticity of resources, without paying a premium for large scale, is unprecedented in the history of IT.

[*] In general a system whose performance improves after adding hardware, proportionally to the capacity added, is said to be a scalable system.

Debate on cloud computing.

- Cloud Computing is likely to have a strong impact on software and technological developments in general.

- Cloud computing has been the main topic for several workshops, conferences, magazines, blogs etc. in recent years, nevertheless confusion remains about exactly what it is and when it is useful.

- Oracle's CEO (chief executive officer), said:

«The interesting thing about Cloud Computing is that we've redefined Cloud Computing to include everything that we already do. . . . I don't understand what we would do differently in the light of Cloud Computing other than change the wording of some of our ads».

Quoted in the Wall Street Journal, September 26, 2008

Debate on cloud computing. (2)

- Hewlett-Packard's Vice President of European Software Sales, said:

«A lot of people are jumping on the [cloud] bandwagon, but I have not heard two people say the same thing about it. There are multiple definitions out there of "the cloud"».

Quoted in *Zdnet News*, December 11, 2008.

- Richard Stallman, known for his advocacy of "free software", thinks Cloud Computing is a trap for users. He said:

«It's stupidity. It's worse than stupidity: it's a marketing hype campaign. Somebody is saying this is inevitable — and whenever you hear somebody saying that, it's very likely to be a set of businesses campaigning to make it true"».

Quoted in *The Guardian*, September 29, 2008.

3. What is Cloud Computing

What is Cloud Computing: Definitions

- Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services.

- The services themselves have long been referred to as Software as a Service (**SaaS**).

- The datacenter hardware and software is what we will call a **Cloud**.

- When a Cloud is made available in a pay-as-you-go manner to the public, we call it a **Public Cloud**. The service being sold is **Utility Computing**.

- By the term **Private Cloud,** we refer to internal datacenters of a business or other organization that are not made available to the public.

- <u>DEFINITION:</u> *Cloud Computing* is the sum of SaaS and Utility Computing, (but does not include Private Clouds).

Users and Providers of Cloud Computing
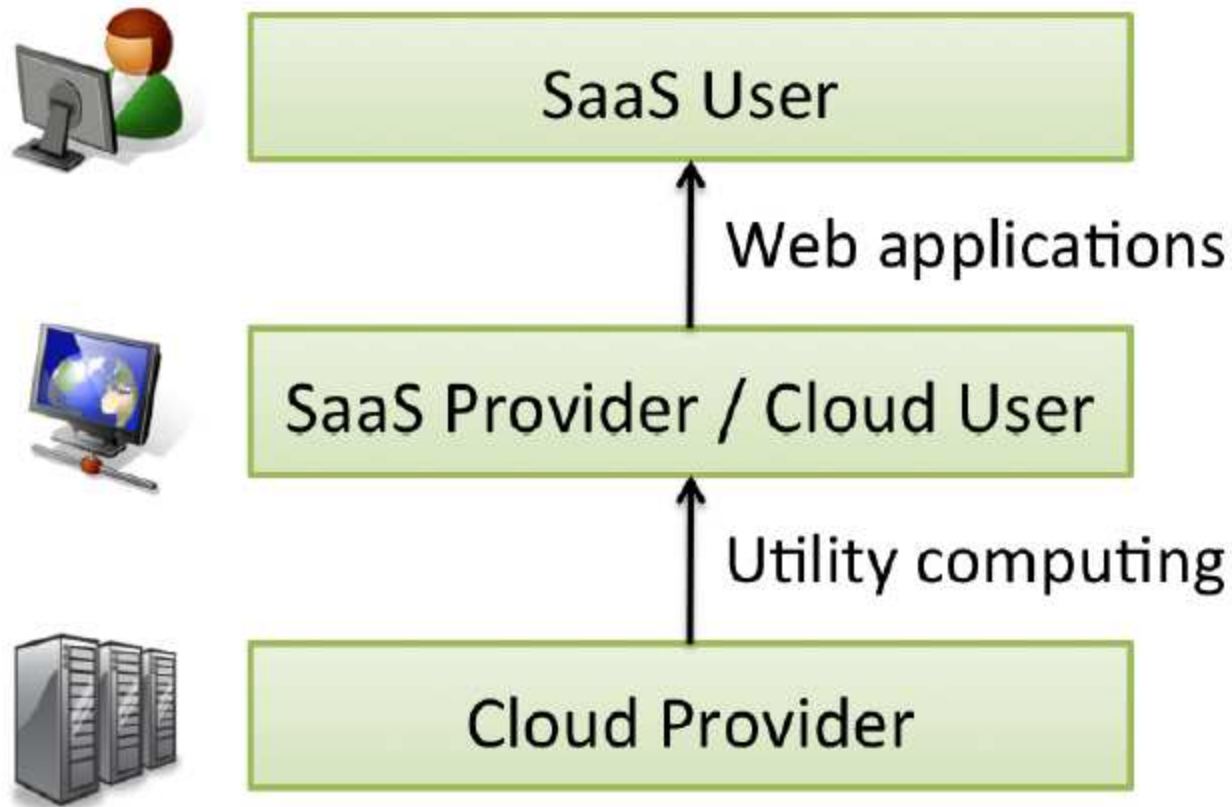
Advantages of SaaS to end users (SaaS users)

- **Affordable**: Unlike traditional software, SaaS is usually sold on a subscription basis that includes upgrades, maintenance and a degree of customer support. Moreover, there are no large up-front costs.

