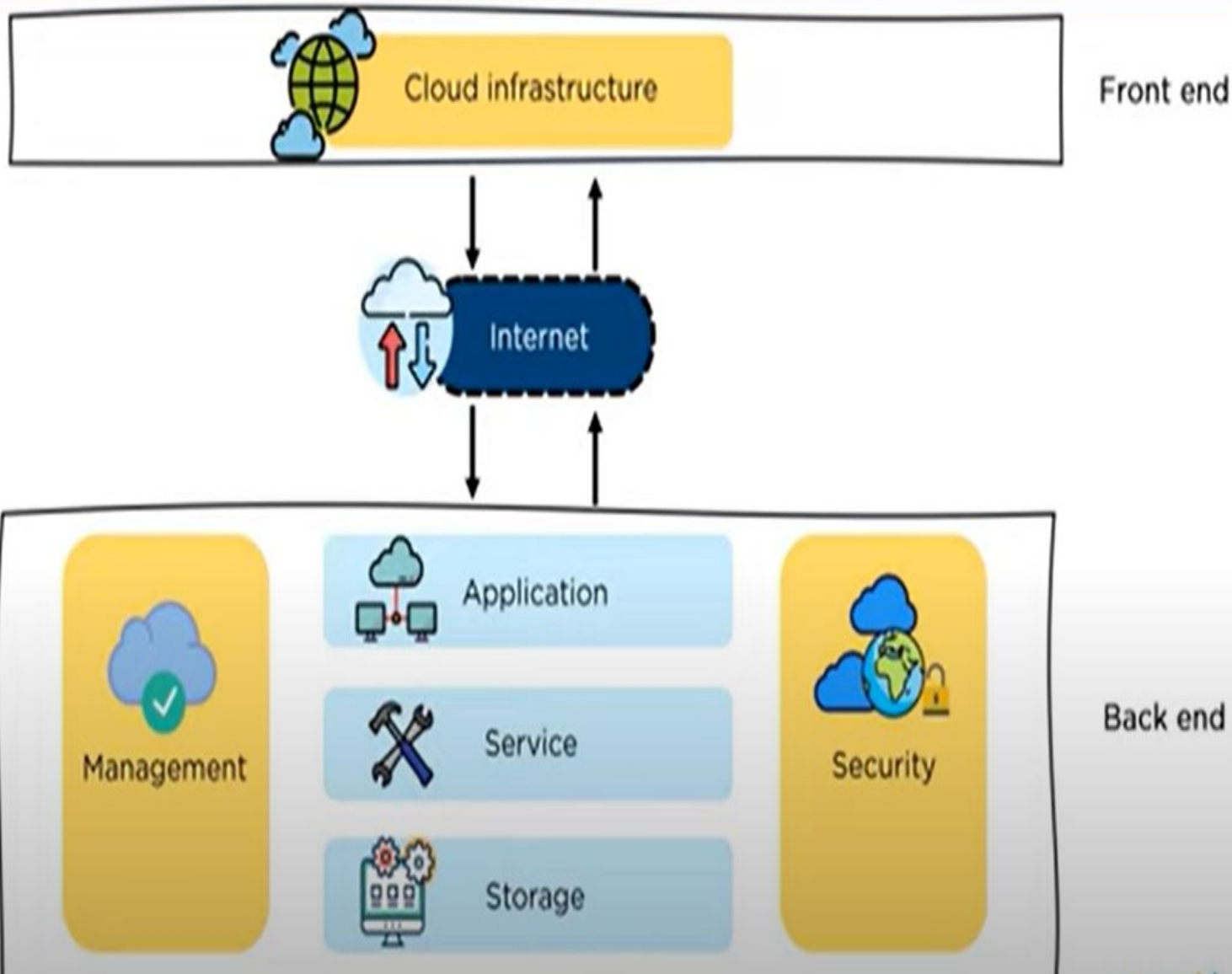


# Cloud Computing Architecture



CLOUD COMPUTING  
ARCHITECTURE IS  
DIVIDED INTO TWO  
PARTS:



FRONT END



- It provides applications and the interfaces that are required for the cloud-based service
- These applications are web browsers such as google chrome and internet explorer
- It includes clients and mobile devices

