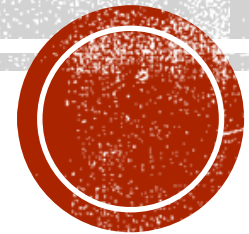


# CLOUD ARCHITECTURE

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# CLOUD COMPUTING - DEFINITION

**“A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.**

# WHY CLOUD?

- Convert expenses from Capital Expenditure to Operational
- Removes the need to maintain physical hardware / resources
- Allow flexibility in amount of service used without significant losses
- Customizable to meet the organizational needs
- 80+% of business are either evaluating, planning, implementing, or have already adopted some form of cloud strategy.

Distributed	Cloud
<ul style="list-style-type: none"><li>• Resources of many computers in a network are used at the same time, to solve a single problem.</li></ul>	<ul style="list-style-type: none"><li>• Usage of a 3rd party service (Web Services) to perform computing needs.</li></ul>
<ul style="list-style-type: none"><li>• Divides the job into small portions and executed on multiple machines</li></ul>	<ul style="list-style-type: none"><li>• <b>Availing various services without investing in the underlying architecture</b></li></ul>

# COMPUTATION COMPLICATIONS

- Infrastructure
- Platform
- Applications
  - Develop
  - Install
- Operators
  - H/w setup & maintenance
  - S/w development
  - S/w installation & maintenance
  - Troubleshoot

# FIVE KEY CLOUD ATTRIBUTES

- On-demand self-service
- Broad network access
- Shared / pooled resources
- Scalable and elastic
- Metered by use

## **On-Demand Self-Service:**

- Completely automated
- Real-time delivery
- Services accessed through a self-serve web interface

## **Broad Network Access:**

- Open standards and APIs
- Available from anywhere with an internet connection

## **Shared / Pooled Resources:**

- Resources are drawn from a common pool
- Location independence

## **Rapid elasticity:**

- Based on load requirements and on demand
- Any quantity ,any time

## **Metered by Use:**

- Services are metered, like a utility
- Users pay only for services used
- Services can be cancelled at any time

# CHARACTERISTICS OF CLOUD COMPUTING

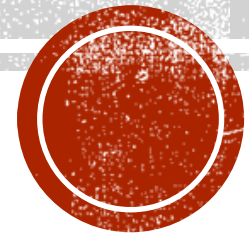
- Scalability
- Flexible / Measured Billing
- Virtualization
- Universal Access
- Simplified Management
- Affordable Resources
- Ease of Utilization
- Quality of Service
- Lower computation costs
- Instant software updates
- Latest version availability
- Improved document format compatibility
- Unlimited storage capacity
- Increased data reliability
- Easier group collaboration
- Device independence

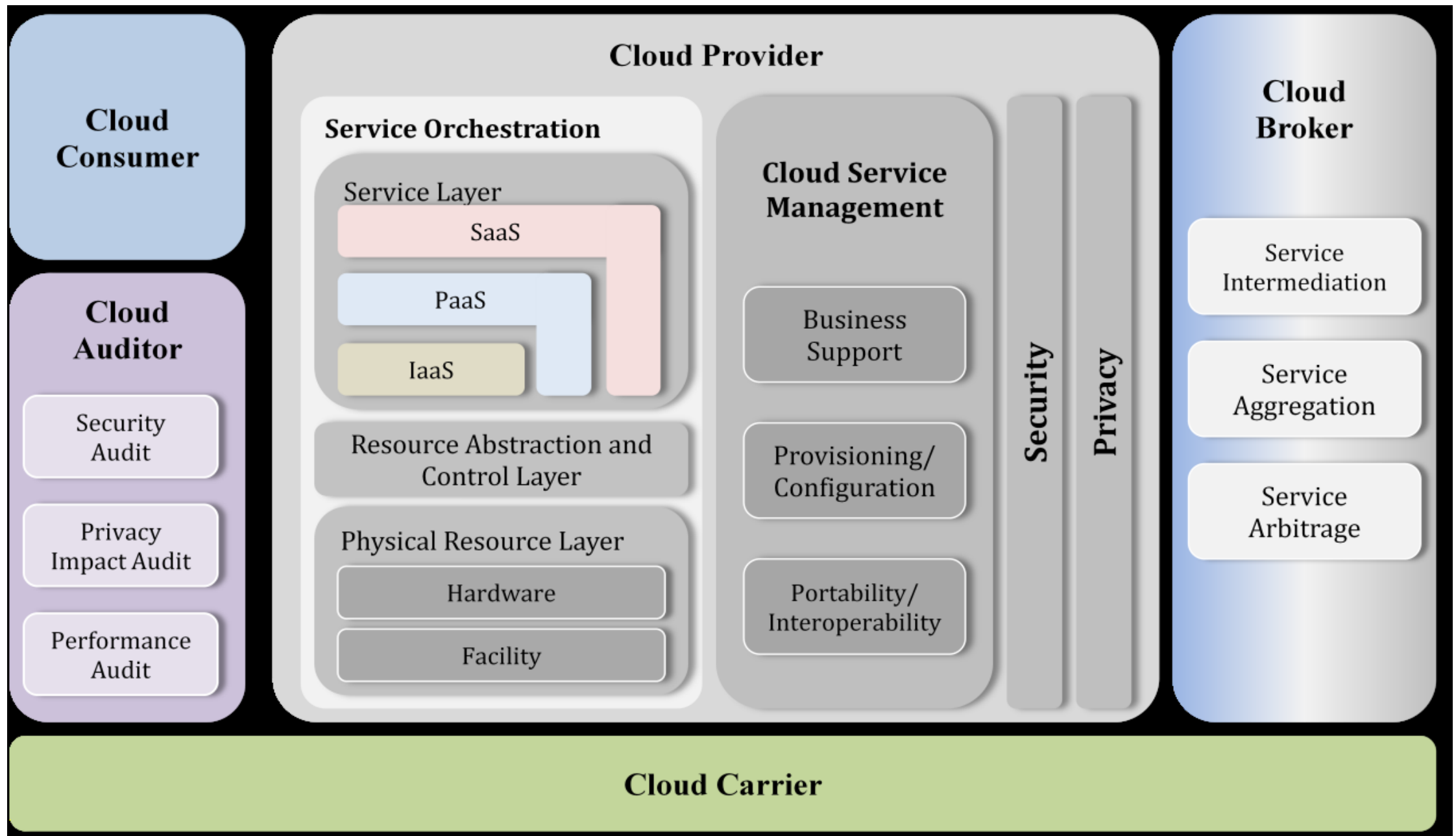


# CHALLENGES IN CLOUD COMPUTING

- Constant Internet connection
- Does not work well with low-speed connections
- Can be slow
- Features might be limited
- Integration & Transition
- Stored data might not be secure
- Stored data can be lost
- Transparency

