

Computing Fundamentals

Planning

Session	Subject	Test – Hand-in
1	Network Models	
2	Internet Protocol Suite	
3	Network segmentation	
4	Network protocols	
5	Operating systems	
6	Command Line	
-- 30/10 – 5/11 --	Autumn break – HERFSTVAKANTIE	
7	Virtualization	
8	Mid-term test	Test
9	Scripting	
10	Virtualization - Cloud computing - Storage	

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Cloud computing

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Cloud computing

- Cloud computing is a **paradigm** for enabling **network access** to a **scalable** and **elastic pool** of shareable **physical** or **virtual** resources with self-service provisioning and administration on-demand." according to ISO (International Organization for Standardization).

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Essential Characteristics

In 2011, the National Institute of Standards and Technology (**NIST**) identified five "essential characteristics" for cloud systems. Below are the exact definitions according to NIST:

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On-demand self-service:

A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

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Broad network access:

Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

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Resource pooling:

The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

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Rapid elasticity:

Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear unlimited and can be appropriated in any quantity at any time.

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Measured service:

Cloud systems **automatically control** and **optimize** resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., **storage**, **processing**, **bandwidth**, and active **user accounts**). Resource usage can be **monitored**, **controlled**, and **reported**, providing transparency for both the provider and consumer of the utilized service.

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Value proposition

Topic	Description
Cost reductions	A public-cloud delivery model converts capital expenditures (e.g., buying servers) to operational expenditure.
Device independence	Device and location independence enable users to access systems using a web browser regardless of their location or what device they use (e.g., PC, mobile phone).
Maintenance	Maintenance of cloud environment is easier because the data is hosted on an outside server maintained by a provider without the need to invest in data center hardware. IT maintenance of cloud computing is managed and updated by the cloud provider's IT maintenance team which reduces cloud computing costs compared with on-premises data centers.
Multitenancy	Multitenancy enables sharing of resources and costs across a large pool of users thus allowing for centralization of infrastructure in locations with lower costs (such as real estate, electricity, etc.)
Performance	Performance is monitored by IT experts from the service provider, and consistent and loosely coupled architectures are constructed using web services as the system interface.
Productivity	Productivity may be increased when multiple users can work on the same data simultaneously, rather than waiting for it to be saved and emailed.
Availability	Availability improves with the use of multiple redundant sites, which makes well-designed cloud computing suitable for business continuity and disaster recovery.
Scalability and elasticity	Scalability and elasticity via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis in near real-time, without users having to engineer for peak loads.
Security	Security can improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernels.

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Challenges and limitations

Security and privacy

One of the main challenges of cloud computing, in comparison to more traditional on-premises computing, is data security and privacy. Cloud users entrust their sensitive data to third-party providers, who may not have adequate measures to protect it from unauthorized access, breaches, or leaks. Cloud users also face compliance risks if they have to adhere to certain regulations or standards regarding data protection, such as GDPR or HIPAA.

Visibility and control

Another challenge of cloud computing is reduced visibility and control. Cloud users may not have full insight into how their cloud resources are managed, configured, or optimized by their providers. They may also have limited ability to customize or modify their cloud services according to their specific needs or preferences.

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Cloud cost overruns

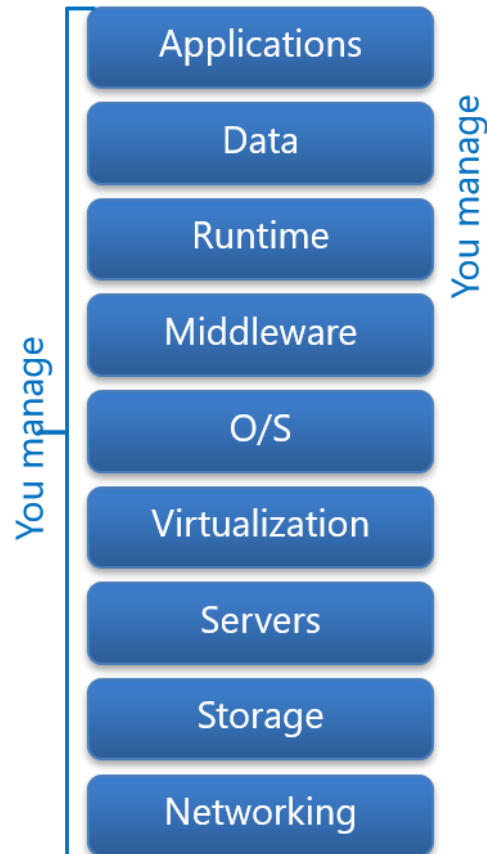
In a report by Gartner, a survey of 200 IT leaders revealed that 69% experienced budget overruns in their organizations' cloud expenditures during 2023. Conversely, 31% of IT leaders whose organizations stayed within budget attributed their success to accurate forecasting and budgeting, proactive monitoring of spending, and effective optimization.

