

IoT App Development

Cloud Computing in IoT

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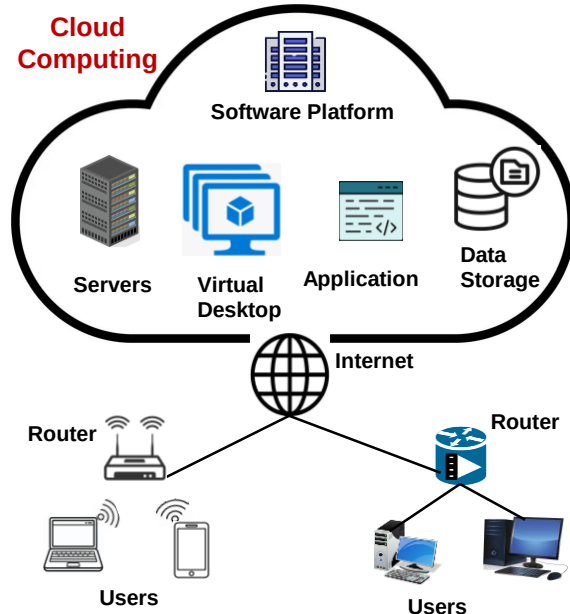
What is Cloud Computing?



“**Cloud Computing** is a model

- for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

– National Institute of Standards and Technology (NIST)



Key resources:

- Server
- Storage
- Network
- Application
- Middleware
- Runtime environment

Important features:

- Scalable resources
- On-demand service
- Web-based access
- Pay-per-use
- No maintenance by user

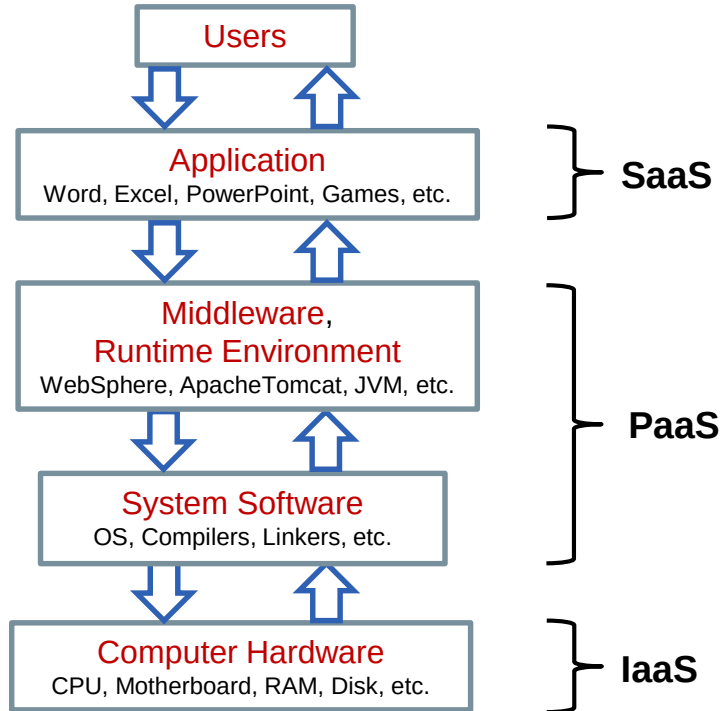


Cloud Computing Reference Model



- Software-as-a-Service
- Platform-as-a-Service
- Infrastructure-as-a-Service

Hierarchy of
Software and
Hardware in
a Computer
System



Cloud Computing Characteristics



- There are two main players
 - Cloud Service Consumer (CSCs)
 - Cloud Service Providers (CSPs)
- } Meeting via Internet

Key Characteristics:

- 1) Broad network access
 - Capabilities are **available over the network** and accessed through standard communication protocol
- 2) On-demand self-service
 - A consumer can unilaterally **provision computing capabilities** as needed **automatically** without requiring human interaction
- 3) Pay-per-use pricing model
 - Cloud systems **automatically monitor, control and optimize** resource use by a pay-per-use pricing model
- 4) Resource pooling
 - Computing resources are pooled to serve multiple consumers using a **multi-tenant model**
- 5) Rapid elasticity
 - Capabilities can be elastically provisioned and released to **scale rapidly outward and inward** corresponding to demand at any time



On-Premise vs IaaS vs PaaS vs SaaS



On-Premise	IaaS	PaaS	SaaS
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware
OS	OS	OS	OS
Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking



Managed by **User / Consumer**



Managed by **Cloud Service Provider**



Cloud Deployment Models



■ Private Cloud

- The cloud infrastructure is provisioned for **exclusive use by a single organization** comprising multiple consumers



- Limited Scalability
- Very High Reliability
- High Security
- Very High Cost
- e.g. VMWare, Azure, AWS, OpenStack

■ Community Cloud

- The cloud infrastructure is provisioned for **exclusive use by a specific community of consumers** from organizations that have shared concerns



- Limited Scalability
- Very High Reliability
- Moderate Security
- Moderate Cost
- e.g. SolaS Community Cloud

■ Public Cloud

- The cloud infrastructure is **provisioned for open use** by the general public.