# **NIST CLOUD COMPUTING REFERENCE ARCHITECTURE**



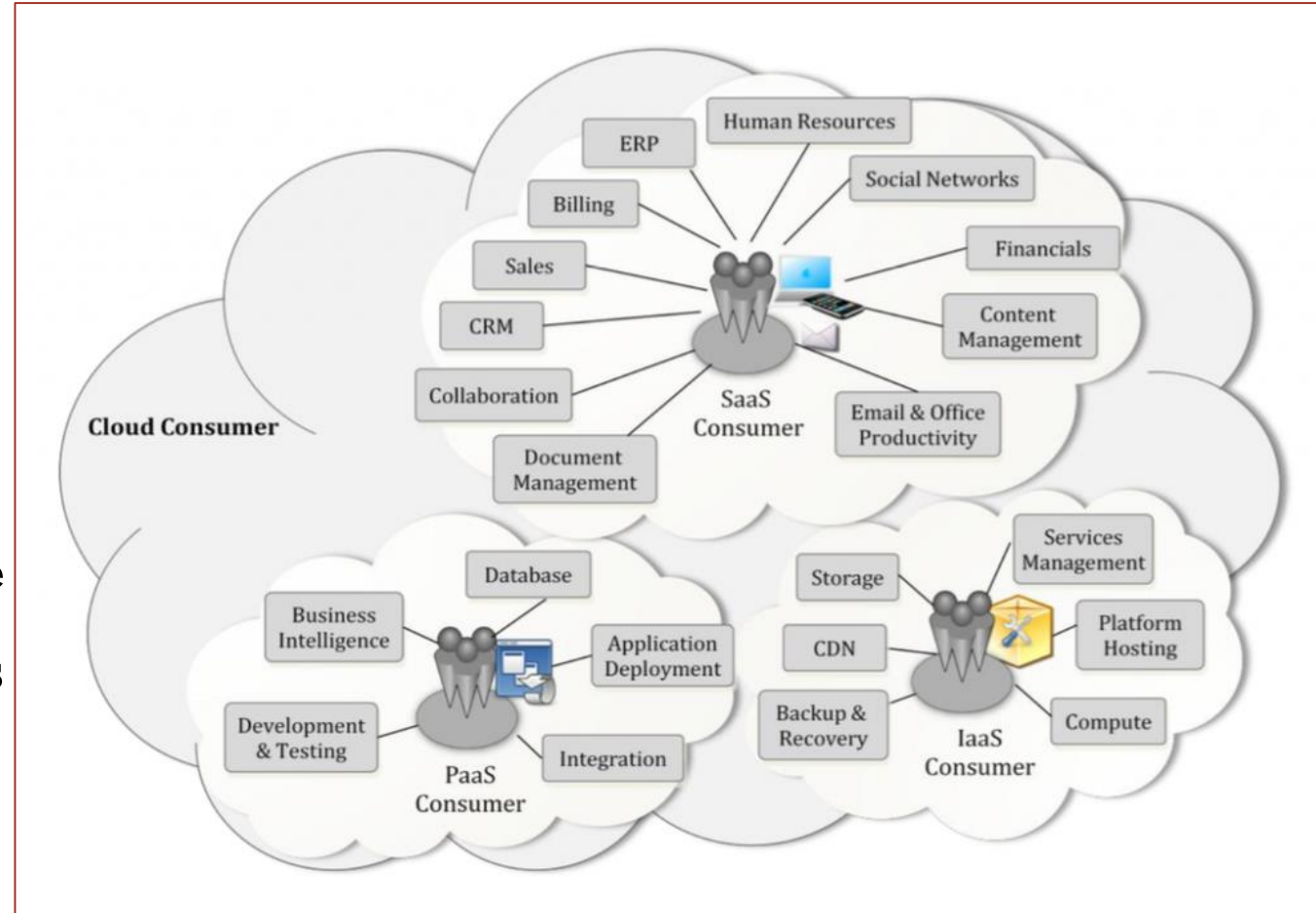


# ACTORS IN CLOUD COMPUTING

Cloud consumer	A person or organization that maintains a business relationship with, and uses service from, Cloud Providers.
Cloud provider	A person, organization, or entity responsible for making a service available to interested parties.
Cloud carrier	An intermediary that provides connectivity and transport of cloud services from Cloud Providers to Cloud Consumers.
Cloud auditor	A party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation.
Cloud broker	An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between Cloud Providers and Cloud Consumers.

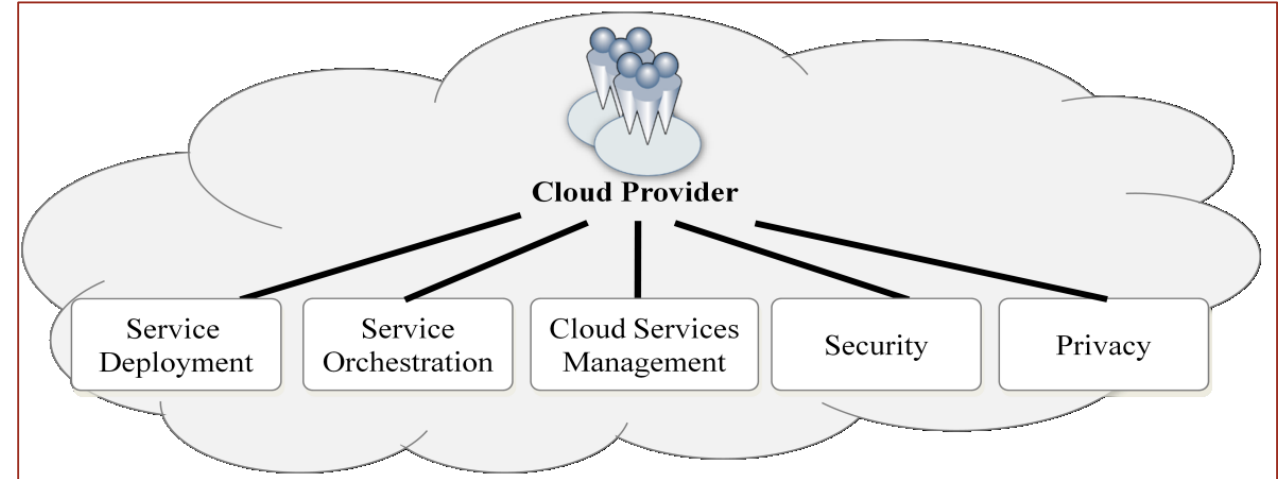
# CLOUD CONSUMER

- The cloud consumer is the principal stakeholder for the cloud computing service.
- A cloud consumer represents a person or organization that maintains a business relationship with, and uses the service from a cloud provider.
- A cloud consumer browses the service catalog from a cloud provider, requests the appropriate service, sets up service contracts with the cloud provider, and uses the service.
- The cloud consumer may be billed for the service provisioned, and needs to arrange payments accordingly.