<https://www.gartner.com/peer-community/oneminuteinsights/omi-keeping-cloud-costs-check-it-leader-perspectives-rfz>

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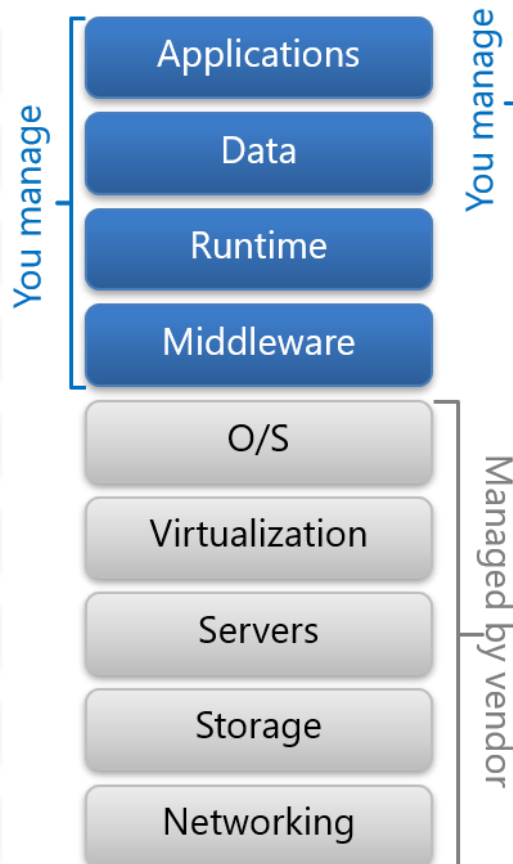
Service models

(On-Premises)



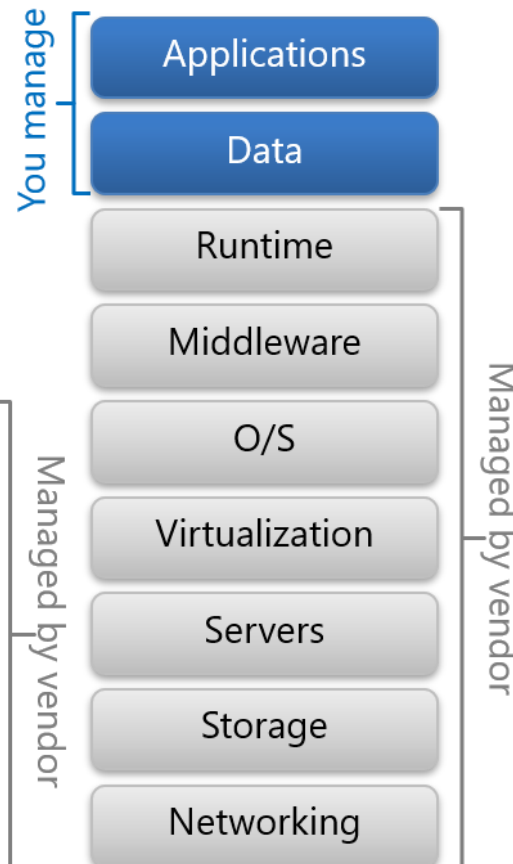
Infrastructure

(as a Service)



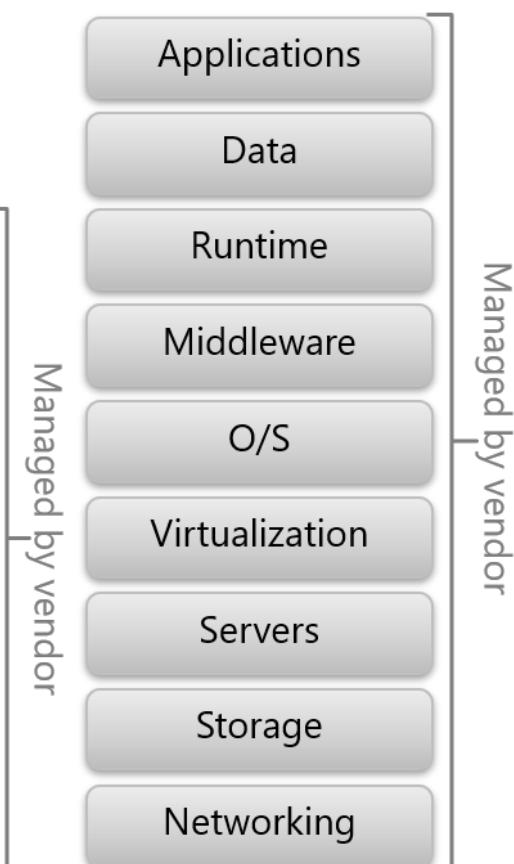
Platform

(as a Service)



