Infrastructure as a Service (IaaS)

- An IaaS company offers physical resources, such as a building, power, and air conditioning.
- IaaS companies also provide servers, networking equipment, and basic data storage facilities (e.g., block storage on disk).
- An IaaS company may offer customers many additional services, such as load balancers, data backup, network security, a way to boot both physical and virtualized servers, and assignment of Internet addresses.
- An IaaS customer does not need to manage or control the cloud infrastructure.
- A customer can choose which operating systems and applications run, and may have the ability to control network access (e.g., to configure a firewall).
- The most advanced IaaS companies use operating systems that can scale the customer's services and the facilities allocated to a customer up or down as needs vary.

Platform as a Service (PaaS)

The primary goal of PaaS is a facility that allows a customer to build and deploy software in a cloud without spending effort configuring or managing the underlying facility.

Basic infrastructure includes many of the IaaS facilities, such as servers, storage facilities, operating systems, databases, and network connections.

Facilities for software development and deployment include compilers, middleware, program libraries, runtime systems (e.g., Java runtime and .NET runtime), and services that host a customer's applications.

It provids a convenient environment for software development, PaaS is sometimes called *application Platform as a Service* (*aPaaS*), and was formerly named *Framework as a Service*(*FaaS*), referring to programming frameworks.

PaaS can also appear in other forms. For example, some PaaS companies sell software development tools that allow a customer to build and deploy apps on the customer's internal network (i.e., behind the customer's firewall).

Other PaaS companies sell a software development tool intended for a cloud environment, but require the customer to obtain servers, storage, network connections and other cloud facilities separately (e.g., from an IaaS company or cloud provider).

Software as a Service (SaaS)

- *Software as a Service* refers to a subscription model in which a customer pays a monthly fee to use software rather than make a one-time purchase.
- When a user accesses a SaaS application, the application runs on a server in a cloud data center rather than on the user's computer.
- Files that the user creates are stored in the cloud data center rather than on the user's local device.
- Well-known SaaS services include Microsoft's Office 365 in which each customer pays a monthly fee to use programs in the Office suite, such as *Word*, *Excel*, and *PowerPoint*.

- SaaS Vendors claim the approach has three advantages:
  Universal access
  Guaranteed synchronization
  High availability

Universal access: SaaS software can be accessed at any time from any device. A user either launches a special app or uses a web browser to access the SaaS site. After entering a login and password, the user can invoke the SaaS app and access a set of files.

The universal access guarantee means a user will be able to access the same apps and the same files from any device.

Guaranteed synchronization. The term *synchronization* refers to keeping data identical across multiple devices. With conventional software, synchronization problems arise because a user must load a copy of a file onto a device before using the file. If a user places copies of a file on two devices and then uses one device to change the file, the changes do not automatically appear in the copy on the other device.

Instead, a user must manage file synchronization by manually copying the changed version to other devices. We say that the copies can be “out of sync.”

- The SaaS synchronization guarantee arises because only one copy of each file exists. All changes are applied to a single copy of the file, even if the changes are made using two devices.
- Consequently, a file created or modified using one device will appear when the user logs in and uses another device; the user will never need to resynchronize the copies across multiple devices.

High availability: Most data centers have uninterrupted power systems that use generators and/or battery backup systems. Thus, the data center can continue operating during a power outage.

In addition, the data storage facilities at a data center usually include a backup mechanism, and many store the backups at another physical location.

Thus, even if a major catastrophe destroys the data center, a user's data can be recovered from a backup.

Because processing and storage occur in a cloud data center, a device used to access a SaaS service does not need a powerful processor, large memory, or storage.

Instead, an access device only needs a user interface and a network connection.

Industry uses the term *thin client* to describe such a device.

Some SaaS systems use a web browser as the access app. As a result, SaaS is also called *web-based software*.

Other synonyms include *on-demand software* and *hosted software*.

A Special Case: Desktop as a Service (DaaS)

Many groups have adopted the phrase *as a Service* to describe their particular market segment, including *Network as a Service*, *Security as a Service*, *Disaster Recover as a Service*, and *Mobile Backend as a Service* (providing communication between mobile apps and the cloud software they use).

One particular form of SaaS stands out as especially relevant to cloud computing. Known as *Desktop as a Service* (*DaaS*), the system implements *remote desktop* access.

Like other SaaS offerings, a user runs an app on a local device (i.e., a thin client) that connects the user to DaaS software running in a cloud data center.

Instead of providing access to a single app, however, DaaS paints a desktop on the user's screen and allows the user to click on icons, run apps, browse files, and perform other actions exactly as if the desktop was local.

The desktop that the user sees, the operating system that supplies the desktop, and the apps a user invokes all run on a server in the cloud instead of the user's local device.

We have already seen the advantages of SaaS systems, and DaaS extends them to all of a user's computing, not just one app. In terms of synchronization, DaaS stores all of a user's files and apps in the cloud data center.

So, instead of merely synchronizing data for one particular app, DaaS ensures that all data and all apps remain synchronized.

Similarly, all of a user's computing has high availability, and a user can access the desktop from any device at any time.