# CLOUD PROVIDER

- A cloud provider is a person, an organization responsible for making a service available to interested parties.
- A Cloud Provider acquires and manages the computing infrastructure required for providing the services, runs the cloud software that provides the services, and makes arrangement to deliver the cloud services to the Cloud Consumers through network access.



# CLOUD AUDITOR

- A cloud auditor is a party that can perform an independent examination of cloud service controls with the intent to express an opinion thereon.
- Audits are performed to verify conformance to standards through review of objective evidence.
- A cloud auditor can evaluate the services provided by a cloud provider in terms of security controls, privacy impact, performance, etc.

# CLOUD CARRIER

- A cloud carrier acts as an intermediary that provides connectivity and transport of cloud services between cloud consumers and cloud providers.
- Cloud carriers provide access to consumers through network, telecommunication and other access devices.
- For example, cloud consumers can obtain cloud services through network access devices, such as computers, laptops, mobile phones, mobile Internet devices (MIDs), etc

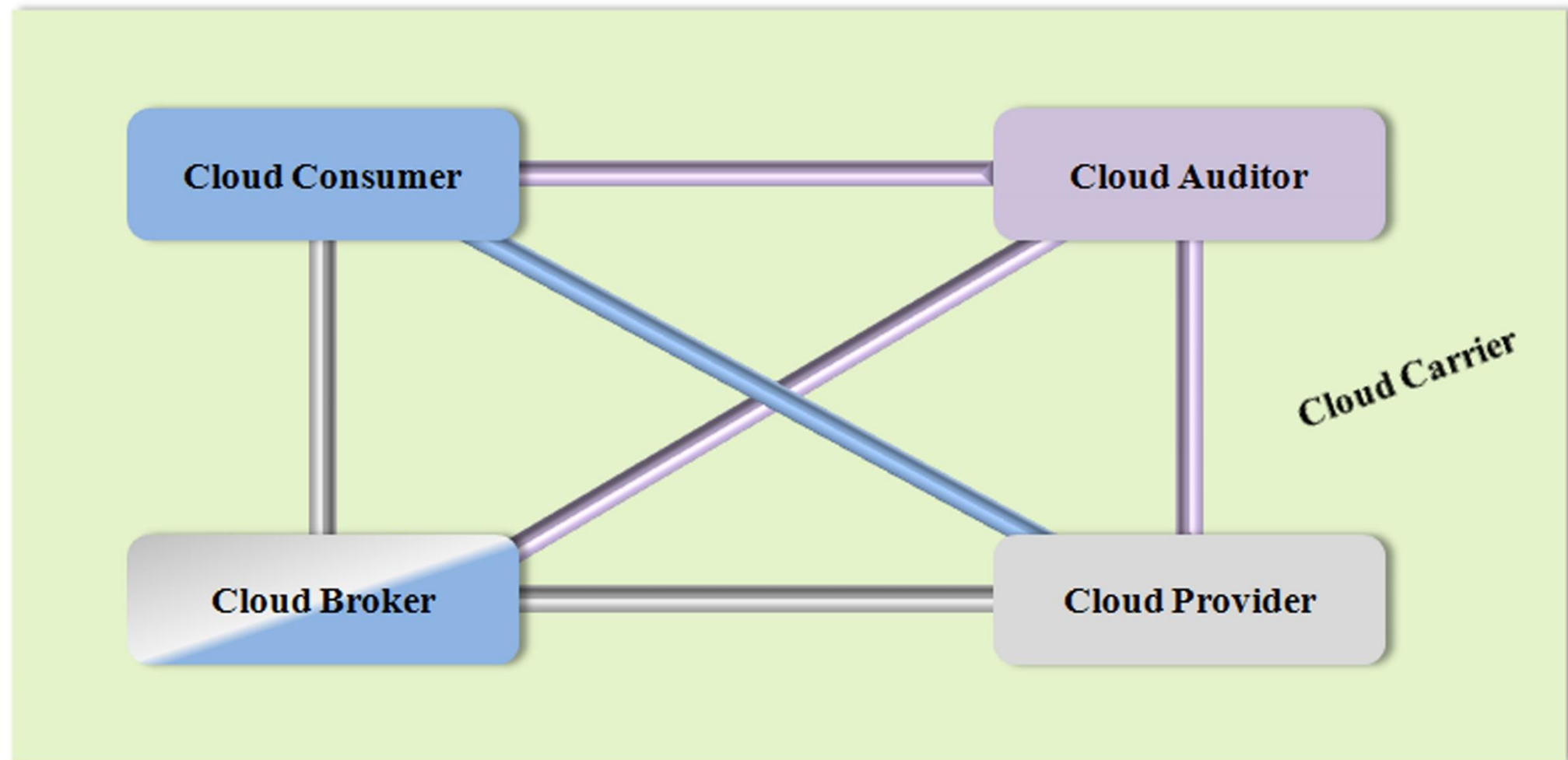





# CLOUD BROKER

- As cloud computing evolves, the integration of cloud services can be too complex for cloud consumers to manage.
- A cloud consumer may request cloud services from a cloud broker, instead of contacting a cloud provider directly.
- A cloud broker is an entity that manages the use, performance and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers.

# CLOUD BROKER DIFFERENT SERVICES

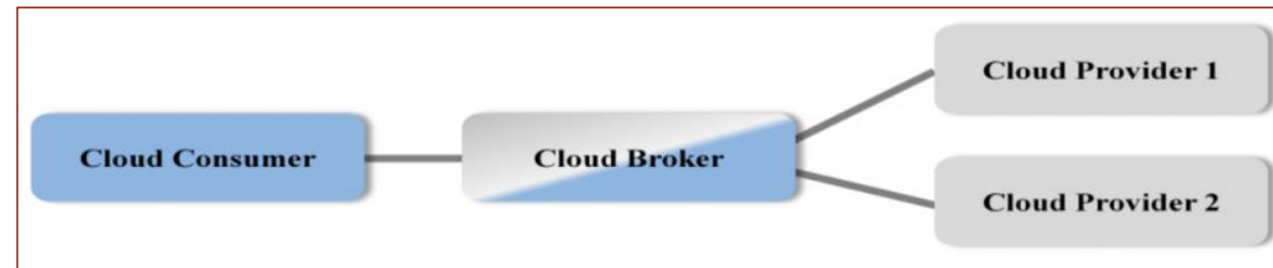
- Cloud broker provide services in three categories:
- *Service Intermediation*: A cloud broker enhances a given service by improving some specific capability and providing value-added services to cloud consumers. The improvement can be managing access to cloud services, identity management, performance reporting, enhanced security, etc.
- *Service Aggregation*: A cloud broker combines and integrates multiple services into one or more new services. The broker provides data integration and ensures the secure data movement between the cloud consumer and multiple cloud providers.
- *Service Arbitrage*: Service arbitrage is similar to service aggregation except that the services being aggregated are not fixed. Service arbitrage means a broker has the flexibility to choose services from multiple agencies.



