

Cloud Computing

UNIT-4

Topics

- ① NIST Definition of IaaS, PaaS, SaaS
- ② Infrastructure as a Service (IaaS)
- ③ characteristics, Suitability, pros and cons of IaaS
- ④ Summary of IaaS providers
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NIST Definition of IaaS, PaaS, SaaS

⇒ The National Institute of Standards and Technology (NIST) describes three main types of cloud services:

① IaaS (Infrastructure as a Service) :-

This is for IT professionals who need to manage and run software. The provider takes care of the hardware like servers, storage, network. Users handle the applications they run on the cloud.

Example: AWS and Google Cloud

② PaaS (Platform as a Service) :-

This is for developers who want to build and deploy applications without worrying about the underlying infrastructure. The provider manages the platform, and the developers focus on their applications.

Example: AWS Elastic Beanstalk, when you develop code and upload it to AWS Elastic Beanstalk. Elastic Beanstalk automatically deploys our code and manages the servers and monitor our application.

③ SaaS (Software as a Service) :-

This is for regular users who want to use applications over the internet. The provider manages everything, and users simply use the software.

Examples include Google Apps and Microsoft Office 365.

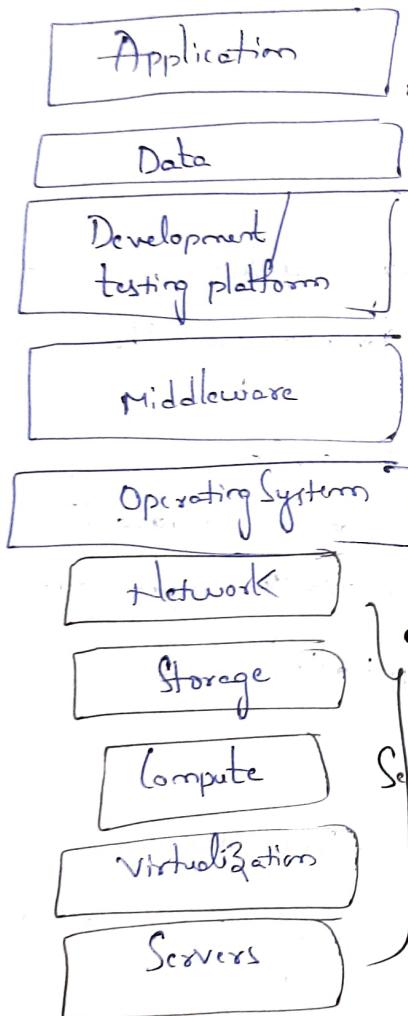
Cloud Deployment Models: Cloud services can be deployed in different ways.

public cloud: Services are available to anyone over the internet.

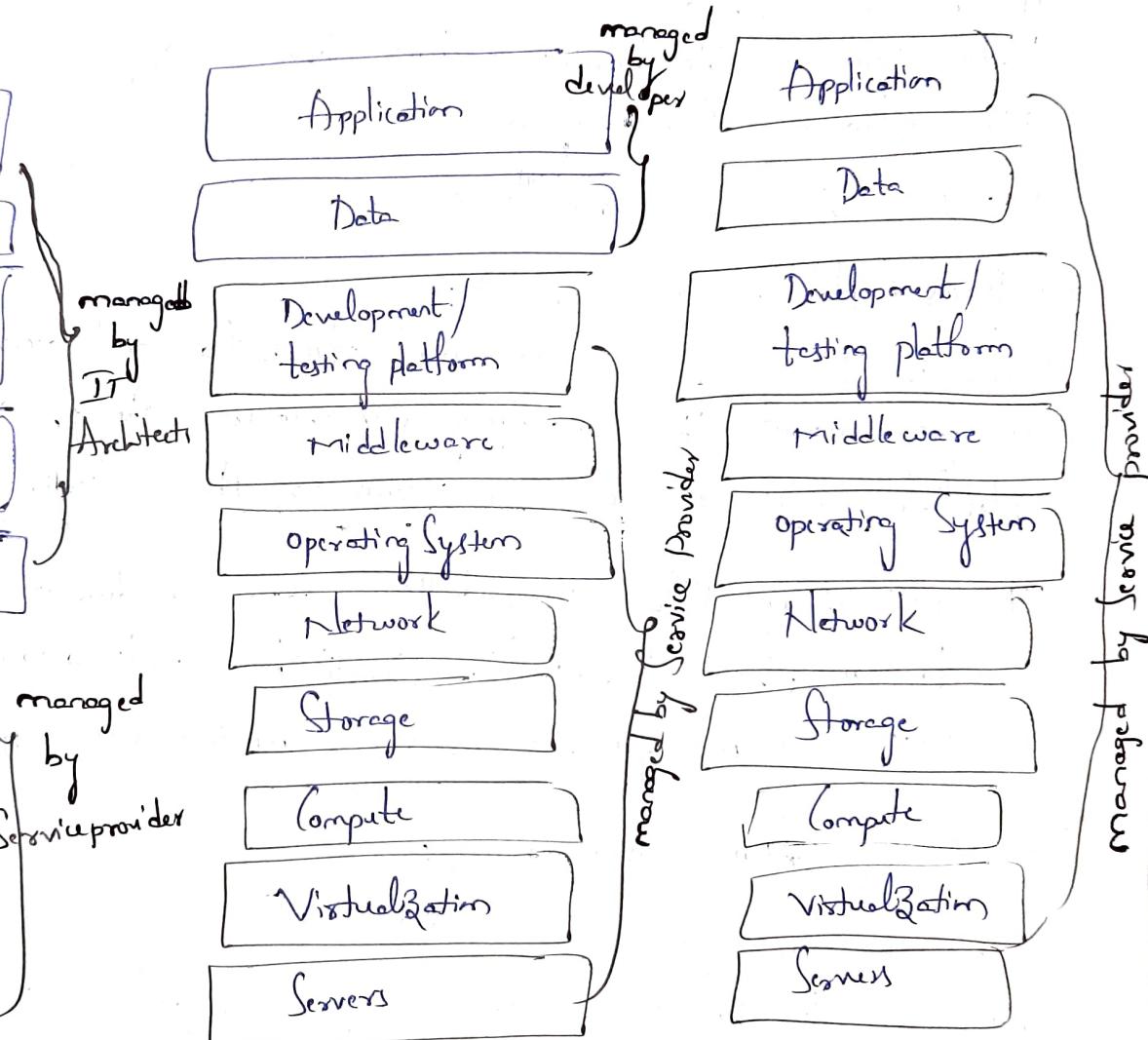
private cloud: Services are used by a single organization, like company