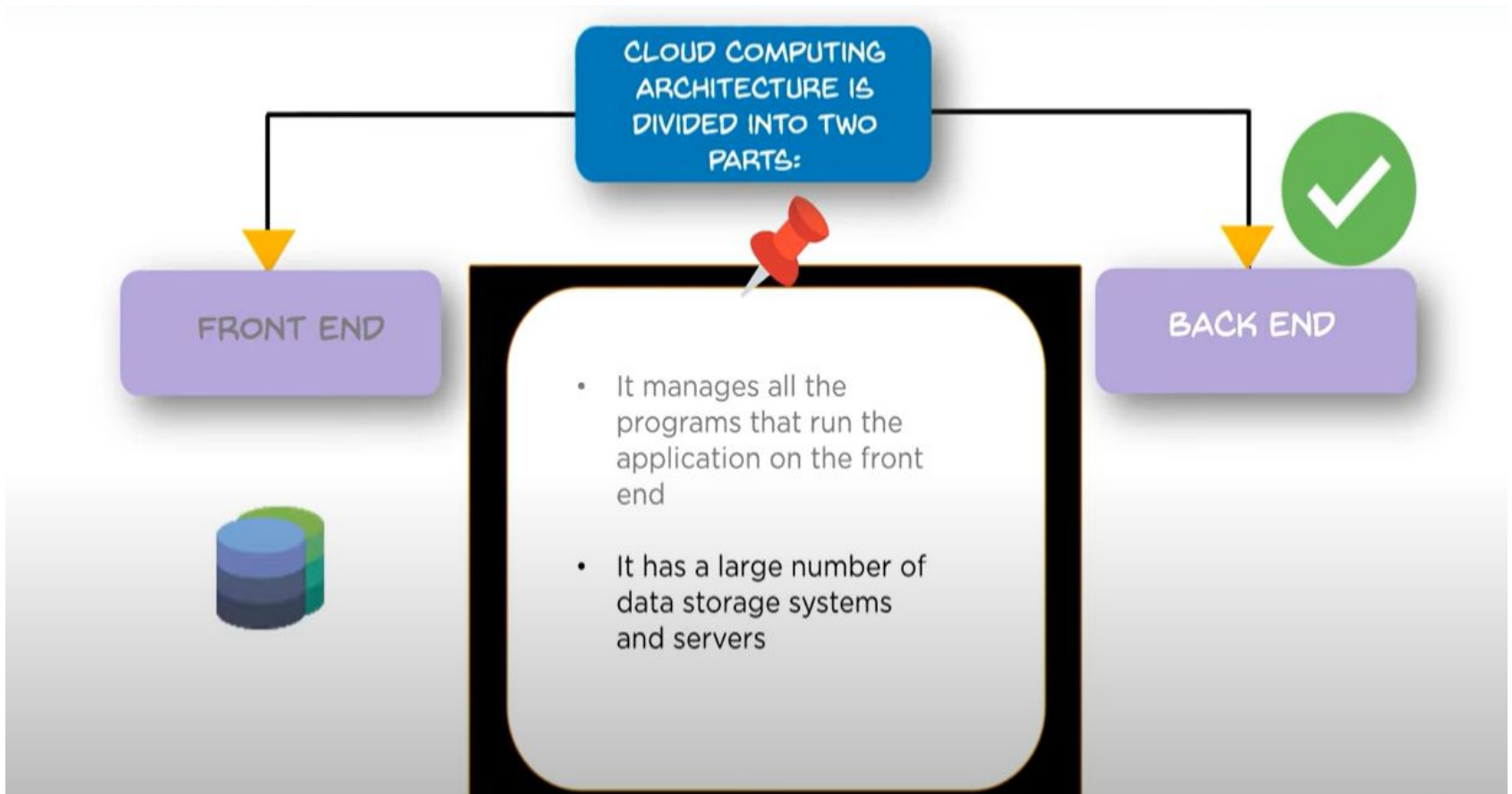
BACK END

# Front End – Cloud Computing Architecture

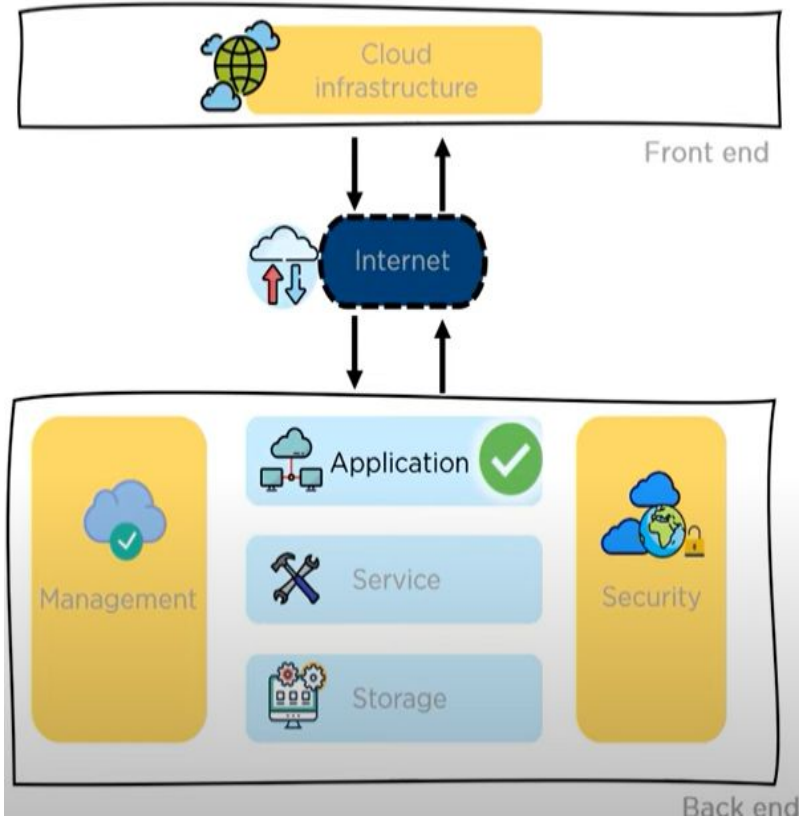
- Cloud infrastructure consists of hardware and software components such as data storage, server, virtualization software etc.
- It also provides Graphical User Interface to end users in order to perform respective tasks



# Back End – Cloud Computing Architecture

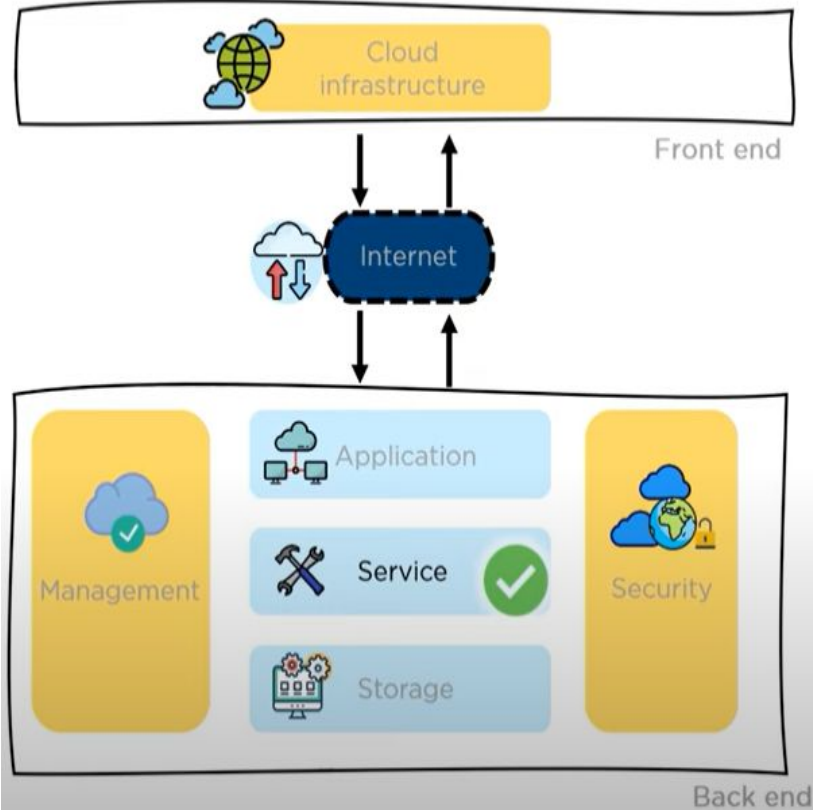


# Back End – Cloud Computing Architecture



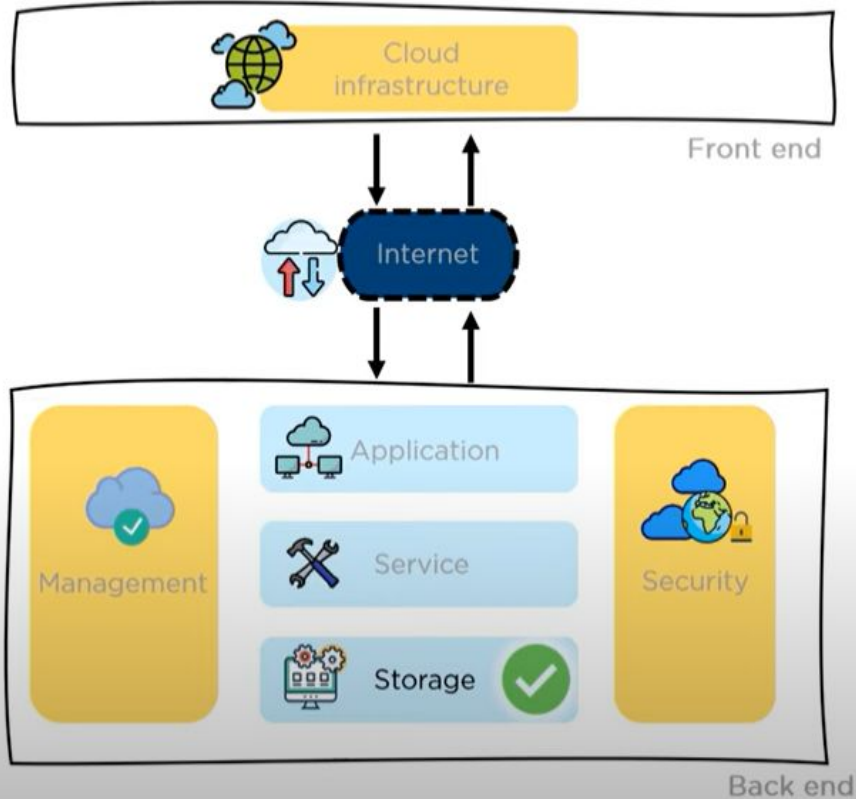
- It can also be a software or a platform
- Based on the requirement, the application provides output to the end-user (with resources) in the back end

# Back End – Cloud Computing Architecture



- It is one of the most important components in the cloud
- Its task is to provide utility in the architecture

# Back End – Cloud Computing Architecture



- It maintains and manages any amount of data over the internet
- Some of the examples of storage services are Amazon S3, Oracle Cloud-Storage, and Microsoft Azure Storage





# Cloud Computing Service Models

Primarily Cloud Computing provides following three types of services :

1. Software-as-a-Service (SaaS)
2. Platform-as-a-Service (PaaS)
3. Infrastructure-as-a-Service (IaaS)



"IaaS"  
Infrastructure-as-a-Service  
host



"PaaS"  
Platform-as-a-Service  
build



"SaaS"  
Software-as-a-Service  
consume



# Cloud Computing Service Models Cont....

## 1. Software-as-a-Service (SaaS):

- In SaaS, application softwares running on a cloud infrastructures are provided by cloud service providers as a service to the consumer.
- These application softwares which are deployed over the cloud are accessible from various client devices e.g. mobile phones, tablets, laptops, desktop PCs etc.
- Consumer can access cloud applications either through web browser or a program interface.
- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities.
- With SaaS, a provider licenses an application to customers either as a service on demand, through a subscription, in a “pay-as-you-go” model, or at no charge when there is opportunity to generate revenue from streams other than the user, such as from advertisement or user list sales.