Software

(as a Service)



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Storage

Computer data storage

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Computer data storage

Computer **data storage** or digital data storage is the technology consisting of computer components and recording media that are used to **retain** digital data. It is a **core function** and **fundamental component** of computers.

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Primary storage

Primary storage (also known as **main memory**, internal memory, or prime memory), often referred to simply as **memory**, is the only one **directly accessible to the CPU**. The CPU continuously reads instructions stored there and executes them as required. Any data actively **operated on** is also stored there in a **uniform** manner.

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Secondary storage

Secondary storage (also known as **external memory** or **auxiliary storage**) differs from primary storage in that it is **not directly accessible by the CPU**. The computer usually uses its **input/output channels** to access secondary storage and transfer the desired data to primary storage. Secondary storage is **non-volatile (retaining data when its power is shut off)**. Modern computer systems typically have two orders of magnitude more secondary storage than primary storage because **secondary storage is less expensive**.

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Secondary storage

In modern computers, hard disk drives (**HDDs**) or solid-state drives (**SSDs**) are usually used as secondary storage. The access time per byte for HDDs or SSDs is typically measured in **milliseconds** (thousandths of a second), while the access time per byte for primary storage is measured in **nanoseconds** (billionths of a second). Thus, secondary storage is significantly **slower** than primary storage. Rotating **optical storage devices**, such as **CD** and **DVD** drives, have even longer access times. Other examples of secondary storage technologies include **USB flash drives**, ~~**floppy disks**~~, ~~**magnetic tape**~~, ~~**paper tape**~~, ~~**punched cards**~~, and ~~**RAM disks**~~ (you do not see these types used anymore).

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Tertiary storage

Tertiary storage or tertiary memory is a **level below secondary storage**. Typically, it involves a robotic mechanism which will mount (insert) and dismount removable mass storage media into a storage device according to the system's demands; such data are often copied to secondary storage before use.

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Off-line storage

Off-line storage is computer data storage on a medium or a device that is not under the control of a processing unit. The medium is recorded, usually in a **secondary or tertiary** storage device **physically connected**, and then **removed or disconnected**. It must be inserted or connected by a human or machine operator before a computer can access it again. Unlike tertiary storage, it cannot be accessed **without interaction**.

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Network connectivity

A secondary or tertiary storage may connect to a computer **utilizing** computer **networks**. This concept does **not** pertain to the **primary storage**, which is shared **between multiple processors** to a lesser degree.

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Network connectivity

- **Direct-attached storage (DAS)** is a traditional mass storage, that does not use any network. This is still a most popular approach. This retronym was coined recently, together with NAS and SAN.
- **Network-attached storage (NAS)** is mass storage attached to a computer which another computer can access at file level over a local area network, a private wide area network, or in the case of online file storage, over the Internet. NAS is commonly associated with the NFS and CIFS/SMB protocols.
- **Storage area network (SAN)** is a specialized network, that provides other computers with storage capacity. The crucial difference between NAS and SAN, is that NAS presents and manages file systems to client computers, while SAN provides access at block-addressing (raw) level, leaving it to attaching systems to manage data or file systems within the provided capacity. SAN is commonly associated with Fibre Channel networks.

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Cloud storage

- **Cloud storage** is a model of computer data storage in which data, said to be on "**the cloud**", is **stored remotely in logical pools** and is accessible to users **over a network**, typically the **Internet**. The physical storage spans **multiple servers** (sometimes in **multiple locations**), and the physical environment is typically owned and **managed** by a cloud computing provider.

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Cloud storage

These **cloud storage providers** are responsible for keeping the data **available** and **accessible**, and the physical environment **secured, protected, and running**. People and organizations buy or lease storage capacity from the providers to store user, organization, or application data.

Cloud storage services may be accessed through a **colocated** cloud computing service, a web service application programming interface (**API**) or by applications that use the API, such as **cloud desktop storage**, a **cloud storage gateway** or **Web-based content management systems**.