Cloud Computing

Case Study Report

INDEX

Microsoft Azure

Introduction

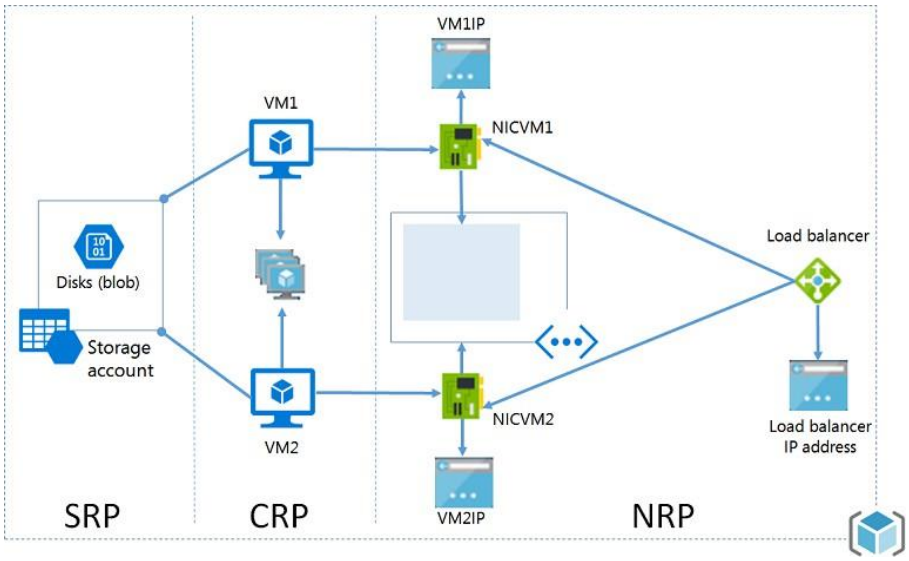
Microsoft Azure is Microsoft's public cloud computing platform. It provides a range of cloud services, including compute, analytics, storage and networking. Users can pick and choose from these services to develop and scale new applications, or run existing applications in the public cloud. The Azure platform aims to help businesses manage challenges and meet their organizational goals. It offers tools that support all industries -- including e-commerce, finance and a variety of Fortune 500 companies -- and is compatible with open source technologies. This provides users with the flexibility to use their preferred tools and technologies.

Microsoft charges for Azure on a pay-as-you-go basis, meaning subscribers receive a bill each month that only charges them for the specific resources they have used. Once customers subscribe to Azure, they have access to all the services included in the Azure portal. Subscribers can use these services to create cloud-based resources, such as virtual machines (VM) and databases.

Deployment Models

The Resource Manager and classic deployment models represent two different ways of deploying and managing your Azure solutions. You work with them through two different API sets, and the deployed resources can contain important differences. The two models aren't compatible with each other. Azure originally provided only the classic deployment model. In this model, each resource existed independently; there was no way to group

related resources together. Instead, you had to manually track which resources made up your solution or application, and remember to manage them in a coordinated approach. To deploy a solution, you had to either create each resource individually through the portal or create a script that deployed all the resources in the correct order. To delete a solution, you had to delete each resource individually. You couldn't easily apply and update access control policies for related resources. Finally, you couldn't apply tags to resources to label them with terms that help you monitor your resources and manage billing.



In 2014, Azure introduced Resource Manager, which added the concept of a resource group. A resource group is a container for resources that share a common lifecycle. When Resource Manager was added, all resources were retroactively added to default resource groups. If you create a resource through classic deployment now, the resource is automatically created within a default resource group for that service, even though you didn't specify that resource group at deployment. However, just existing within a resource group doesn't mean that the resource has been converted to the Resource Manager model.

Popular Services

Microsoft sorts Azure cloud services into nearly two dozen categories, including:

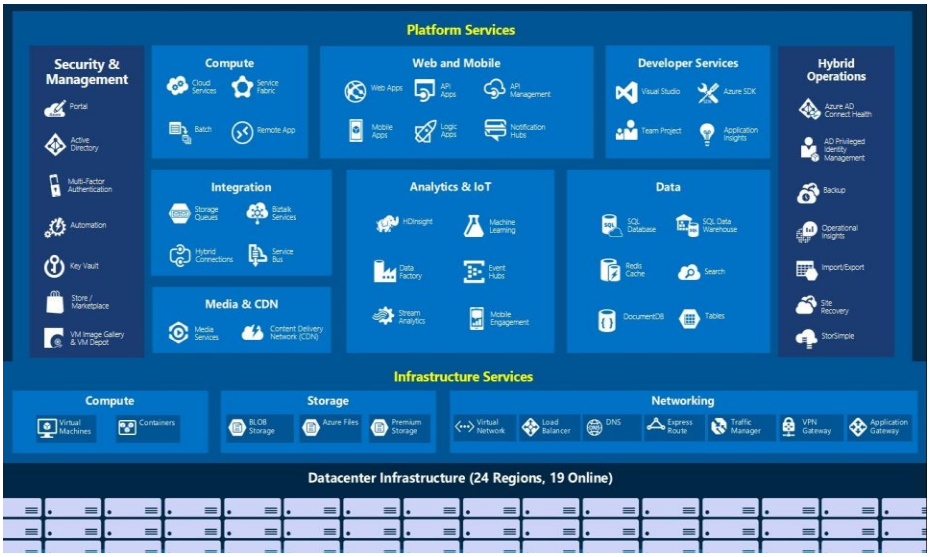
- **IaaS on Azure:** With Azure's IaaS offering you outsourceall your network and computing needs to Microsoft. Azure offers a massive range of IaaS facilities depending on the needs of your business, from compute and networking to security and storage, including Container Service and Virtual Machines through which you can host websites, store and backup data, develop and test environments, build web apps,

and run high-performance computing. It also enables companies to get rid of having to operate infrastructure and hardware of their own.

- **PaaS on Azure:** PaaS on Azure offers plenty of services to help implement a cloud-powered development platform. App Services, Azure Search, and Azure CDN, Azure will offer everything you need to deliver cloud applications on a pay-as-you-go basis, from the smallest web apps to enterprise-level software. Azure's PaaS offerings give developers total control over their application, allowing them the freedom to work on building, safe in the knowledge that things like operating system patches or load balancing will just work. With services like Azure Functions, businesses can take advantage of PaaS power without having to worry about server configuration or scaling, which is automatic.

- **SaaS on Azure:** Main SaaS offerings on Azure are products like Dynamics 365, Outlook, and Office 365 are all built and hosted on Azure. Azure can be also used both to host apps you've created yourself, beside accessing other Microsoft SaaS services. Azure as a foundation for your SaaS apps lets you take advantage of powerful technology and intelligent tools like analytics and machine learning.
- **Compute:** These services enable a user to deploy and manage VMs, containers and batch jobs, as well as support remote application access. Compute resources created within the Azure cloud can be configured with either public IP addresses or private IP addresses.
- **Web:** These services support the development and deployment of web applications. They also offer features for search, content delivery, API management, notification and reporting.
- **Storage:** This category of services provides scalable cloud storage for structured and unstructured data. It also supports big data projects, persistent storage and archival storage.
- **Internet of things:** These services help users capture, monitor and analyze IoT data from sensors and other devices. Services include

notifications, analytics, monitoring and support for coding and execution.



- **Security:** These products provide capabilities to identify and respond to cloud security threats, as well as manage encryption keys and other sensitive assets.
- **Management and governance:** These services provide a range of backup, recovery, compliance, automation, scheduling and monitoring tools that can help a cloud administrator manage an Azure deployment.
- **Blockchain:** The Azure Blockchain Service allows you to join a blockchain consortium or to create your own.

Day-to-Day Applications hosted on Microsofl Azure

Examples of famous apps housed by the Microsoft Azure Cloud Provider are:

➔ **Project Bonsai:** Create intelligent industrial control systems using simulations