community cloud: Services are shared by a group of organizations with common interests

hybrid cloud: A mix of public, private and community clouds.

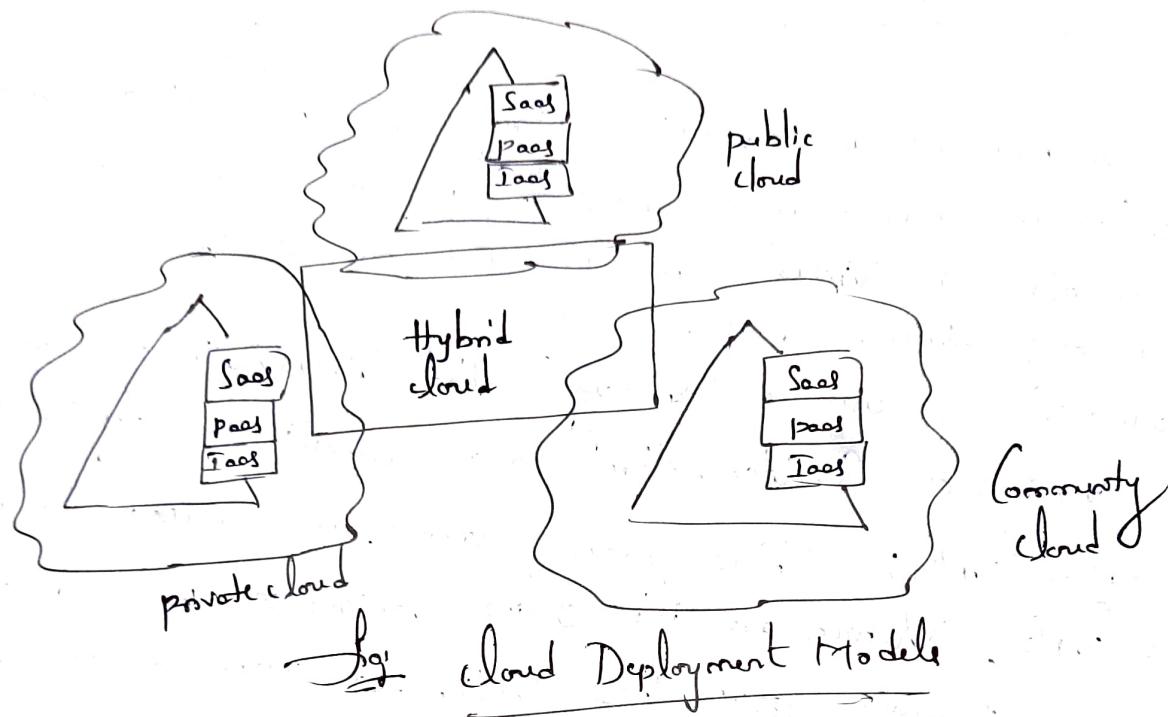


fig@ IaaS



fig(b) paas

fig(c) Saas



In IaaS, Users handle the application, while The providers manage the hardware. In PaaS, Users handle their apps, and the provider manages the platform and Infrastructure. In SaaS, Users simply use the apps and the provider manages everything else.

Infrastructure as a Service (IaaS)

⇒ IaaS changes how we use computing, storage, and network resources. In the past, these resources were accessed physically in data centers. With IaaS everything is virtual, meaning you can use them over the internet without needing physical access.

Virtual Resources- IaaS uses a technology called Virtualization to create virtual versions of computers, storage and networks from physical resources.

Virtual Machines (VMs):- These virtual resources are grouped into virtual machines (VMs), which are like online versions of real computers. The service provider sets up these VMs, and users can use them as needed.