# Cloud Computing Service Models Cont....

## 1. Software-as-a-Service (SaaS) Cont....

### Characteristics of SaaS:

1. Web access to commercial software.
2. Software is managed from central location.
3. Software is delivered in a 'one to many' model.
4. Users not required handling software upgrades and patches.
5. Application Programming Interfaces (API) allow for integration between different pieces of software.

### Applications of SaaS:

1. Email newsletter campaign software
2. Software that is only to be used for a short term need.
3. Software where demand spikes significantly. E.g. Tax/Billing software's.
4. E.g. of SaaS: Sales Force Customer Relationship Management (CRM) software.



# Cloud Computing Service Models Cont....

## 1. Software-as-a-Service (SaaS) Cont....

### Applications of SaaS Cont....

5. Social networking, online games, communication, video conferencing.
6. Users subscribe to web applications instead of buying and licensing software instances. For example - Google Docs and Google spreadsheet can be used for free instead of buying Microsoft Word, Microsoft Excel.

### Scenarios where SaaS is not useful:

1. Applications where extremely fast processing of real time data is needed.
2. Applications where an existing on-premise solution fulfills all of the organization's needs.



# Cloud Computing Service Models Cont....

## 1. Software-as-a-Service (SaaS) Cont....

| SaaS Provider                          | Type of Service                            |
|--|--|
| Salseforce.com                         | CRM  |
| Google                                 | Email, Google Docs and Google Spreadsheets |
| SmugMug                                | Data Sharing                               |
| Process Maker Live,<br>Appian Anywhere | Business Process Management                |
| MuxCLoud                               | Data Processing                            |



# Cloud Computing Service Models Cont....

## 2. Platform-as-a-Service (PaaS) :

- PaaS is an integrated environment with complete stack of development tools accessible via a web browser that supports the development , deployment and management of applications in a cloud environment.
- PaaS provides capability to the consumer to deploy consumer-created or acquired applications which are created using programming languages, libraries and tools. These applications are deployed onto cloud infrastructure and are supported by the cloud service provider.
- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.
- PaaS provides web based Integrated Development Environment for development and deployment of application on the cloud. Hence developers can directly write applications on the cloud and don't have to buy separate licenses of IDE.



# Cloud Computing Service Models Cont....

## 2. Platform-as-a-Service (PaaS) Cont....

- PaaS makes easy to migrate code from development environment to the actual production environment.
- PaaS is the set of development tools and services designed to make coding and deploying applications quickly and efficiently.
- It brings the benefits to the software development world. PaaS can be defined as a computing platform that allows the creation of web applications quickly and easily and without the complexity of buying and maintaining the software and infrastructure underneath it.
- PaaS is analogous to SaaS except that, rather than being software delivered over the web, it is a platform for the creation of software, delivered over the web.
- PaaS is a set of services to develop, test, deploy, host and maintain applications in the same integrated development environment. All the varying services needed to fulfill the application development process.



# Cloud Computing Service Models Cont....

## 2. Platform-as-a-Service (PaaS) Cont....

- It consists of multi-tenant architecture where multiple concurrent users utilize the same deployed application.
- PaaS offers integration of deployed application with external web services and databases via common standard.
- It supports development team to collaboratively carry out project planning and development. Hence multiple concurrent developers can simultaneously work on same project to be developed on cloud.

### Scenarios where PaaS is useful:

- PaaS is especially useful in any situation where multiple developers will be working on a development project or where other external parties need to interact with the development process.
- PaaS is useful where developers need to automate testing and deployment services.





# Cloud Computing Service Models Cont....

## 2. Platform-as-a-Service (PaaS) Cont....

### Scenarios where PaaS is useful Cont....

- PaaS is useful when a group of software development methodologies are based on iterative and incremental development. It helps for rapid development and iteration of software.

### Scenarios where PaaS is not useful:

- Where a proprietary language would cause a issue while moving deployed application from one provider to another provider. This is called as vendor lock in.
- Where application performance requires customization of the underlying hardware and software.



# Cloud Computing Service Models Cont....

## 2. Platform-as-a-Service (PaaS) Cont....

| PaaS Provider    | Type of application development           | Type of platform used                            |
|------------------|---|--|
| Aneka            | Enterprise applications, Web applications | .NET   |
| Google AppEngine | Web Applications                          | Python, Java                                     |
| Force.com        | Enterprise applications                   | Apex   |
| MS Azure         | Enterprise applications, Web applications | .NET   |
| Heroku           | Web Applications                          | Ruby on Rails, Node.js, Scala, Python, PHP       |
| Amazon EC2       | Data processing                           | Hive and Pig, Java, Ruby, Perl, Python, PHP, C++ |



# Cloud Computing Service Models Cont....

## 3. Infrastructure-as-a-Service (IaaS) :

- ❑ Infrastructure as a Service (IaaS) is a way of delivering Cloud Computing infrastructure – servers, storage, network and operating systems – as an on-demand service.
- ❑ Rather than purchasing servers, software, datacenter space or network equipment, clients instead rent those resources as a fully outsourced service on demand.
- ❑ IaaS is the delivery of computing services including hardware, networking , storage and data center space to the consumers.
- ❑ The capability provided by IaaS service provider to consumer is to provision processing, storage, networks, and other fundamental computing resources
- ❑ Consumer procures cloud infrastructure as a service to deploy and run arbitrary softwares.



# Cloud Computing Service Models Cont....

## 3. Infrastructure-as-a-Service (IaaS) Cont....

### Characteristics of IaaS

- Resources like servers, network, storage, operating systems are distributed as a service.
- Allows for dynamic scaling.
- Generally includes multiple users on a single piece of hardware.

### Scenarios where IaaS is useful :

- Where infrastructure demand is very volatile and unpredictable.
- For new organizations without investing capital in infrastructure.
- Where the organization is growing rapidly and scaling hardware would be problematic.
- Where there is pressure on the organization to limit capital expenditure and to move to operating expenditure.
- For trial projects or temporary infrastructural needs.



# Cloud Computing Service Models Cont....

## 3. Infrastructure-as-a-Service (IaaS) Cont....

### Scenarios where IaaS is not useful :

- Where the infrastructure is expected to offer highest levels of performance.
- On-premise infrastructure has the capacity to meet the organization's needs.

| IaaS Provider | User Interfaces and APIs              | Guest Operating Systems |
|---------------|---------------------------------------|-------------------------|
| Amazon EC2    | CLI, Portal                           | Linux, Windows, Mac     |
| Flexiscale    | Web console                           | Linux, Windows          |
| GoGrid        | REST, Java, PHP, Python, Ruby         | Linux, Windows          |
| RackSpace     | Portal, REST, Python, PHP, Java, .NET | Linux, Windows, Mac     |

# Cloud Computing Service Models Cont....

## Software (as a Service)

Applications

Runtimes

Security & Integration

Databases

Servers

Virtualization

Server HW

Storage

Networking

Managed by vendor

## Platform (as a Service)

Applications

Runtimes

Security & Integration

Databases

Servers

Virtualization

Server HW

Storage

Networking

You manage

Managed by vendor

## Infrastructure (as a Service)

Applications

Runtimes

Security & Integration

Databases

Servers

Virtualization

Server HW

Storage

Networking

You manage

Managed by vendor

# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

- Now a new concept has emerged i.e Everything as a Service (XaaS) means anything can now be a service with the help of cloud computing and remote accessing.
- In Everything as a Service (XaaS), various products, tools and technologies, and services are provided to users as a service.