-  The communication path between a cloud provider and a cloud consumer
-  The communication paths for a cloud auditor to collect auditing information
-  The communication paths for a cloud broker to provide service to a cloud consumer

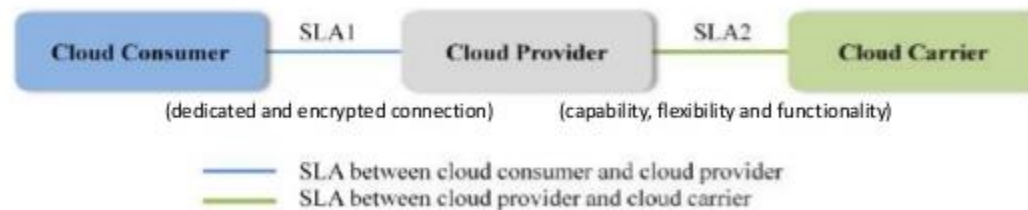
# EXAMPLE USAGE SCENARIO 1

- A cloud consumer may request service from a cloud broker instead of contacting a cloud provider directly.
- The cloud broker may create a new service by combining multiple services or by enhancing an existing service.
- In this example, the actual cloud providers are invisible to the cloud consumer and the cloud consumer interacts directly with the cloud broker.



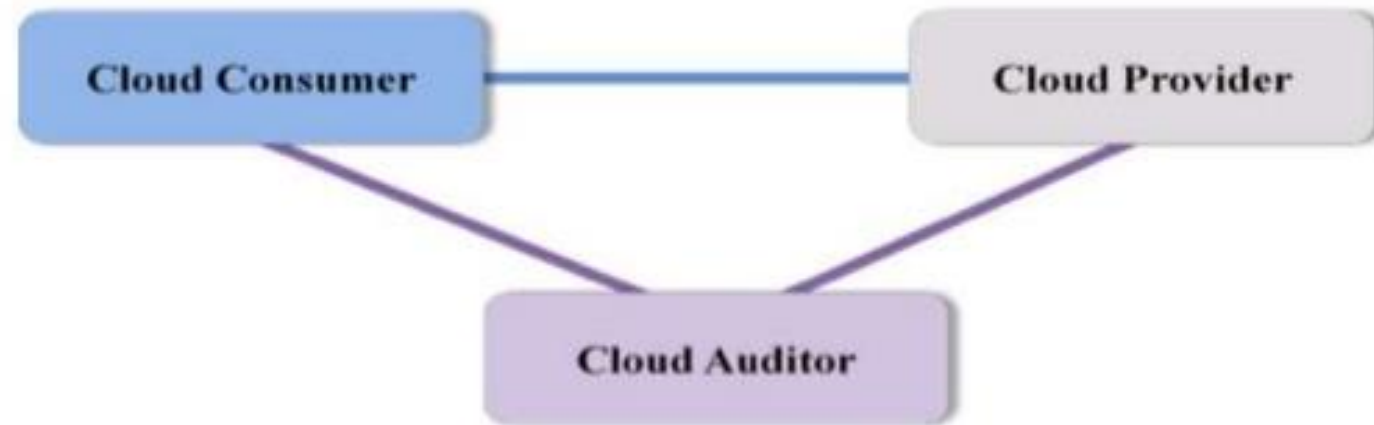
# EXAMPLE USAGE SCENARIO 2

- Cloud carriers provide the connectivity and transport of cloud services from cloud providers to cloud consumers.
- A cloud provider participates in and arranges for two unique service level agreements (SLAs), one with a cloud carrier (e.g. SLA2) and one with a cloud consumer (e.g. SLA1).
- A cloud provider arranges SLAs with a cloud carrier and may request dedicated and encrypted connections to ensure the cloud services are consumed at a consistent level according to the contractual obligations with the cloud consumers.
- In this case, the provider may specify its requirements on capability, flexibility and functionality in SLA2 in order to provide essential requirements in SLA1.



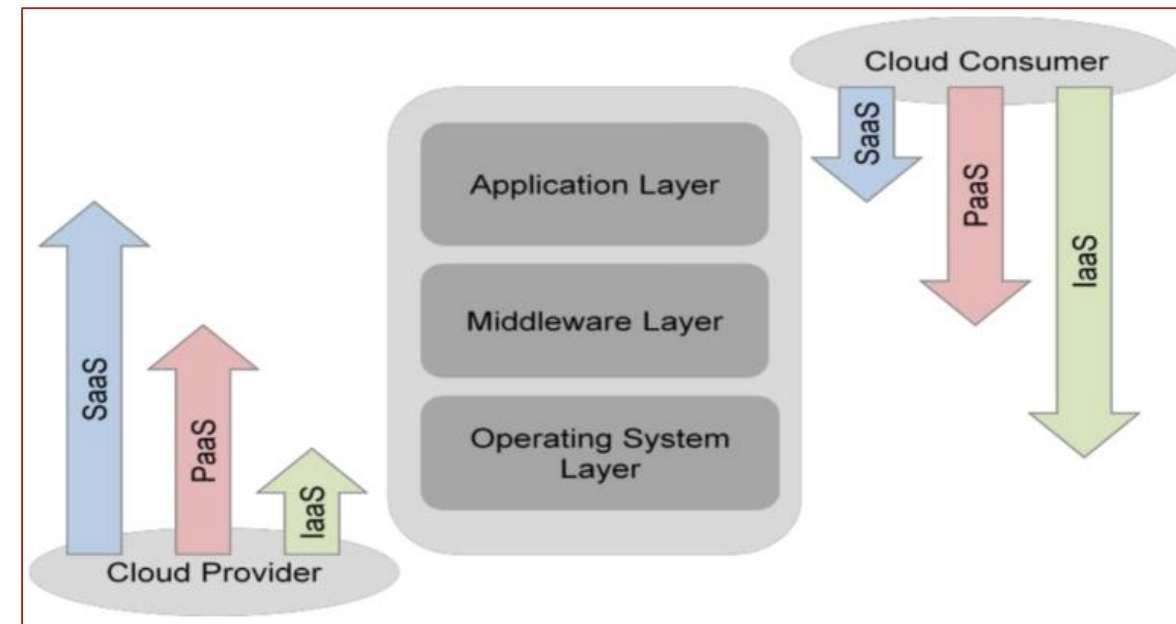
# EXAMPLE USAGE SCENARIO 3

- For a cloud service, a cloud auditor conducts independent assessments of the operation and security of the cloud service implementation.
- The audit may involve interactions with both the Cloud Consumer and the Cloud Provider.