Who Uses IaaS:-

IT architects are the main users, they can design and manage virtual infrastructures, such as networks and load balancers, without worrying about physical servers. The service provider manages the physical infrastructure, making it simpler for IT architects.

IaaS Services:-

- ① Compute:- provides virtual CPUs (the computer's brain) and memory for running VMs.
- ② Storage:- Also called Storage as a Service (StaaS), it offers space for VM data and files.
- ③ Network:- Network as a Service (NaaS) gives virtual tools like routers and switches to connect VMs.
- ④ Load Balancers:- This service spreads the workload across different VMs to keep everything running smoothly.

⇒ In Simple terms, IaaS lets you rent Virtual Computers and network online.
 the Service provider handles the physical hardware, so you only need to
 focus on using the Virtual resources.

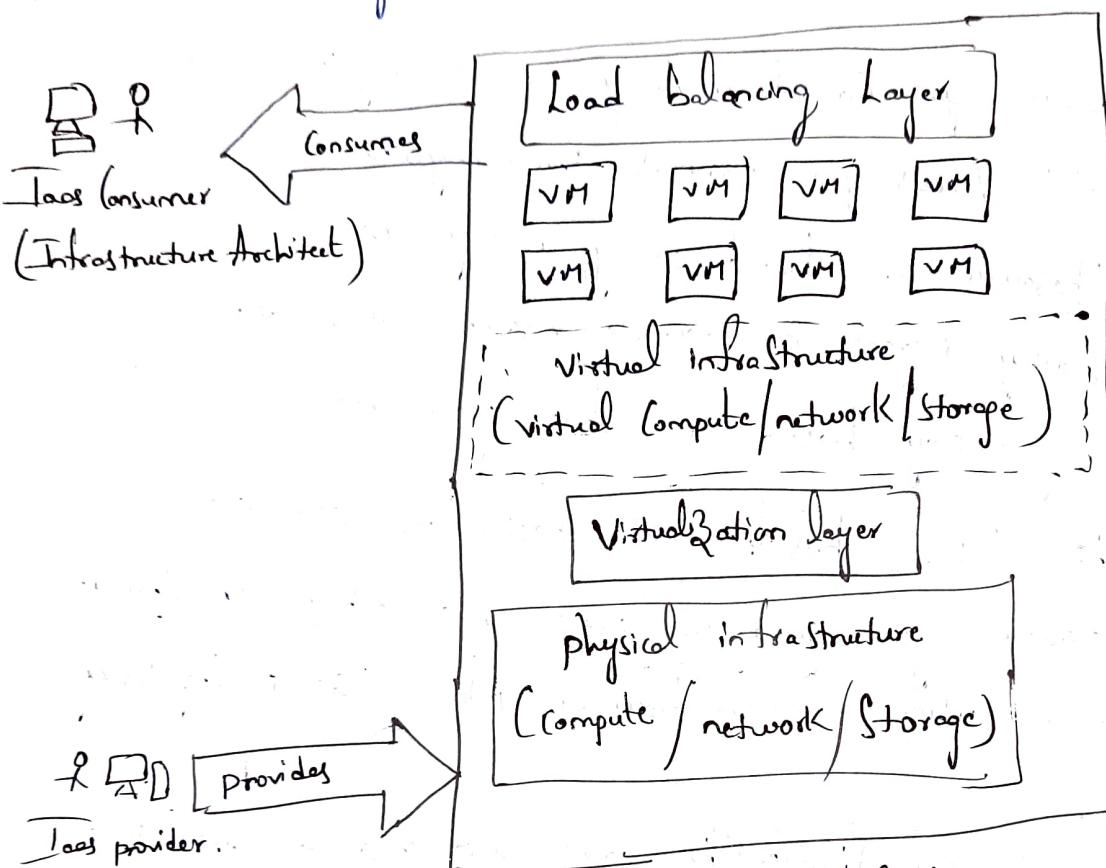


Fig: Overview of IaaS

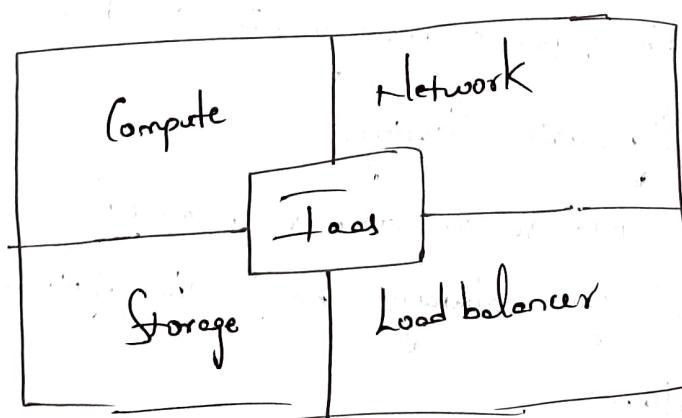


Fig: Services provided by IaaS providers

Characteristics of IaaS

IaaS Providers offer Virtual Computing resources, and you pay only for what you use (pay-as-you-go). IaaS has the general features of cloud computing like:

One-demand Self Service: you can get what you need anytime.

Broad network access: Access your resources from anywhere.