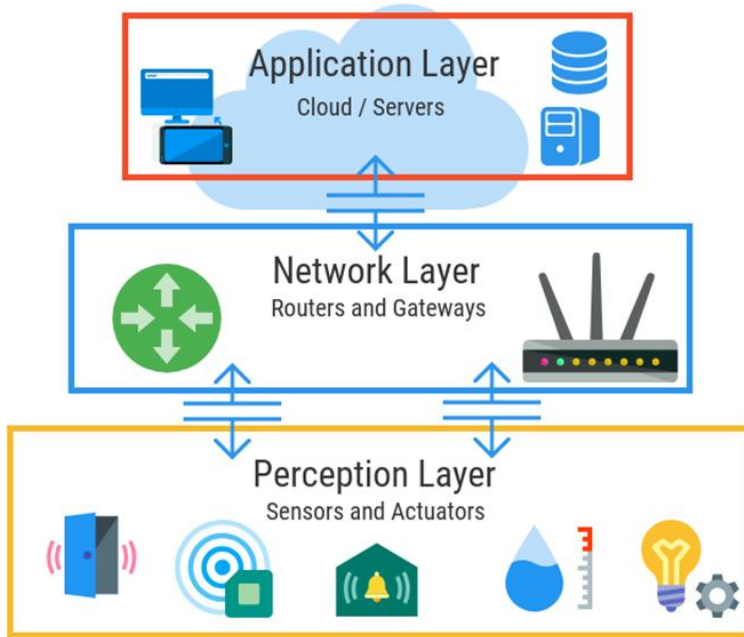
- High Scalability
- Moderate Reliability
- Security depends on service providers
- Low Cost
- e.g. Amazon EC2, Google AppEngine

■ Hybrid Cloud

- Any combination of the above clouds.



Cloud Layer in IoT Architecture



- The **cloud layer** primarily deals with the **storage** and **processing** of the sensed data, which is acquired from the IoT devices through the IoT gateway.
- For **analyzing the collected IoT data**, different **statistical analysis tools** are employed in cloud.
- **Sensor data analytics in Cloud** can also involve **machine learning** and **deep learning models**.

Cloud Computing in IoT



- Key Benefits:

- **Data Storage and Processing:** IoT devices collect large amounts of data. Cloud computing helps to store and process this data quickly.
- **Remote Access:** Cloud-based IoT systems let users access data, service, and devices from anywhere.
- **Scalability:** Cloud computing allows IoT systems to grow easily by providing resources when needed, like extra storage or computing power.
- **Cost Efficiency:** Cloud services offer pay-as-you-go plans. Companies don't need to buy expensive servers or storage devices upfront.
- **Improved Device Communication:** Cloud computing supports easy communication between IoT devices using APIs
- **Faster Innovation:** Developers can quickly build, update, or scale applications using Cloud-hosted IoT Platforms. They can use built-in analytics, storage, and connectivity features.



Limitations of IoT Cloud



- In Cloud based IoT applications, **all data needs to be sent to the cloud** over the Internet, which puts **heavy load on the network**, and also **security & privacy** is a big concern.
- After processing of those data, the **control signals need to traverse back** to the device, which causes **high latency**.



Google's Self-Driving Car

- *Example:* A self-driving car generates **gigabytes of data per second** containing information about its **route**, **speed**, operating **condition**, **traffic** situation, surrounding **environment**, **weather**, **video** streaming, etc.



Edge Computing



- To address the limitations of Cloud Computing in IoT, the Edge Computing have emerged.
- Objective is to use the proximal computational resources for processing the sensor data.
- Push the computation as close as possible to actual data source, so that the *latency* and *privacy* requirements of the IoT applications can be satisfied
- Edge computing processes data directly on or near the device that generates it
- Edge nodes are including industrial controllers, network gateways, and connected devices.
- They pre-process, reduce, and analyze data locally, sending only the necessary information to the cloud or central data centers for further processing or long-term storage.



Edge Computing



- Edge computing operates by **processing data near the source** of data generation, effectively at the “edge” of the network.
- This method contrasts with **cloud computing's centralized data processing**.
- It is particularly advantageous for **applications requiring fast decision-making**, where real-time processing is critical.
 - E.g. autonomous vehicles, industrial automation, augmented reality, health monitoring, etc.

Advantages:

- ✓ Reduced Latency
- ✓ Increased Security
- ✓ Greater Bandwidth Efficiency

Disadvantages:

- ✓ Low Processing Power
- ✓ Increased Cost
- ✓ Increased Complexity



Cloud vs Edge Computing



- Few key differences between cloud and edge computing

Features	Cloud	Edge
Data Processing Location	Central cloud server	On the edge device or sensor itself
Processing Power and Storage Capability	High	Low to Medium
Internet Connectivity Requirement	Needs 24/7 internet access	Not required
Data Security	Less secured as all data need to bring into cloud	Highly secure as only essential data is transferred to cloud
Installation and Management	Easy-to-implement and cost-efficient	More overhead and cost



Thank You

See You
Next Time