# SCOPE OF CONTROL BETWEEN PROVIDER AND CONSUMER

- The Cloud Provider and Cloud Consumer share the control of resources in a cloud system.
- Different service models affect an organizations control over the computational resources and thus what can be done in a cloud system.
- The figure shows these differences using a classic software stack notation comprised of the application, middleware, and OS layers.

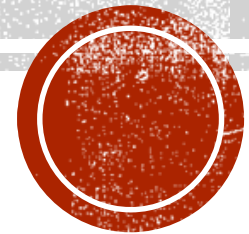


# CONT..

- The application layer includes software applications targeted at end users or programs. The applications are used by SaaS consumers, or installed/managed/maintained by PaaS consumers, IaaS consumers, and SaaS providers.
- The middleware layer provides software building blocks (e.g., libraries, database, and Java virtual machine) for developing application software in the cloud. The middleware is used by PaaS consumers, installed/managed/maintained by IaaS consumers or PaaS providers, and hidden from SaaS consumers.
- The OS layer includes operating system and drivers, and is hidden from SaaS consumers and PaaS consumers. An IaaS cloud allows one or multiple guest OS's to run virtualized on a single physical host. Generally, consumers have broad freedom to choose which OS to be hosted among all the OS's that could be supported by the cloud provider. The IaaS consumers should assume full responsibility for the guest OS's, while the IaaS provider controls the host OS.



# CLOUD MODELS



# CLOUD MODELS

- Service Models
  - SaaS
  - PaaS
  - IaaS
- Deployment Models
  - Public
  - Private
  - Community
  - Hybrid

# SERVICE MODELS

- Cloud Service models mainly come in three types:
- Software as a Service (SaaS),
- Infrastructure as a Service (IaaS)
- Platform as a Service (PaaS)
- Each of the cloud models has their own set of benefits that could serve the needs of various businesses.

# SAAS

- Software as a Service is a model that gives quick access to cloud-based applications.
- The vendor controls the entire computing stack, which you can access using a web browser.
- These applications run on the cloud and you can use them by a paid licensed subscription or for free with limited access.
- SaaS does not require any installations or downloads in your existing computing infrastructure.
- This eliminates the need for installing applications on each of your computers with the maintenance and support taken over by the vendor.
- Examples: Google G Suite, Microsoft Office 365 etc.

# CONT..

- SaaS has its own disadvantages since it leaves you no control over the hardware allotted to you as only the vendor can manage the software.
- With SaaS, communication, transferring of content and scheduling meetings are made easy.
- SaaS is the ideal choice for small-scale businesses who do not have the necessary budget and resources to deploy on-premise hardware.
- Besides, companies that require frequent collaboration on their projects will find SaaS platforms useful.

# BENEFITS

- **Affordable:** SaaS is affordable as it eliminates the costs involved in the purchase, installation, maintenance and upgrades of computing hardware.
- **Accessibility:** With SaaS, you can access the services from anywhere using any device such as smartphones, which eliminates the constraints set by on-premise software.
- **Ready to Use:** You can quickly set up SaaS services so that they become functional in no time. All it takes is that you sign up for the service to get access to fast and powerful computing resources.

# IAAS

- Infrastructure as a Service is basically a virtual provision of computing resources over the cloud.
- An IaaS cloud provider can give you the entire range of computing infrastructures such as storage, servers, networking hardware alongside maintenance and support.
- Businesses can opt for computing resources of their requirement without the need to install hardware on their premises.
- Amazon Web Services, Microsoft Azure, and Google Compute Engine are some of the leading IaaS cloud service providers.

# CONT..

- IaaS being the most flexible of cloud models gives the best option when it comes to IT hardware infrastructure.
- IaaS is the right option if you need control over the hardware infrastructure such as in managing and customizing according to your requirements.
- Whether you are running a startup or a large enterprise, IaaS gives access to computing resources without the need to invest in them separately.
- Downside with IaaS is that it is much costlier than SaaS or PaaS cloud models.



# BENEFITS

- **Minimize Costs:** Deploying an IaaS cloud model eliminates the need to deploy on-premise hardware that reduces the costs.
- **Enhanced Scalability:** As the most flexible cloud computing model, IaaS allows you to scale the computing resources up or down based on demand.
- **Simple Deployment:** IaaS lets you easily deploy the servers, processing, storage, and networking to make it up and running in no time.

# PAAS

- Platform as a Service is essentially a cloud base where you can develop, test and organize the different applications for your business.
- Implementing PaaS simplifies the process of enterprise software development.
- The virtual runtime environment provided by PaaS gives a favorable space for developing and testing applications.
- The entire resources offered in the form of servers, storage and networking are manageable either by the company or a platform provider.
- Google App Engine and AWS Elastic Beanstalk are two typical examples of PaaS.
- PaaS is also subscription based that gives you flexible pricing options depending on your business requirements.

# CONT..

- PaaS is the preferred option if your project involves multiple developers and vendors.
- With PaaS, it is easy to create customized applications as it leases all the essential computing and networking resources.
- Being a different model, PaaS simplifies the app development process that minimizes your organizational costs.
- It is flexible and delivers the necessary speed in the process, which will rapidly improve your development times.
- Disadvantage with PaaS is that since it is built on virtualized technology, you will have less control over the data processing.
- In addition, it is also less flexible compared to the IaaS cloud model.

# BENEFITS

- **Minimal Development Time:** PaaS reduces the development time since the vendor provides all computing resources like server-side components, which simplifies the process and improve the focus of the development team.
- **Multiple Programming Language Support:** PaaS offers support for multiple programming languages, which a software development company can utilize to build applications for different projects.
- **Enhanced Collaboration:** With PaaS, your business can benefit from having enhanced collaboration, which will help integrate your team dispersed across various locations.