## Examples of Everything as a Service (XaaS) Model:

### 1. Hardware as a Service (HaaS):

- Service Providers provide and install some hardware on the customer's site on demand.
- The customer uses the hardware according to service level agreements {SLA}.
- This model is very similar to IaaS as physical computing resources are provided to users by service provider.





# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 2. Analytics as a Service (AaaS1):

- Analytics-as-a-Service (AaaS1) provides subscription-based data analytics software and procedures through the cloud.
- AaaS1 typically offers a fully customizable BI solution with end-to-end capabilities, organizing, analyzing, and presenting data in a way that lets even non-IT professionals gain insight and take action.

### 3. Authentication as a Service (AaaS2):

- Authentication as a Service (AaaS2) provides authentication services like multi-factor authentication, single sign-on, and password management in the cloud.
- Multi-factor Authentication (MFA) is an authentication method that requires the user to provide two or more verification factors to gain access to a resource such as an application, online account, network resource.



# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 3. Authentication as a Service (AaaS2):

- Single sign-on is an authentication scheme that allows a user to log in with a single ID to any of several related, yet independent, software systems.
- With Authentication as a Service, organizations can control access to their applications and servers from various devices and networks.
- Authentication as a Service enables organizations to track password usage, comply with strict password requirements, and provide employees with a secure way to log in to resources.

### 4. Artificial Intelligence as a Service (AIaaS):

- AIaaS refers to AI tools provided as a service



# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 4. Artificial Intelligence as a Service (AIaaS):

- **Common types of AIaaS include:**

- Chatbots and digital assistants:**

- Chatbots** are computer programs that simulate and process written or spoken human conversation so that people can interact with digital devices as if they were communicating with a real person.

- For Example: If you speak into your phone to order your favorite coffee drink, you are interacting with a chatbot. These are relatively simple conversations.

- Digital assistant** is an advanced type of chatbot that can handle more complex interactions in a conversational way. A digital assistant, for example, can respond to a complex request such as, “Schedule a flight to Delhi for me next Sunday using my usual seating preferences, and arrange transportation to and from the airport.” To respond to this request, the digital assistant will need to access multiple sources—a capacity that the ordinary chatbot does not possess.



# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 4. Artificial Intelligence as a Service (AIaaS):

- **Cognitive computing APIs** used to make an attempt to have computers mimic the way a human brain works.
- **Machine learning frameworks and services.**

### 5. Communication as a Service (CaaS1):

- Communication as a Service (CaaS1) is an outsourced enterprise communications solution that can be leased from a service provider's cloud infrastructure.
- Such communications can include Voice over IP (VoIP or Internet telephony), instant messaging (IM), collaboration and video conferencing applications using fixed and mobile devices.

### 6. Desktop as a Service (DaaS1):

- A form of desktop virtualization in which the software applications and data that traditionally reside on a desktop computer are made available remotely by a cloud provider to a user's device, typically via a web browser interface.

# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 6. Desktop as a Service (DaaS):

- DaaS provider mainly manages storing, security, and backing up user data for desktop apps.
- Using DaaS, client can also work on PCs using third-party servers.

### 7. Security as a Service (SECaaS):

- A set of services delivered by a security provider on a pay-as-you-go basis and typically without the installation of on-premises hardware.
- These security services often include authentication, anti-virus, anti-malware/spyware, intrusion detection, penetration testing, and security event management.



# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 8. Healthcare as a Service (HaaS):

- The healthcare industry has opted for the model HaaS service through electronic medical records (EMR).
- Using EMR, an electronic record of health-related information on an individual that can be created, gathered, managed, and consulted by authorized clinicians.
- IoT and other technologies have enhanced medical services like online consultations, health monitoring 24/7, medical service at the doorstep e.g. lab sample collection from home, etc.

### 9. Backup as a Service (BaaS):

- Backup as a service (BaaS) is an approach to backing up data that involves purchasing backup and recovery services from an online data backup service provider.
- Instead of performing backup with a centralized, on-premises IT department, BaaS connects systems to a private, public or hybrid cloud managed by the outside service provider for backing up data.

# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 10. Compute as a Service (CaaS):

- Compute services are also known as Infrastructure-as-a-Service (IaaS). Compute platforms supply a virtual server instance and storage and APIs that let users migrate workloads to a virtual machine.
- Users have allocated compute power and can start, stop, access, and configure their computer resources as desired.

### 11. Data as a Service (DaaS):

- An information provision and distribution model in which data files (including text, images, sounds, and videos) are made available to customers over a network.





# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 12. Database as a Service (DBaaS):

- DBaaS lets users access and use a cloud database system without purchasing and setting up their own hardware, installing their own database management software, or managing the database themselves.
- In DBaaS, the provider maintains the physical infrastructure and database. Delivers database as a private cloud service.
- Database Administration (DBA) services, such as backup and performance management are provided by service provider.
- Control over the content and usage of the database is the responsibility of the customer.
- DBaaS offerings are available for both Relational and NoSQL database types. Relational databases are constructed by using traditional database management systems like Oracle, SQL Server and MySQL. NoSQL DBaaS offerings span multiple DBMS types, including graph, document, wide column and key/value stores.



# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 12. Database as a Service (DBaaS):

- Reduced management requirements, Elimination of physical infrastructure, Reduced IT costs are the advantages of DBaaS.
- Lack of control over the IT infrastructure, Outage, Security, Latency are the disadvantages of DBaaS.

### 13. Disaster Recovery as a Service (DRaaS):

- A productized service offering in which the provider manages server image and production data replication to the cloud.
- The failover operation switches production data from a primary site to a backup (recovery) site.
- A failback operation returns production data from backup site to the original primary site after a disaster (or a scheduled event) is resolved.



# Cloud Computing Service Models Cont....

## Everything as a Service (XaaS):

### 14. High-Performance Computing as a Service (HPCaaS):

- HPCaaS provides high-level processing capacity to customers through the cloud.
- HPCaaS provides the resources required to process complex calculations, working with massive amounts of data through existing platforms.
- HPCaaS makes compute-intensive processing possible for those without the investment capital required for the skilled staff, hardware and development of a high-performance computing platform.
- AWS, Google, IBM, Microsoft Azure, Oracle all offer access to their supercomputing platforms as a HPCaaS.