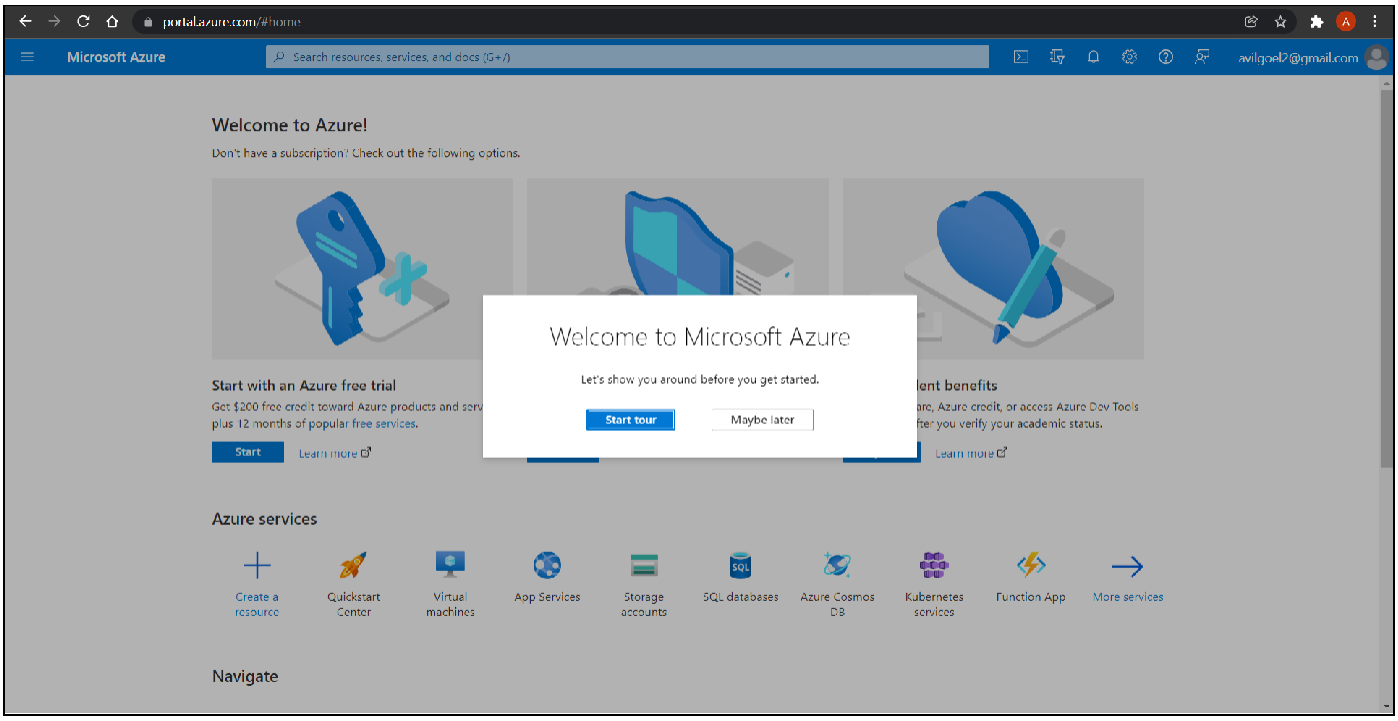
➔ **Visual Studio:** The powerful and flexible environment for developing applications in the cloud

➔ **Azure DevOps:** Services for teams to share code, track work and ship software

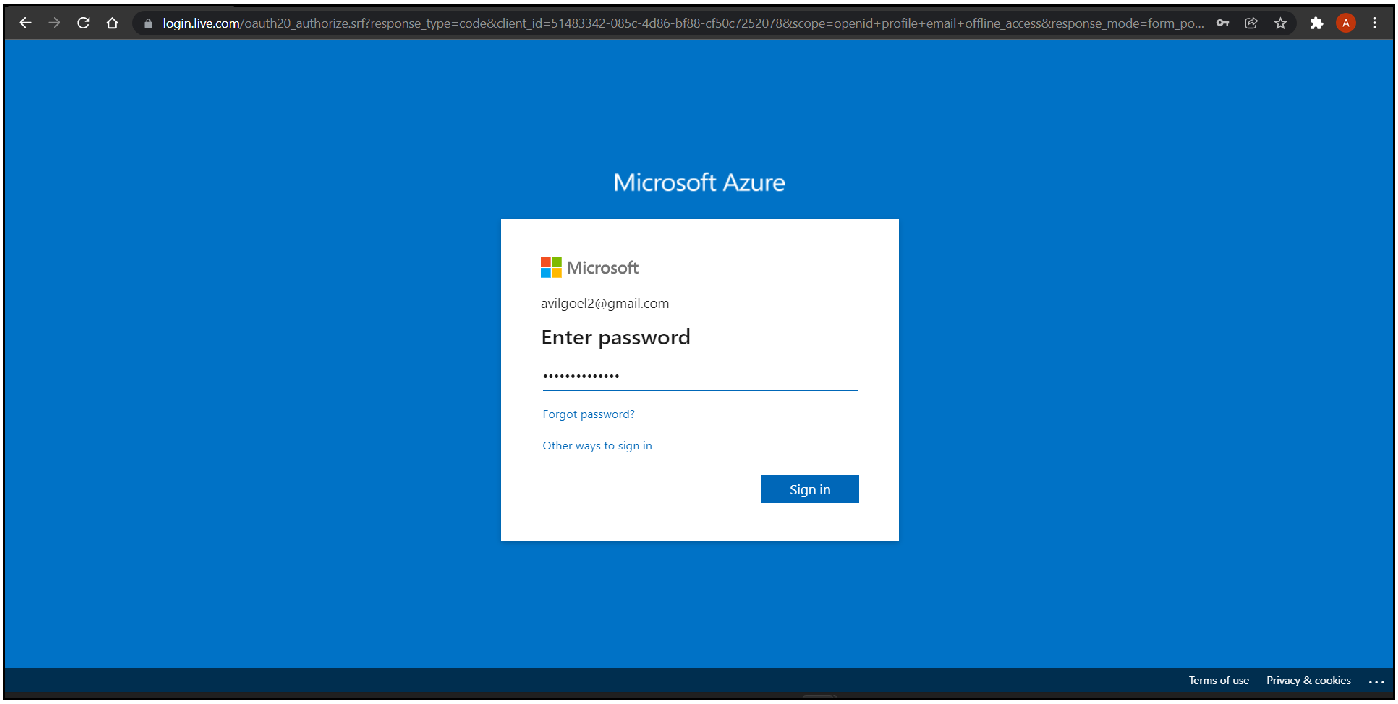
➔ **Azure IoT Edge:** Extend cloud intelligence and analytics to edge devices managed by Azure IoT Hub