Resource pooling: Resources are shared among many users.

Rapid elasticity: Easily increase or decrease resources as needed.

Measured Service: you pay based on what you use.

In addition to these, IaaS has its own Special characteristics:

① Web Access to Resources: you can access servers and other infrastructure through the internet using a web browser. No need to physically access the servers.

② Centralized Management: Even though the servers and resources are in different locations, they are managed from a single place using a management console. This makes resource management efficient.

③ Elasticity and Dynamic Scaling:

IaaS can automatically increase or decrease resources based on the application load. This ensures you always have the right amount of resources.

④ Shared Infrastructure:

IaaS uses a shared model, where multiple users share the same physical hardware but have their own virtual machines (VMs). This improves resource usage.

⑤ PreConfigured VMs:

IaaS providers offer ready-to-use VMs with Operating Systems and network settings. You can start using them immediately or configure your own as needed.

⑥ Metered Services:

Instead of buying physical servers, you rent resources. You're charged based on the amount you use, making it cost-effective.

Suitability of IaaS

Why IaaS is Useful:-

① Reduces Costs for Start-ups: - IaaS helps start-up companies save money because they don't need to buy expensive hardware. Instead, they can rent it when needed, which lowers their total cost and increases their profits.

② Handles Sudden Usage Spikes: IaaS is great when a company's demand for computing resources suddenly increases or decreases. Traditional setups can't quickly add or remove hardware to match the changes, but IaaS can do this easily.

③ Low Initial Investment: New companies often don't have a lot of money to spend on buying infrastructure. IaaS allows them to rent what they need, helping them save large initial investment.

④ Temporary Needs: Some businesses need more computing power for a short time. Buying hardware for just a few months is costly, but renting it through IaaS is much cheaper.

When IaaS Might Not Be Suitable:

- (1) Strict Rules: Some companies have regulations that don't allow them to store data on third-party servers. They can't use IaaS because it's hosted off-site.
- (2) Low Usage: If a company doesn't need much computing power and their current hardware is enough, IaaS might not be necessary.
- (3) High Performance Needs: Sometimes, IaaS may not perform as well due to internet delays. Companies needing very fast and reliable performance might find this a problem.
- (4) Need for physical control: Some organizations prefer to have direct control over their physical hardware, which IaaS doesn't provide since it's all virtual.

Pros and Cons of IaaS

Pros (Benefits) of IaaS:-

- (1) Pay-as-you-use Model:- IaaS charges you based on how much you use. You only pay for what you use, like renting. So you don't have to spend a lot of money on buying expensive hardware.
- (2) Lower Total Cost of Ownership (TCO):- You don't need to buy physical hardware because you rent it from the IaaS provider. This reduces the overall cost of owning IT resources.

③ Elastic Resources: IaaS can adjust the amount of resources based on your needs. If you need more resources, you can scale up, and if you need less, you can scale down. This happens automatically, improving efficiency.

④ Better Resource Utilization: IaaS ensures that the IT resources you rent are used efficiently, which increases the return on investment (ROI). You get more value from the resources you use.

⑤ Supports Green IT: In traditional setups, many servers are used, which consumes a lot of power. With IaaS, multiple users share the same infrastructure, reducing the number of servers and power usage, making it more environmentally friendly.

• Cons (Drawbacks) of IaaS :-

① Security Issues :-

IaaS uses virtualization technology, which depends on hypervisors. If the hypervisor is attacked, all virtual machines (VMs) running on it can be compromised. This makes it difficult to ensure complete security.

② Interoperability Issues :-

Different IaaS providers use different standards, making it hard to move a VM from one provider to another. This can lead to being locked in with one provider (Vendor lock-in).

③ Performance Issues :-

IaaS resources come from multiple servers connected over a network. The speed of the network affects performance. If the network is slow, the VMs may not perform well.

Summary of IaaS Providers

There are many companies, both public and private, that provide Infrastructure as a Service (IaaS). IaaS providers give users the resources they need, like virtual machines, storage and networks. The table below summarizes some popular IaaS providers, showing details like their license, deployment model, and the type of operating system and hypervisors they support.

Provider	License	Deployment model	Host OS (Operating system you connect to the provider)	Guest OS (Operating systems you can use)	Support Hypervisors (software that creates and runs virtual machines)
Amazon web Services (AWS)	Proprietary (not open source)	Public (services are available to everyone)	Not available	Linux, windows and more	Xen
Google Compute Engine	Proprietary	Public	Not available	Linux, windows, and more	KVM
Microsoft Azure	Proprietary	Public	Not available	Linux and windows and more	Azure Hypervisor
Eucalyptus	GPLv3 (open source)	Private/Hybrid	Linux	Linux and windows	Xen, KVM, VMware
Apache Cloudstack	Apache 2 (open source)	Private (used inside company)	Linux	windows, Linux, BSD	KVM, VSphere, XenServer, XCP
open Nebula	Apache 2	Private (public, hybrid)	Linux	windows, Linux	Xen, KVM, VMware
openStack	Apache 2	Private (public)	Linux	windows, Linux, FreeBSD	libvirt, hyperv, VMware, others

Public IaaS: - the Service provider manages the host OS, so users don't need to worry about it.