# Cloud Computing Service Models Cont....

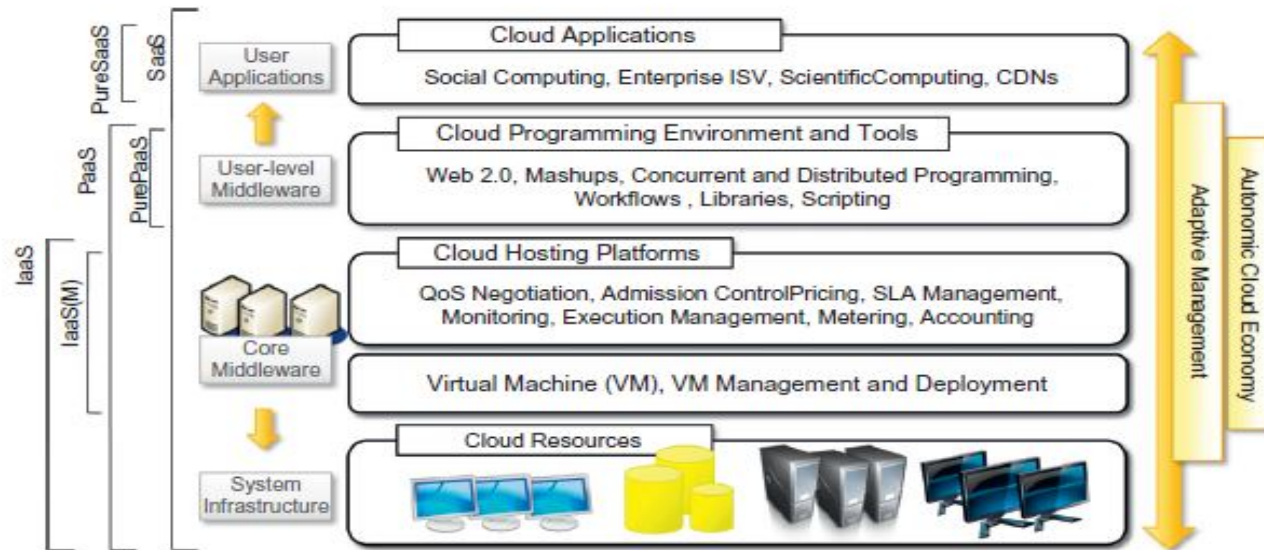
## Everything as a Service (XaaS):

### 15. Monitoring as a Service (MaaS):

- A framework that facilitates the deployment of monitoring functionalities for various other services and applications within the cloud.
- The most common application for MaaS is online state monitoring, which continuously tracks certain states of applications, networks, systems, instances or any element that may be deployable within the cloud.
- Service provider can run the MaaS server within their data center that manages the customers data. Individual software probes are installed within endpoints of each customer's site to gather data and transmit it back to the MaaS server.



# Cloud Computing Architecture:

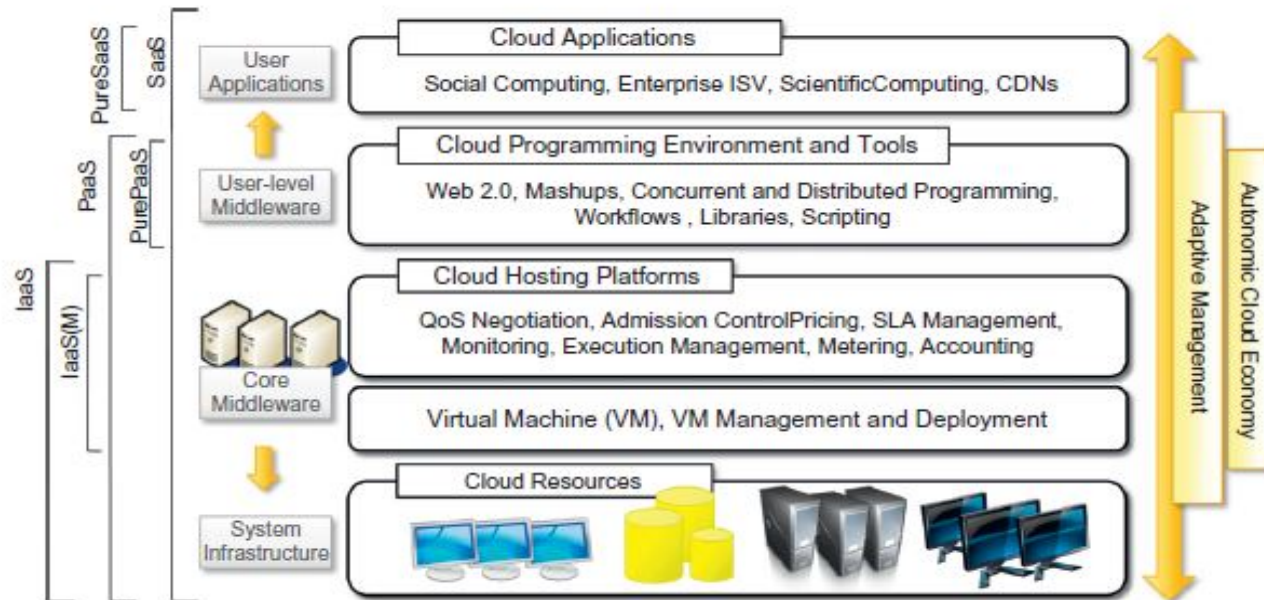


**Cloud Computing Architecture**

## System Infrastructure (Physical Infrastructure Layer):

- Cloud resources within system infrastructure layer are harnessed to offer computing required for providing services.
- System infrastructure layer is implemented using a datacenter in which hundreds and thousands of nodes are stacked together.
- Cloud infrastructure can be heterogeneous in nature as variety of resources, such as clusters, networked PCs, database systems and other storage services can be part of the infrastructure.

# Cloud Computing Architecture:



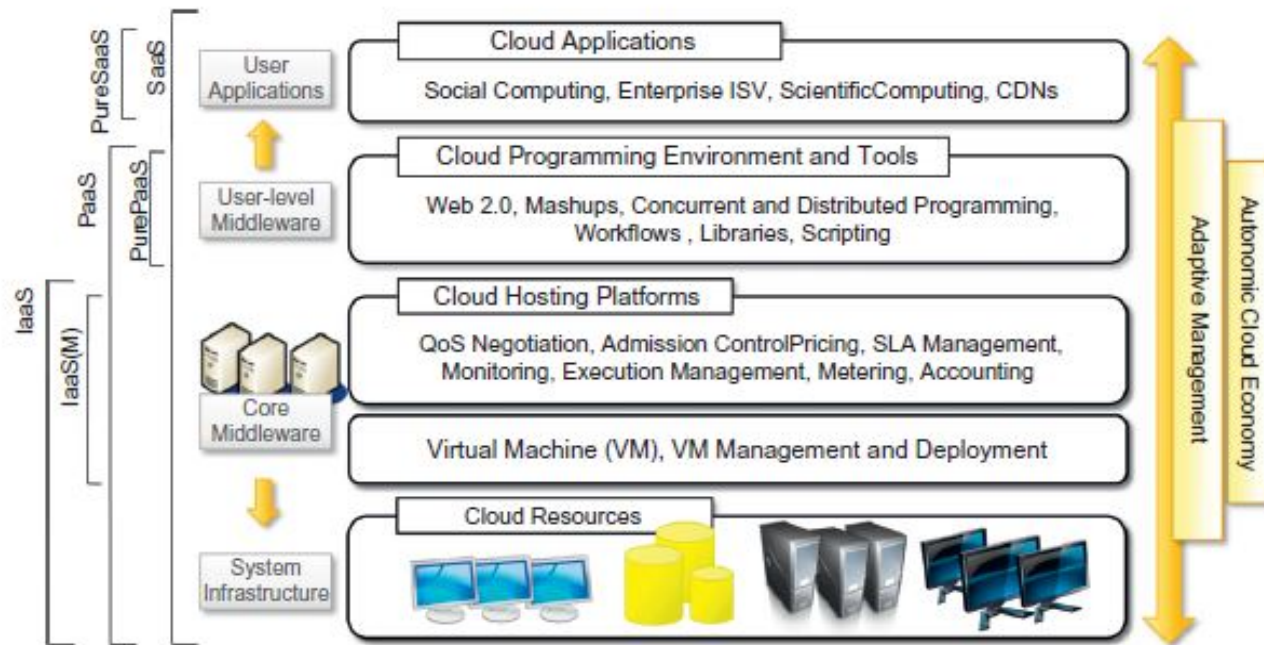
**Cloud Computing Architecture**

## Core Middleware (Management Layer):

- The physical infrastructure is managed by the core middleware.
- The objectives of core middleware is to provide an appropriate runtime environment for applications and to best utilize cloud resources available within system infrastructure.
- At the bottom of the stack, virtualization technologies are used to guarantee runtime environment customization, application isolation, sandboxing and quality of service.