# OTHER SERVICE MODELS

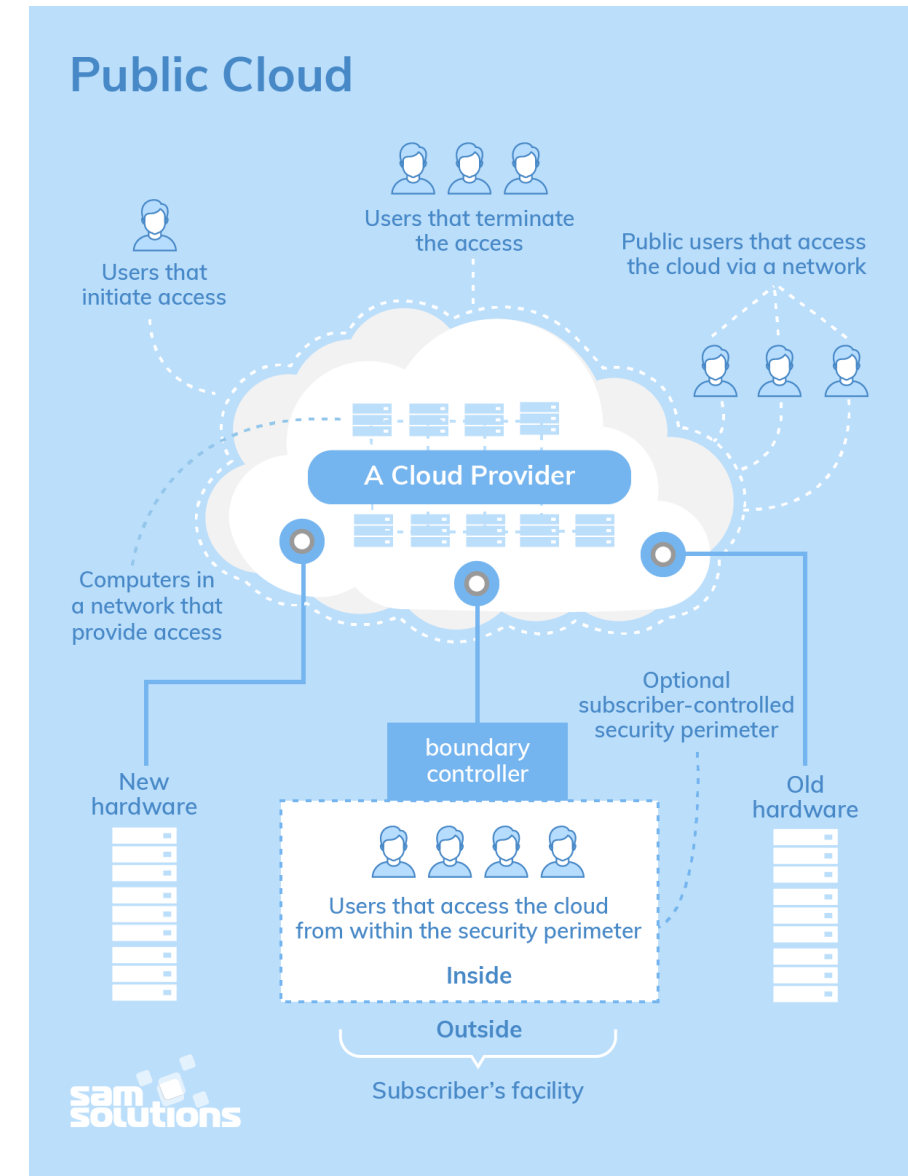
- **Security as a Service (SECaaS):** Security as a service is a cloud computing model that delivers managed security services over the internet. It is basically software as a service (SaaS) model but limited to specialized information security services.
- **Hardware as a service (HaaS)** in Cloud computing is a computer hardware solution in which a business assigns the responsibility of replacing, updating and maintaining their computer equipment to a third party.
- **Anything as a Service (XaaS):** XaaS is a general, collective term that refers to the delivery of anything as a service. It recognizes the vast number of products, tools and technologies that vendors now deliver to users as a service over a network.

# CLOUD DEPLOYMENT MODELS

- A Cloud Deployment model is a specific configuration of environment parameters such as the accessibility and proprietorship of the deployment infrastructure and storage size.
- It means that deployment types vary depending on who controls the infrastructure and where it resides.
- Most popular cloud deployment models:
  - Public Cloud
  - Private Cloud
  - Hybrid Cloud
  - Community Cloud.
- Additional models
  - Distributed clouds,
  - multiclouds,
  - Poly clouds etc.

# PUBLIC CLOUD

- This deployment model of cloud renders all its applications and services available and open to public use, over a network.
- These services may be free most of the times. The user can meet his needs for little or no cost sometimes.
- These clouds can be used by anyone, a single user or an organization.
- Some of the known public clouds are Amazon Web Services, Google AppEngine, Windows Azure, IBM Blue Cloud, etc.