Private IaaS: - the guest OS is what you install on your virtual machines, and most IaaS providers support common OS like Linux and Windows. In Private IaaS, organization has more control over the infrastructure, including host OS and hardware.

Platform as a Service (PaaS)

→ platform as a Service (PaaS) changes how software is made and used. In the old way, software was created on a local computer and then moved to a central server to be used. Once the software was created, companies had to buy a license to use it legally.

→ with PaaS, software development happens online. PaaS providers give developers tools and services from a data center over the internet. So developers don't need to setup everything on their own computers.

What PaaS offers:-

Online Development: - Developers can create and immediately launch their applications on the same platform.

Tools and Services: - PaaS provides various tools like programming languages, application frameworks, databases, testing tools and deployment tools over the internet. This makes it easier and cheaper for developers, as they don't have to buy or maintain these tools themselves.

Some Tools PaaS provides:-

- ① Programming Languages: - PaaS supports many languages like Java, Python, PHP, Ruby etc.
- ② Application Frameworks: - These frameworks make development easier. Examples: Node.js, WordPress, Django, Rails.

③ Databases: Paas also provides database, which are essential for most applications. Popular databases include PostgreSQL, MongoDB and Redis.

④ Other Tools:

Paas includes everything needed to develop, test and deploy applications.

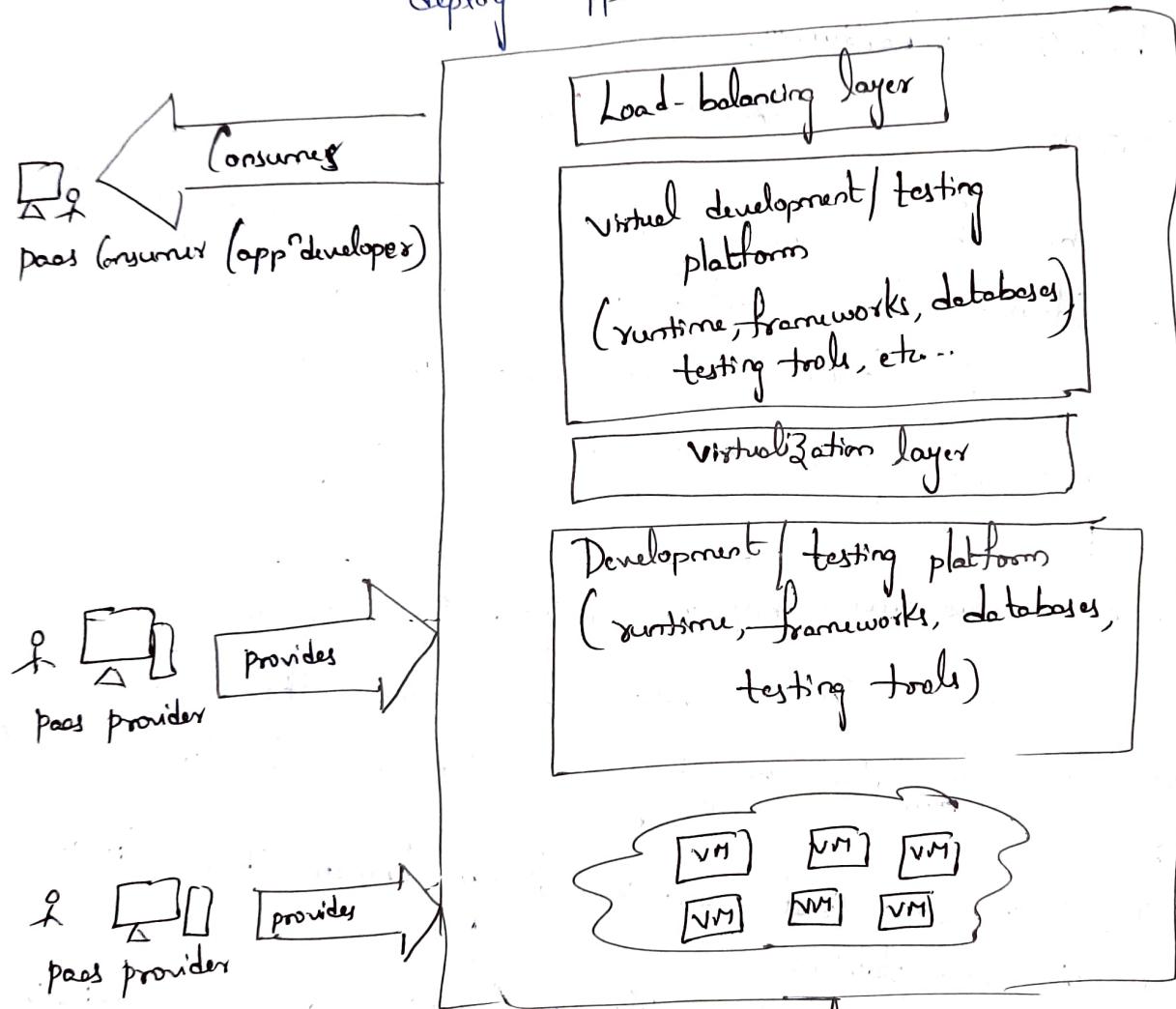


fig: Overview of Paas

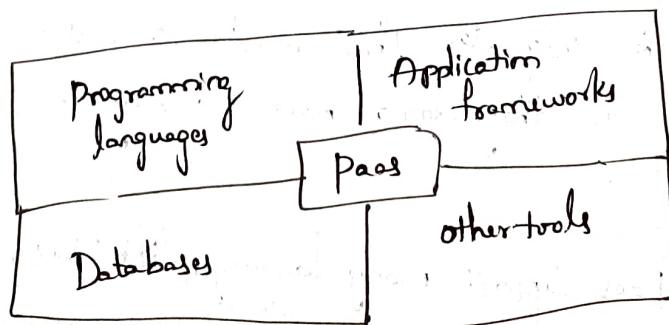


fig: Services provided by Paas providers

Characteristics of platform as a Service (PaaS)

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PaaS platforms are different from the traditional ways of developing software. Here are the key features that make PaaS unique:

- ① All-in-one:- PaaS providers offer everything needed to develop, test, deploy, host and maintain applications in one place. They provide many programming languages, frameworks, databases and other services, giving developers a lot of choices.
- ② Web Access:- In traditional development, you install a special tool (IDE) on your computer to write code. But with PaaS, you can access the development platform through a web browser, from anywhere. This makes it easy to create, edit, test and launch applications online.
- ③ Offline Access:- Sometimes, developers may not have internet access all the time. Some PaaS providers let developers work offline by syncing their local tools with PaaS services. Developers can work on their code offline and upload it when they are back online.
- ④ Built-in Scalability:- Scalability means that an application can handle more users or traffic when needed. PaaS platforms make it easy to scale applications, unlike traditional methods, where this is harder to do.
- ⑤ Collaboration:- Developers often work in teams spread across different locations. PaaS platforms provide tools that help developers work together on the same project, making it easier to communicate and plan their work.
- ⑥ Variety of Tools:- PaaS providers offer different tools to help developers, such as command-line interfaces (CLI), web-based interfaces, and APIs. Developers can choose the tools that work best for them. These tools can also handle things like billing and subscriptions.

Suitability of platform as a Service (PaaS)