# Cloud Computing Architecture:



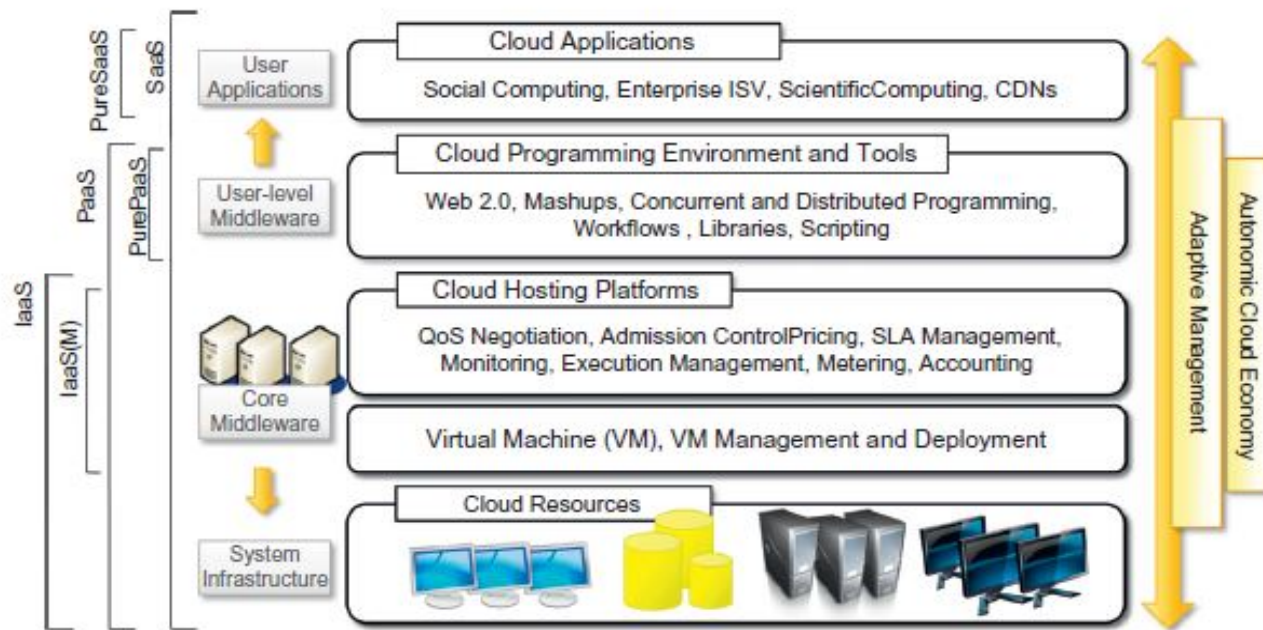
**Cloud Computing Architecture**

## Core Middleware Layer:

- Sandboxing - The practice of isolating a piece of software so that it can access only certain resources, programs, and files within a computer system, so as to reduce the risk of errors or malware affecting the rest of the system.
- Hardware virtualization is most commonly used at this level.
- Hypervisor (i.e. virtual machine monitor) which is a software that creates and runs virtual machines (VMs).



# Cloud Computing Architecture:

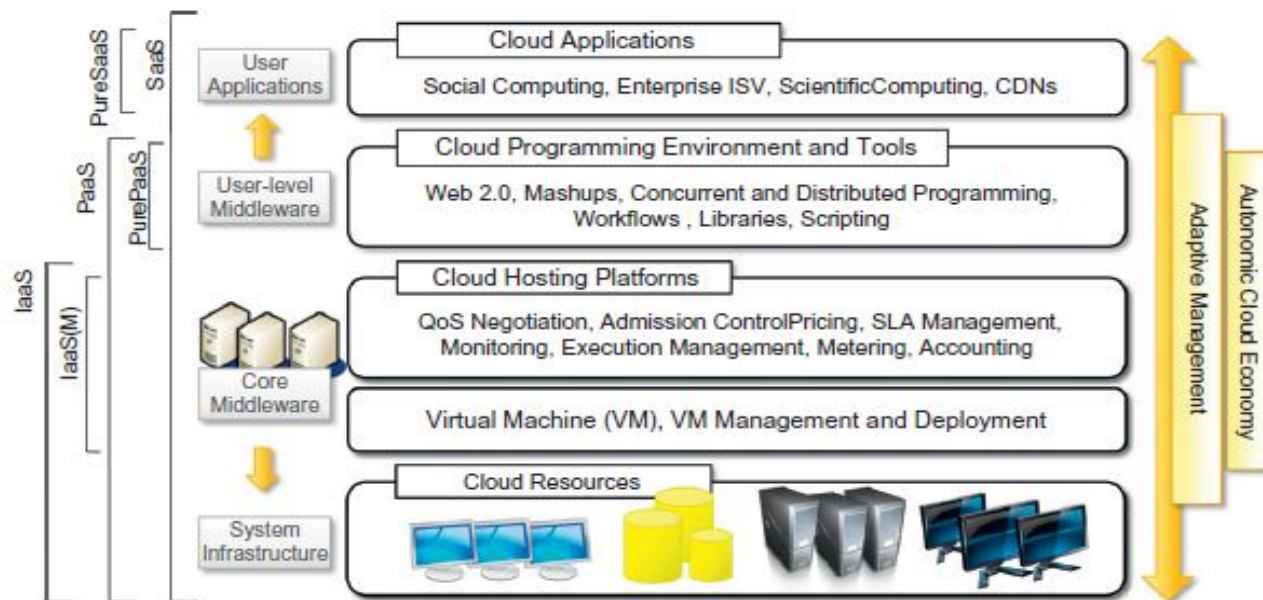


**Cloud Computing Architecture**

## Core Middleware Layer:

- Hypervisor is used to manage the pool of hardware resources and expose the distributed infrastructure as a collection of virtual machines.
- Using virtual machine technology it is possible to finely partition the hardware resources such as CPU, storage and memory and to virtualize specific devices, thus meeting the requirements of several users and applications.

# Cloud Computing Architecture:



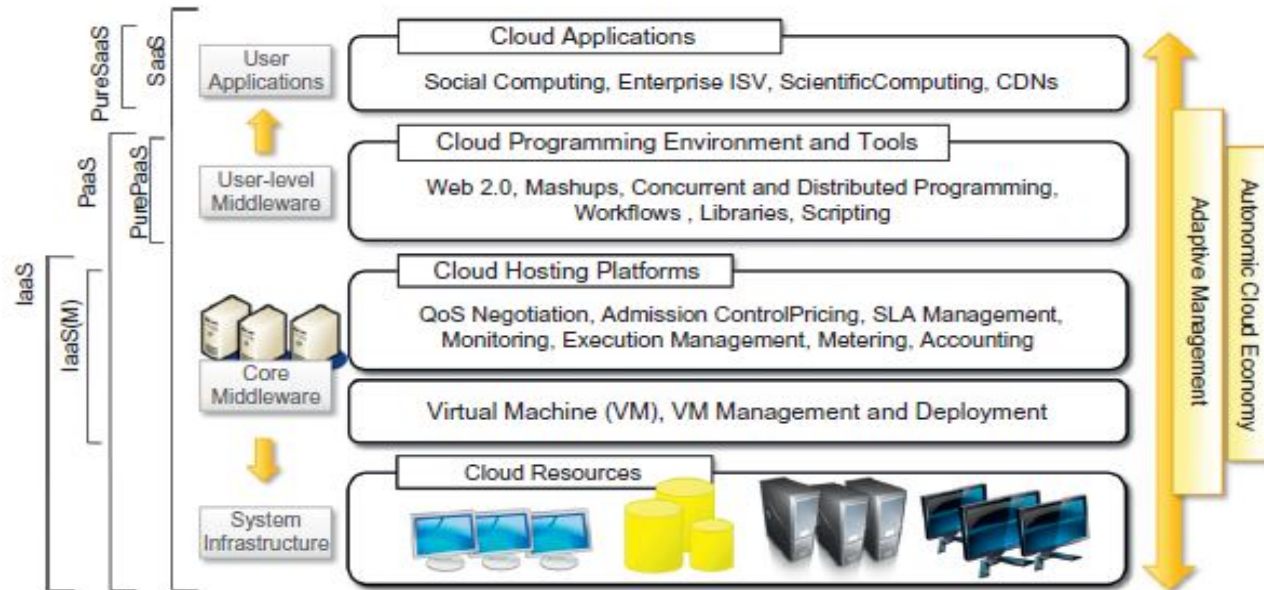
Cloud Computing Architecture

## Core Middleware Layer:

- Infrastructure management is the key function of core middleware, which supports capabilities such as negotiation of the quality of service, admission control, execution management and monitoring, accounting, and billing.
- The combination of **cloud hosting platforms** and **cloud resources** is generally classified as a Infrastructure-as-a-Service (IaaS) solution.