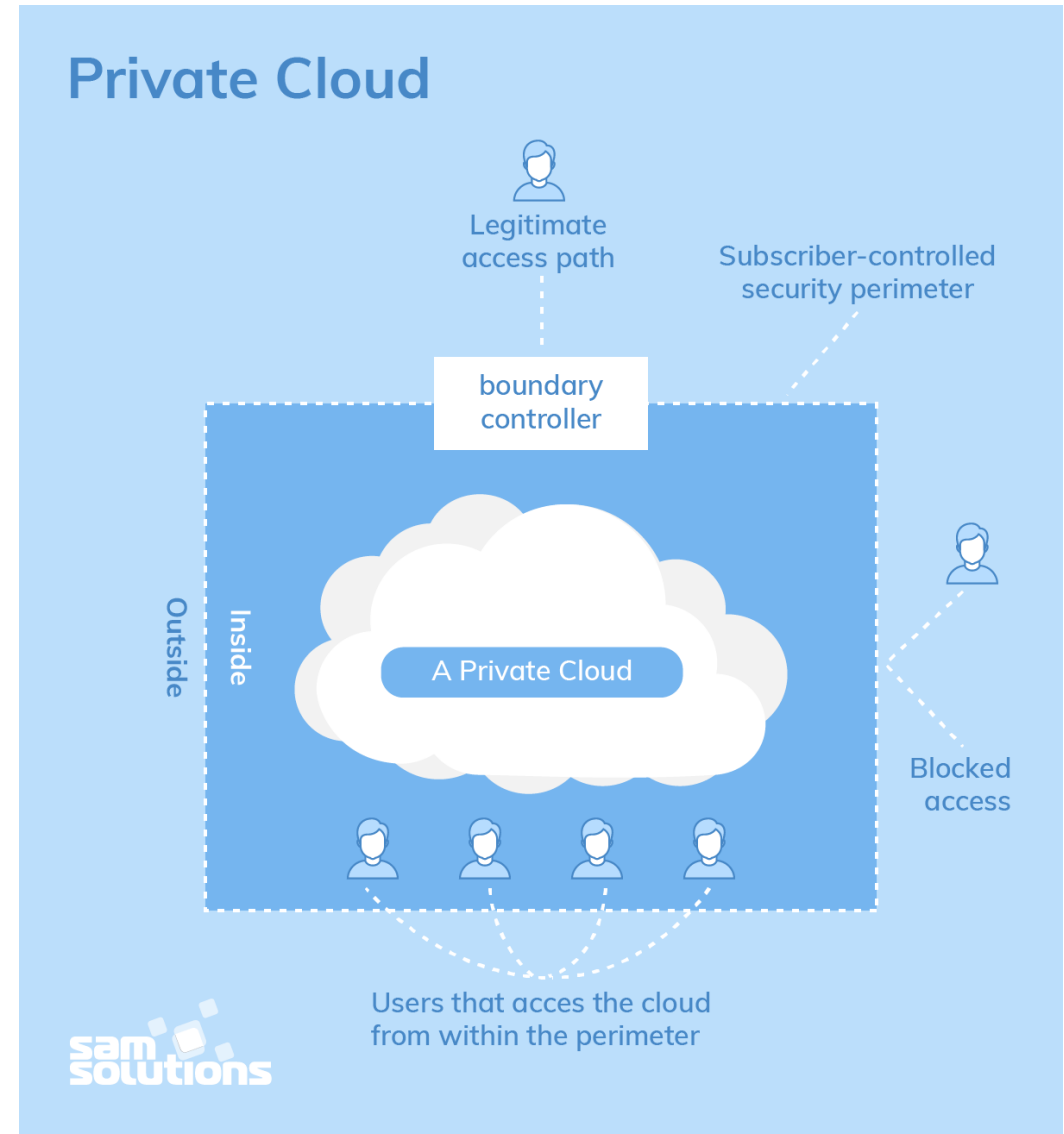
# ADVANTAGES OF PUBLIC CLOUD

- Hassle-free infrastructure management. you do not need to develop and maintain your software as the service provider does it for you.
- High scalability. You can easily extend the available capacity as your company requirements increase.
- Reduced costs. You pay only for the service you use, no hardware or software investment.
- Available 24X7.



# PRIVATE CLOUD

- Private Cloud is limited to a particular organization.
- This deployment model run organization workloads, and the server can be hosted externally or on the premises of the user company.
- Regardless of their physical location, these infrastructures are maintained on a designated private network and use software and hardware that are intended for a specific company.

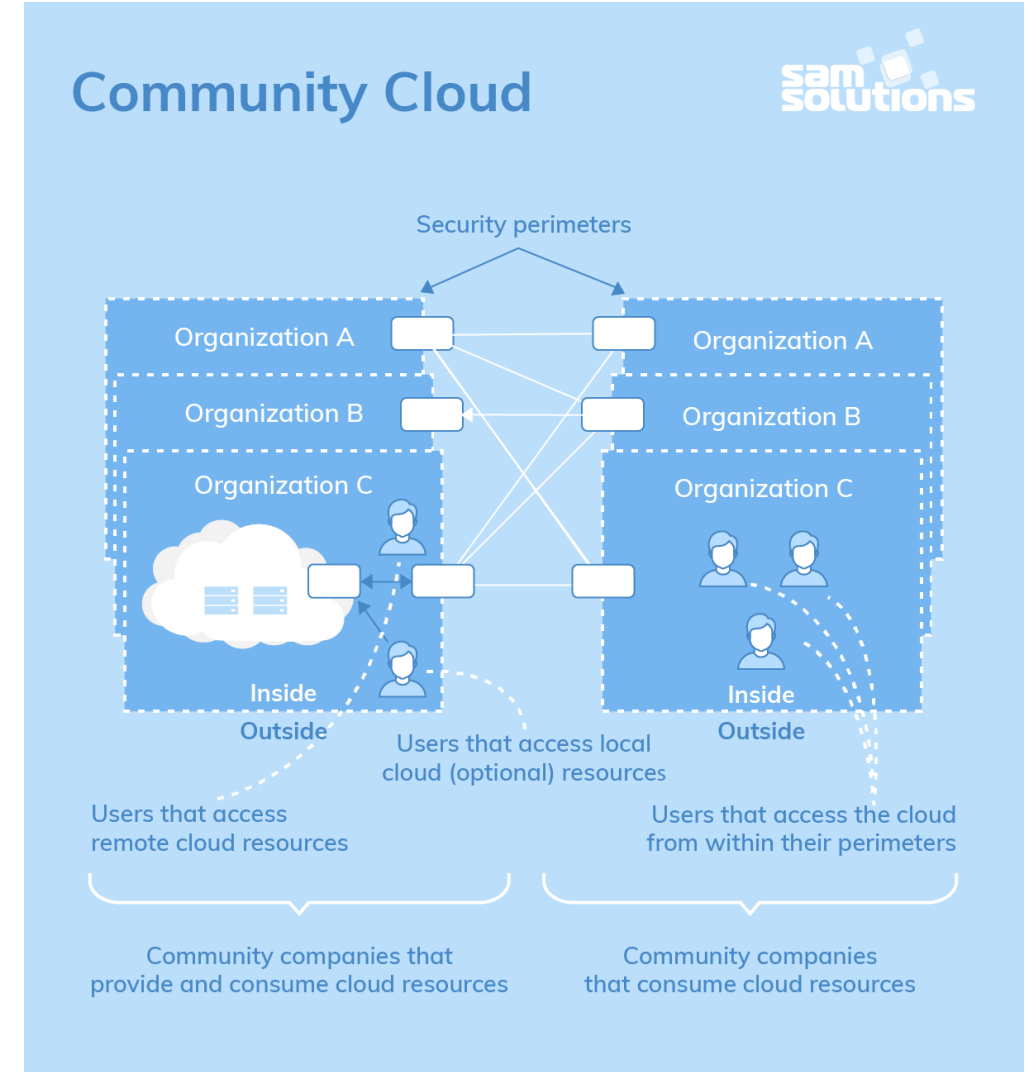


# BENEFITS AND DRAWBACKS OF PRIVATE CLOUD

- All the benefits of this deployment model result from its autonomy.
- Bespoke and flexible development and high scalability, which allows companies to customize their infrastructures in accordance with their requirements
- High security, privacy and reliability as only authorized persons can access resources
- The major disadvantage of the private cloud deployment model is its cost, as it requires considerable expenses on hardware, software and staff training.
- Not a suitable for small companies.

# COMMUNITY CLOUD

- A community deployment model largely resembles a private one; the only difference is the set of users.
- While a private type implies that only one company owns the server, in the case of a community one, several organizations with similar backgrounds share the infrastructure and related resources.
- If the organizations have uniform security, privacy and performance requirements, this multi-tenant data center architecture helps companies achieve their business-specific objectives.
- That is why a community model is particularly suited for organizations that work on joint projects.