When is PaaS a good Option:-

① Collaborative Development: PaaS is great for teams that need to work together, especially when team members are in different places. PaaS provides a shared online space where developers and other people involved in the project can easily collaborate.

② Automated Testing and Deployment:

PaaS offers tools that automatically test and deploy applications. This saves time because developers don't have to do as much manual testing or spend time on deployment. It's very useful when applications need to be developed quickly.

③ Quick Time-to-market: PaaS helps get applications to market faster because it supports quick and repeated updates. For example, it's a good choice for companies using agile methods, where the software is developed in small, quick steps.

many Start-ups and Software Vendors use PaaS to speed up the development process and launch applications quickly.

When is PaaS not the best option:-

① Frequent Application Migration: moving an application from one PaaS provider to another can be hard because each provider has different standards, causing "Vendor lock-in".

⑤ Infrastructure Customization: PaaS doesn't give full control over the underlying hardware. If your application needs special hardware configurations, PaaS might not be the best fit.

⑥ Platform Flexibility: PaaS comes with predefined templates for programming languages, databases and tools. This is great for general applications but not ideal if you need something very custom.

⑦ Integration with On-premise Applications:

If a company uses PaaS for some applications and traditional on-premise platforms for others, it might be hard to integrate them. This is because PaaS uses its own specific technologies that might not match the on-premise ones.

Pros and Cons of PaaS

Pros of PaaS :-

- ① Easy Platform Management: PaaS hides the complexity of managing hardware and software, allowing developers to focus on building applications.
- ② Quick Development and Deployment: PaaS offers tools for developing, testing and deploying software in one place, speeding up the process.
- ③ Lower Costs (TCO - Total Cost of Ownership): Developers can rent the tools and infrastructure they need, which is cheaper than buying everything outright.
- ④ Supports Agile Development: PaaS works well with agile development methods, which involve frequent updates and changes to software.
- ⑤ Team Collaboration: Developers can work together from different locations because PaaS provides an online platform for collaboration.

- ⑥ Flexible tools:- PaaS offers a variety of tools like command-line interfaces, web interfaces, APIs, making it easier for developers to choose what suits them best.
- ⑦ Less Maintenance:- The PaaS provider handles server maintenance, so developers can focus on building the application.
- ⑧ Scalability:- PaaS can easily handle increased demand by scaling up resources, which is helpful for web applications that may experience variable traffic.

Cons of PaaS:-

- ① Vendor Lock-in:- Once you choose a PaaS provider, it's hard to switch to another because they use different technologies and standards.
- ② Security Concerns:- Your data is stored on the provider's servers, which can raise security concerns.
- ③ Limited Flexibility:- You have to use the tools and languages the PaaS provider offers, which might not meet all your needs.
- ④ Internet Dependence:- Since PaaS is accessed online, a reliable internet connection is essential. Slow or no internet can slow down development.