- **Quick to Deploy**: With SaaS solutions, all users need is a web browser and internet access, and they are ready to go. Whereas traditional software can take weeks or even months to deploy, SaaS solutions don't require any software to be installed and so users are able to access their new software immediately.

- **Zero Infrastructure**: When delivering business applications via SaaS, the complexity of the underlying IT infrastructure is all handled by the SaaS provider. Users do not need to worry about the maintenance of hardware, or which operating system version supports which database - the SaaS provider will take care of all of this.

- **Seamless Upgrades**: The SaaS provider will manage software updates and upgrades, eliminating the need to install or download patches. At any one time, SaaS users can be assured that they will always have the most up to date software.

- **Guaranteed Levels of Service**: With most traditional software, users are not given a guarantee on how well it will perform, with SaaS they are. Typically SaaS providers guarantee applications will be available 100% of the time. In the event they don't deliver, there are penalties to be paid by them.

Advantages of SaaS to end users (SaaS users) (2)

- **Backups and Data Recovery**: With traditional software, unless a costly automated solution has been implemented, the process of backing up data can be laborious. SaaS solutions eradicate this painstaking task, instigating automatic backups without user intervention and thus ensuring the integrity of data.

- **Work Anytime Anywhere**: Providing there is an internet connection, SaaS solutions can be accessed from anywhere in the world, anytime. Users are able to access their data and work more efficiently from anywhere and anytime, making life easier for home-workers or for those people that work across multiple sites.

- **Security**: An organizations' business information could be more secure in a SaaS solution, than in traditional software. Typically, cloud providers run two or more geographically separate datacenters. In the unfortunate event that a disaster occurs in one of the centers, the other ones can continue delivering the service.

- **High Adoption Rates**: As SaaS solutions are delivered over the internet, there is virtually no learning curve involved with adopting a new solution as employees tend to already be used to working on the internet.

- **Customer Relationship**: It is crucial for SaaS and Cloud providers to offer high quality services and care about customers need. Therefore it is of great interest to providers that SaaS users are happy with the services.

From now on, we focus on both cloud provider's and cloud user's point of view (we leave the SaaS user's point of view).

Cloud computing's effects on cloud users.

- Service providers enjoy greatly simplified software installation and maintenance and centralized control over versioning.

- <u>Cloud Computing gives to application providers the choice of deploying their product as SaaS without provisioning a datacenter.</u>

Cloud computing's effects on cloud users. (2)

From a hardware point of view, three aspects are new in Cloud Computing:

1. The illusion of infinite computing resources available on demand, thereby eliminating the need for Cloud Computing users to plan far ahead for provisioning;

2. The elimination of an up-front commitment by Cloud users, thereby allowing companies to start small and increase hardware resources only when there is an increase in their needs;

3. The ability to pay for use of computing resources on a short-term basis as needed (e.g., processors by the hour and storage by the day) and release them as needed, thereby rewarding conservation by letting machines and storage go when they are no longer useful.

Cloud computing's effects on cloud providers.

Who would become a Cloud Computing provider, and why?

- Amazon's bet is that by statistically multiplexing multiple instances onto a single physical box, that box can be simultaneously rented to many customers who will not in general interfere with each others' usage.

- However, realizing the economies of scale afforded by statistical multiplexing (that increases utilization compared a private cloud) and bulk purchasing requires the construction of extremely large datacenters.

- Building, provisioning, and launching such a facility is a hundred-million-dollar undertaking.

Cloud computing's effects on cloud providers. (2)

- However, because of the phenomenal growth of Web services through the early 2000's, many large Internet companies, including Amazon, eBay, Google, Microsoft and others, were already doing so.

- Summarizing, a necessary but not sufficient condition for a company to become a Cloud Computing provider is that it must have existing investments not only in very large datacenters, but also in large-scale software infrastructure and operational expertise required to run them.

Factors might influence companies to become Cloud Computing providers.

1. Make a lot of money. James Hamilton's (Professor of Economics) estimates that very large datacenters (tens of thousands of computers) can purchase hardware, network bandwidth, and power for 1/5 to 1/7 the prices offered to a medium-sized (hundreds of computers) datacenter. Further, the fixed costs of software development and deployment can be amortized over many more machines. Thus, a sufficiently large company could leverage these economies of scale to offer a service well below the costs of a medium-sized company and still make a tidy profit.

2. Leverage existing investment. Adding Cloud Computing services on top of existing infrastructure provides a new revenue stream at (ideally) low incremental cost, helping to amortize the large investments of datacenters. Indeed, according to Werner Vogels, Amazon's CTO (chief technical officer), many Amazon Web Services technologies were initially developed for Amazon's internal operations.

3. Defend a franchise. As conventional server and enterprise applications embrace Cloud Computing, vendors with an established franchise in those applications would be motivated to provide a cloud option of their own.