# STRENGTHS & SHORTCOMINGS

## **The Strengths**

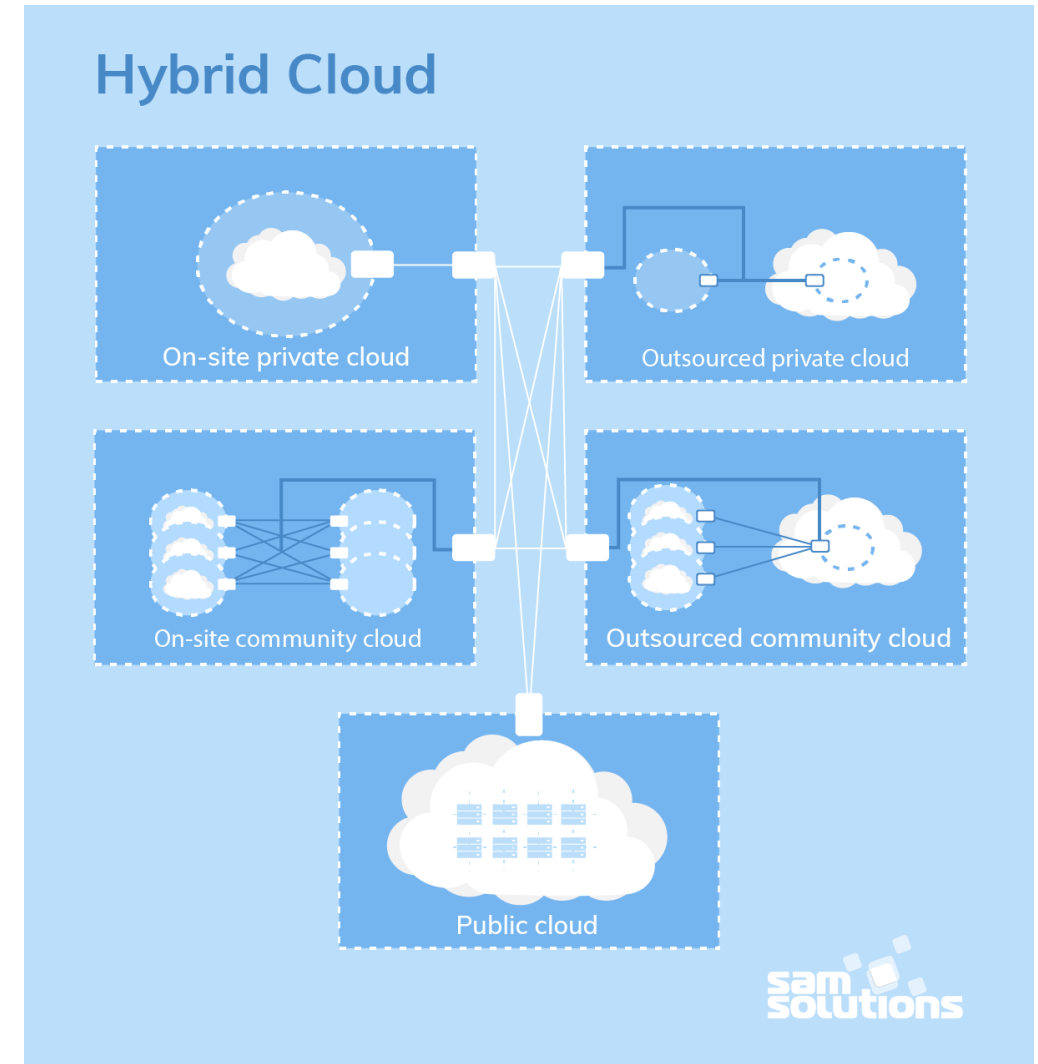
- Cost reduction
- Improved security, privacy and reliability
- Ease of data sharing and collaboration

## **The Shortcomings**

- High cost if compared to a public deployment model
- Sharing of fixed storage and bandwidth capacity
- It is not widespread so far

# HYBRID CLOUD

- Hybrid Cloud allows companies to mix and match the face of all three types that best suit their requirements.
- Usually hybrid cloud encompasses the best features of the public, private and community deployment models.
- For Example a company can balance its load by locating critical workloads on a secure private cloud and deploying less sensitive ones to a public one.



PC: <https://www.sam-solutions.com/blog/wp-content/uploads/2017/08/hybrid-cloud@2x.png>

# BENEFITS OF HYBRID CLOUD

- Improved security and privacy
- Enhanced scalability and flexibility
- Reasonable price
- The hybrid deployment model only makes sense if companies can split their data into mission-critical and non-sensitive.

# COMPARISON OF CLOUD DEPLOYMENT MODELS

	Public	Private	Community	Hybrid
Ease of setup and use	Easy	Requires IT proficiency	Requires IT proficiency	Requires IT proficiency
Data security and privacy	Low	High	Comparatively high	High
Data control	Little to none	High	Comparatively high	Comparatively high
Reliability	Vulnerable	High	Comparatively high	High
Scalability and flexibility	High	High	Fixed capacity	High
Cost-effectiveness	The cheapest one	Cost-intensive & expensive one	Cost is shared among community members	Cheaper than a private & costly than a public model
Demand for in-house hardware	No	Depends	Depends	Depends

# CASE STUDY

## Background

Candor Business Solutions (CBS) is a company established around 5 years ago in Bangalore. It has 8 companies partnered as a client all over the world. The company values its clients and the relationship with them. To achieve that CBS manages and analyzes its own interactions with its past, current and potential customers.

## Situation

Many Client Companies of CBS are established all over the world. It is becoming difficult for Customer Relationship Management in this competitive world. The firm prides itself on its early and innovative adoption of leading technology. CBS wants to adopt a Customer Relationship Management (CRM) cloud application.

Suggest the Cloud deployment and service model to implement the CRM



# ON-DEMAND COMPUTING

- On-demand computing is a delivery model in which computing resources are made available to the user as needed.
- A cloud consists of an integrated arrangement of hardware, networking infrastructure, storage devices, interfaces, and services.
- On-demand functionality of cloud computing is ensured via internet and by delivering configurable computing resources from a shared pool of servers, storage devices, networks, and software applications.
- This utility based provisioning of computing resources is highly useful for special temporary projects, sudden burst of resource needs or workloads, routine tasks, or long term requirements of technological and computing resources.

# CONT..

- On Demand Computing (ODC) is also referred as web based services that are procured on pay and use basis.
- Computing resources that are provided to users can be made available at user's premises or can be provided as a service by third party vendors.
- On demand functionality of cloud computing was developed to cater to varying demands of computing resources by users.
- It is not feasible to maintain optimum resources because there can be huge fluctuations in demands.

# CONT..

- Due to on demand computing functionality, businesses and individuals need not worry about availability of resources at any given time.
- On demand functionality of cloud computing is the foundation of utility based services provided to cloud computing users.
- In the absence of on demand functionality, organizations will find it difficult to maintain huge computing resources to cater to large number of computer systems.
- It has helped small as well as large organizations reap the benefits of cloud computing.