Summary of PaaS Providers

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Provider	License	Deployment model	Supported Languages	Supported Frameworks	Supported Databases	click hole	
						click	hole
Cloud Foundry	open source and proprietary	public	Python, PHP, Java, Groovy, Scala, Ruby	Spring, Grails, Play, Node.js, Lift, Rails, Sinatra, Rack	MySQL, PostgreSQL, MongoDB, Redis	cf, cfUI, IDE's, Build tool	
Google App Engine	Proprietary	"	Python, Java, Groovy, JRuby, Scala, Clojure, Goo, PHP	Django, CherryPy, Pyramid, Flask, Webapp, Webapp2	Google cloud SQL, Database, BigTable, Blobstore	API's	
Heroku	Proprietary	"	Ruby, Java, Scala, Clojure, Python, PHP, Perl	Rails, play, Django, Node.js	ClearDB, PostgreSQL, cloudant, Membase, mongoDB, Redis	CLI, RESTful API	
Microsoft Azure	Proprietary	"	PHP, Python, Ruby, Java, .Net	Django, Rails, Drupal, Joomla, WordPress, DotNetNuke, Node.js	SQL Azure, MySQL, mongoDB, CouchDB	RESTful API, IDE's	
CloudBees	Proprietary	private	Java, Groovy, Scala	Spring, JBoss Seam, JRuby, Grails	MySQL, PostgreSQL, mongoDB, CouchDB	most of the framework form. NLP	
Apprenda	"	"	.Net and Java		SQL Server	REST APIs	
Cumologic	"	"			MySQL, mongoDB, Couchbase	RESTful API, SASS	

Software as a Service (SaaS)

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- ⇒ SaaS changes how software is given to users. In the old way, Software had to be bought and installed on your computer. But with SaaS, the software is available online, so there's no need to install it on your device; you can use SaaS services whenever you want, and you can stop using them anytime.
- ⇒ You can access SaaS through any web browser on devices like laptops, tablets, or smartphones. Some SaaS services work with thin clients, which are simple devices with little storage and processing power. Thin clients are safer from attacks, last longer, use less power and are cheaper.

SaaS providers offer different services like:

- ① Business Services :- These include tools for managing businesses like ERP (Enterprise Resource planning), CRM (Customer Relationship management), billing, sales and human resources.
- ② Social Networks :- Social networking sites use SaaS to handle many users because the number of users keeps growing, and cloud computing helps manage this increase.
- ③ Document Management :- Businesses use electronic documents a lot, so, SaaS providers offer services to create, manage and track these documents.
- ④ Mail Services :- Many people use email, and its usage can change unpredictably. To handle this, email providers use SaaS to offer their services online.

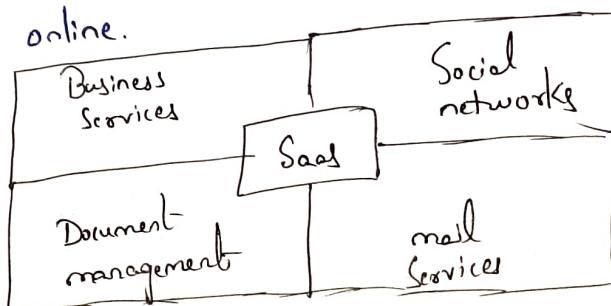


fig. - Services provided by SaaS providers.

Characteristics of SaaS

- SaaS Services are different from traditional Software and offer many benefits.
- Here are key features that make SaaS Special.
- ① One-to-many:- One application can serve many users at the same time. This means one version of the software can be used by multiple customers.
 - ② Web Access:- You can use SaaS applications from anywhere, as long as your device is connected to the internet. There's no need to install the software on your device.
 - ③ Centralized management:- SaaS is managed from a central location by the provider. They take care of updates automatically, so users always have the latest version without needing to do anything.
 - ④ Multi-device Support:- You can access SaaS services on different devices like desktops, laptops, tablets, smartphones, and even simple devices like thin clients.
 - ⑤ Better Scalability:- SaaS can easily handle more or fewer users because it uses cloud resources that can grow or shrink based on the need, ensuring smooth performance even with changing loads.
 - ⑥ High Availability:- SaaS services are available almost all the time (99.99%) with proper backup and recovery systems to protect your data.
 - ⑦ API Integration:- SaaS can work with other software or services through APIs (Application Programming Interfaces), making it flexible and easy to connect with different tools.

Suitability of SaaS

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SaaS is popular with individual and startups because of its many benefits. Here's why SaaS is a good choice for some situations.

- ① On-Demand Software :- Traditional Software requires buying a full packages, which can be costly, especially if the Software is used only occasionally. SaaS lets users pay only when they need the Software, making it a better choice for those looking for on-demand Software.
- ② For Startup Companies :- Traditional software often needs expensive, high-end devices to run. Startups can save money with SaaS because it doesn't require expensive hardware, making it a more affordable option.
- ③ multiple Device Compatibility :- Some applications, like word processor or email services, need to be accessible on different devices. SaaS works well on almost all devices, providing flexibility.
- ④ Handling Varying loads :- Predicting how many users will be on an application, like Social networking sites, is hard. SaaS can easily handle these changing loads without disrupting the service, thanks to its ability to scale up or down.