# Cloud Computing Architecture:

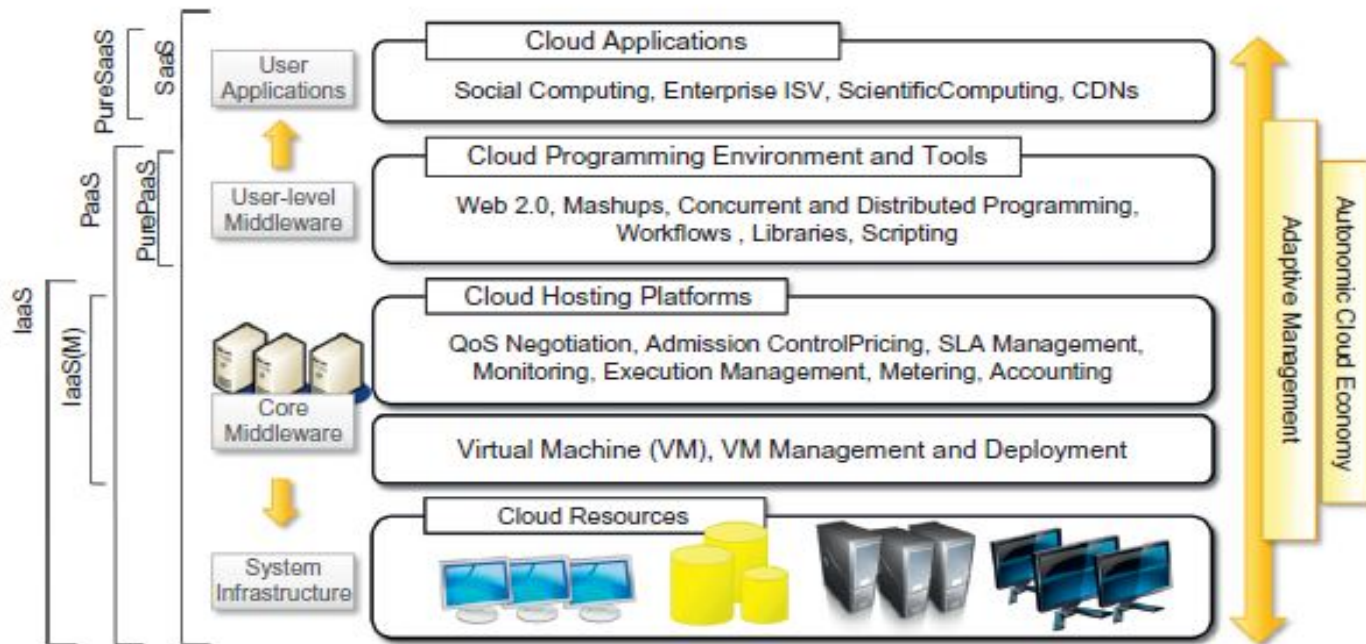


Cloud Computing Architecture

## User-level Middleware Layer:

- User-level middleware provides **Cloud Programming Environments and Tools** for offering users a development platform for building applications.
- The range of tools include Web-based interfaces, command-line tools, and frameworks for concurrent and distributed programming.
- User-level middleware contains APIs that are used by users to develop their applications specifically for the cloud.

# Cloud Computing Architecture:



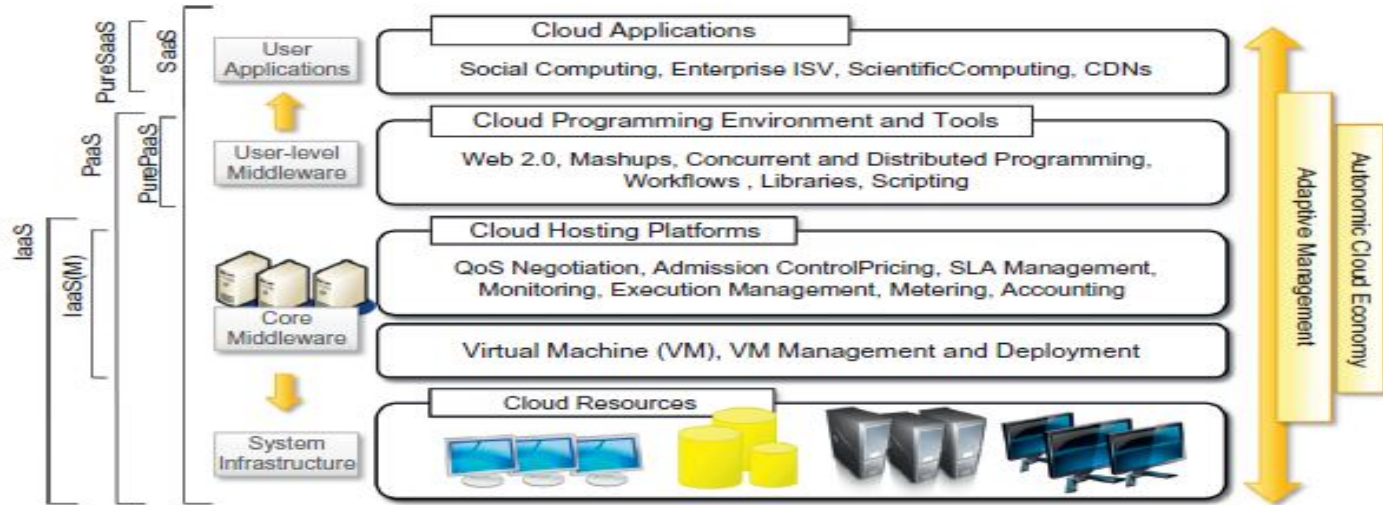
Cloud Computing Architecture

## User-level Middleware Layer:

- PaaS solutions generally include the infrastructure as well, which is bundled as part of the service provided to users.
- In the case of Pure PaaS, only the **User-level middleware** is offered, and it has to be complemented with a virtual or physical infrastructure.