However, SaaS is not suitable for every situation. Here are some cases where SaaS might not be the best choice.

- ① Real-Time Applications :- SaaS depends on the internet, which can cause delays if the connection is slow or if data is stored far away. Real-time applications need fast processing, which can be an issue with SaaS due to these delays.

② Confidential Data: SaaS stores data with third-party providers, which raises concerns about data security. If sensitive data is lost or compromised, it can cause serious problems for an organization. So, SaaS may not be best choice for applications that handle confidential data.

③ Better On-premise Solutions: - Sometimes, on-premise applications already meet an organization's needs perfectly. In such cases, switching to SaaS might not be necessary or beneficial.

Pros and Cons of SaaS

⇒ SaaS (Software as a Service) is widely used by individuals and start-up companies because it saves costs and has many benefits. Here are some of the main advantages of using SaaS.

Pros of SaaS :-

① No Need for Installation: - SaaS services don't require installing software on your device. You can use the software directly from the provider's data center, which means you don't need expensive, high-end hardware. It works on simple devices like thin clients or smartphones, saving you money.

② Cost Savings: - SaaS uses a "pay-as-you-go" model, so you only pay for what you use. Many providers offer different subscription plans, and some services, like basic word processors, are even free.

- (3) Less maintenance:- with traditional software, users have to handle updates and maintenance. In SaaS, the provider takes care of updates, monitoring and maintenance automatically.
- (4) Easy Access:- You can access SaaS services from any devices with an internet connection, making it convenient to use anywhere, on any device.
- (5) Dynamic Scaling:- SaaS can easily handle changes in the number of users or workload. Unlike traditional software, which needs extra hardware to scale up, SaaS uses cloud resources that can expand or shrink as needed without any disruption.
- (6) Disaster Recovery:- SaaS providers keep backups and copies of your data on multiple servers. If one server fails, you can still access your data from another, ensuring high availability and no single point of failure.
- (7) Multitenancy:- SaaS allows multiple users (tenants) to share the same application instance, which helps providers use resources more efficiently.

Cons of SaaS:

Even though SaaS is popular, large companies are slower to adopt it because of some major concerns.

- ① Security:- Security is a big worry, since many users share the same SaaS service, there is a risk of data leaks. your sensitive data is stored with the provider, so you need to trust them with your important information, which can be risky.
- ② Internet Dependency:- SaaS requires a stable internet connection if your connection is slow, it can be hard to use the service smoothly. this dependency on the fast internet connection can be a problem for some users.
- ③ Loss of control:- with SaaS, your data is stored off-site with the provider. this means you have less control over your data compared to using on-premise software, where you manage everything locally.

Summary of SaaS Providers

there are many SaaS providers who provide SaaS services such as ERP, CRM, billing, document management, and mail services. Table below gives a summary of popular SaaS Vendors in the market.

Provider	Services provided
Salesforce.com	Customer Relationship management (CRM) Solutions
Google Apps	Gmail, Calendar, Talk, Docs and Sites
microsoft office 365	online office Suite (word, excel, etc.) and other Services
NetSuite	ERP, accounting, order management, inventory, CRM and E-Commerce applications.
Concur	Travel and expense management Solutions
GoToMeeting	online meetings, desktop sharing, video conferencing
Constant Contact	Email marketing, Social media marketing, online surveys and event marketing
workday.Inc	Human Resources, payroll, Financial management
oracle CRM	CRM applications
Intacct	Financial management and accounting Software

Other cloud Service Models

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- ⇒ many people and small companies use the basic cloud services like IaaS, PaaS, SaaS. These services have made cloud computing a key technology in the IT world. As people use these services more, they realized the need for specific services like network, storage, databases.
- ⇒ Because of this, cloud providers are now offering separate services to meet these needs. Here are some of the newer cloud services.
- ① NaaS (Network as a Service) :- This allows users to access virtual network services like virtual private networks (VPNs) and bandwidth on demand. Instead of buying expensive network hardware, companies can now use these services on a pay-as-you-go basis.
 - ② DEaaS (Desktop as a Service) :- This provides virtual desktops that users can access from anywhere. The service provider manages storage, backup, security, and updates, while users manage their own applications and settings.
 - ③ StaaS (Storage as a Service) :- This service lets users store and access their data in the cloud. It's useful for backup and disaster recovery because the data can be accessed anytime from anywhere.
 - ④ DBaaS (Database as a Service) :- This allows users to use databases without installing or maintaining them. The service provider handles everything, and users pay based on their usage.
 - ⑤ DaaS (Data as a Service) :- This service provides access to data like text, images, videos over the internet. It is often used in services that require geographic or financial data.

⑥ SEaaS (Security as a Service) :- This offers Security Services like antivirus, Intrusion Detection, event management on Subscription basis. It helps Secure both cloud and On-premise Systems.

⑦ IDaaS (Identity as a Service) :- This helps Companies manage Users identities and authentication without needing their own infrastructure.

⇒ As Cloud Computing grows, more Services are being created to meet User needs. This idea of providing everything as a Service is called XaaS (Everything as a Service). In the future, we might see more Services like Backup as a Service, Communication as a Service, and many others.