# Cloud Computing Architecture:

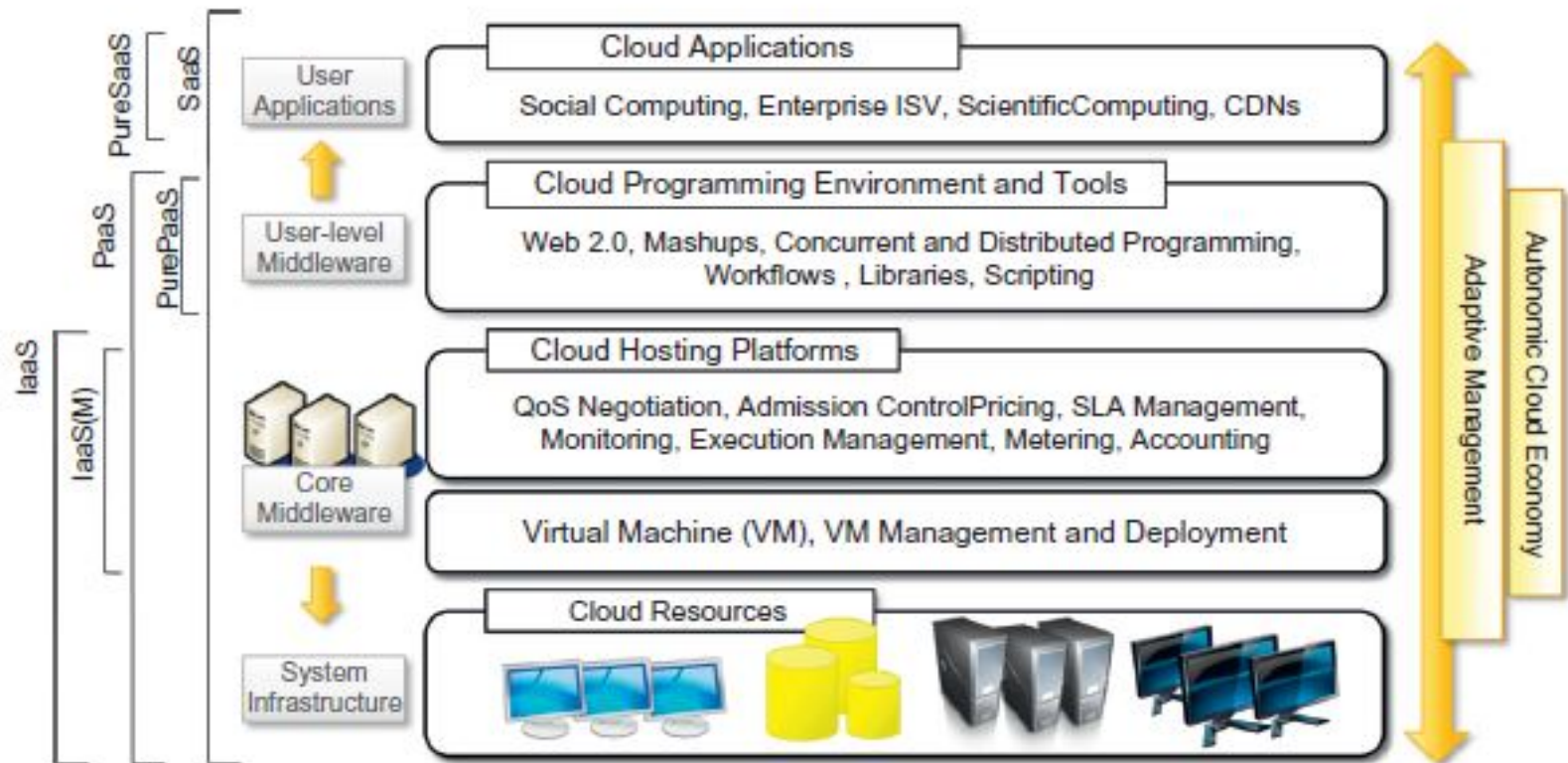


Cloud Computing Architecture

## User Applications Layer:

- User applications layer contains services delivered at the application level, these services are mostly referred to as Software-as-a-Service (SaaS).
- In most cases user applications layer consists of Web-based applications that rely on the cloud to provide service to end users.
- Other applications belonging to this layer are those that strongly leverage the Internet for their core functionalities that rely on the cloud to sustain a larger number of users; this is the case of gaming portals and, in general, social networking websites.

# Cloud Computing Architecture:

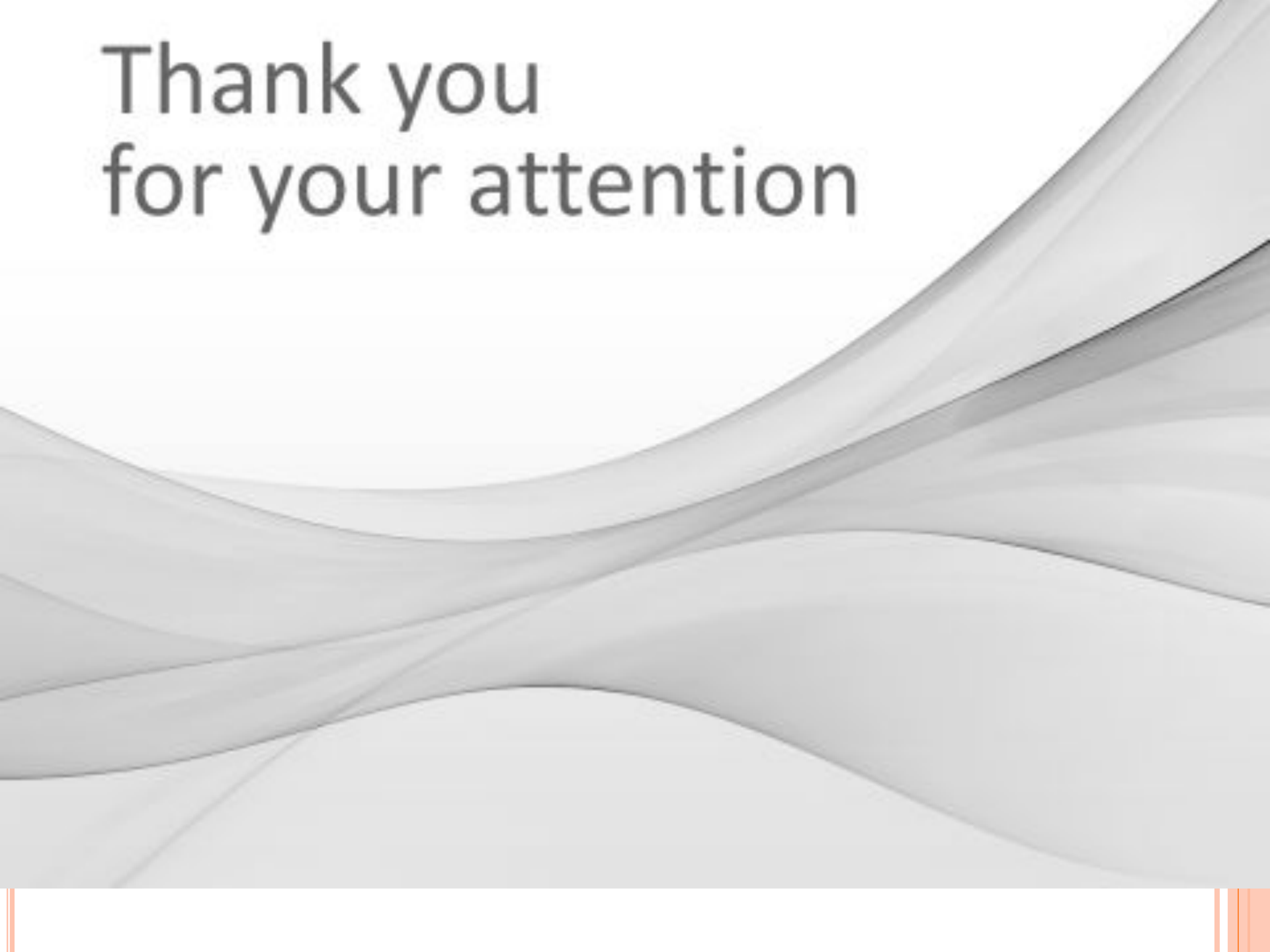


## Cloud Computing Architecture

- **Adaptive management** indicates that any service offered in the cloud computing environment should be able to adaptively change and expose an autonomic behavior, for its availability and performance.
- Adaptive management layer ensures elastically scaling on demand.



Thank you  
for your attention

The background of the slide features a series of overlapping, wavy, light gray shapes that create a sense of movement and depth. These shapes are set against a plain white background. At the very bottom of the slide, there is a thin, solid orange horizontal bar.