➔ **Kinect DK:** Build computer vision and speech models using a developer kit with advanced AI sensors

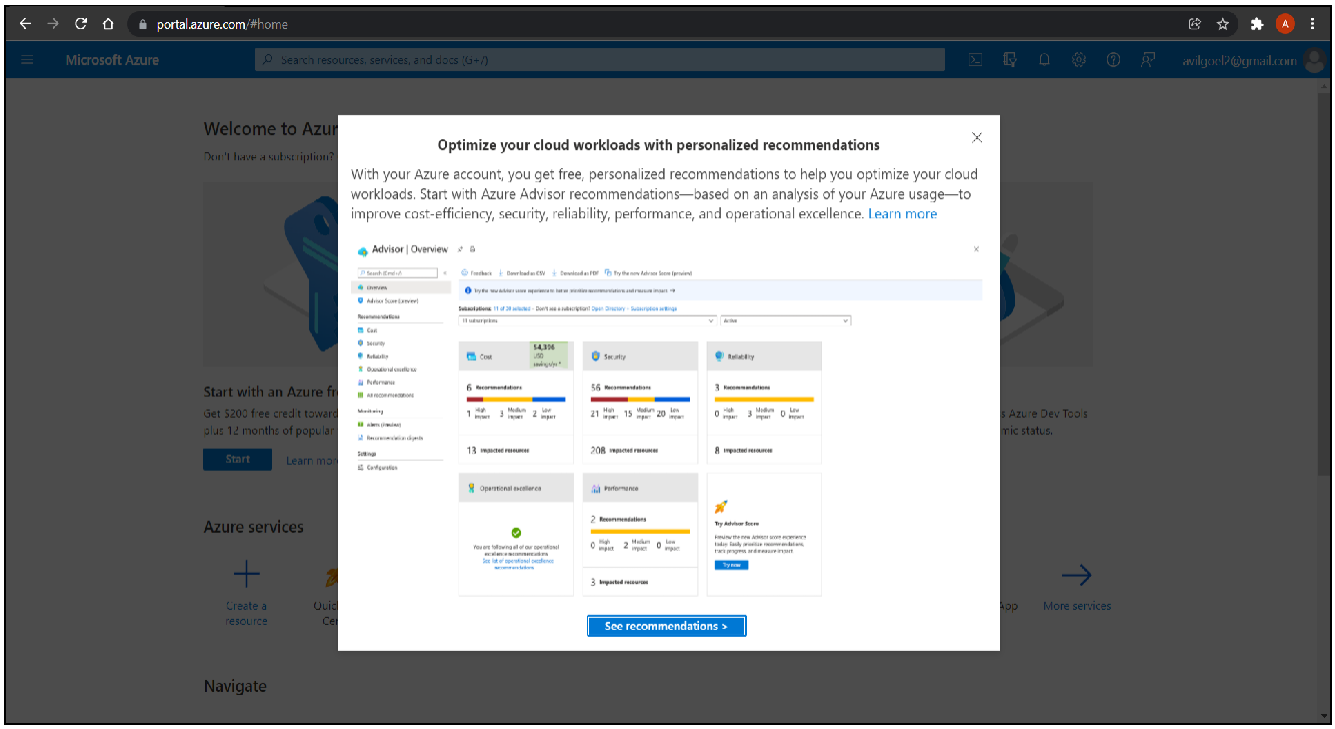
Hands-On Experience



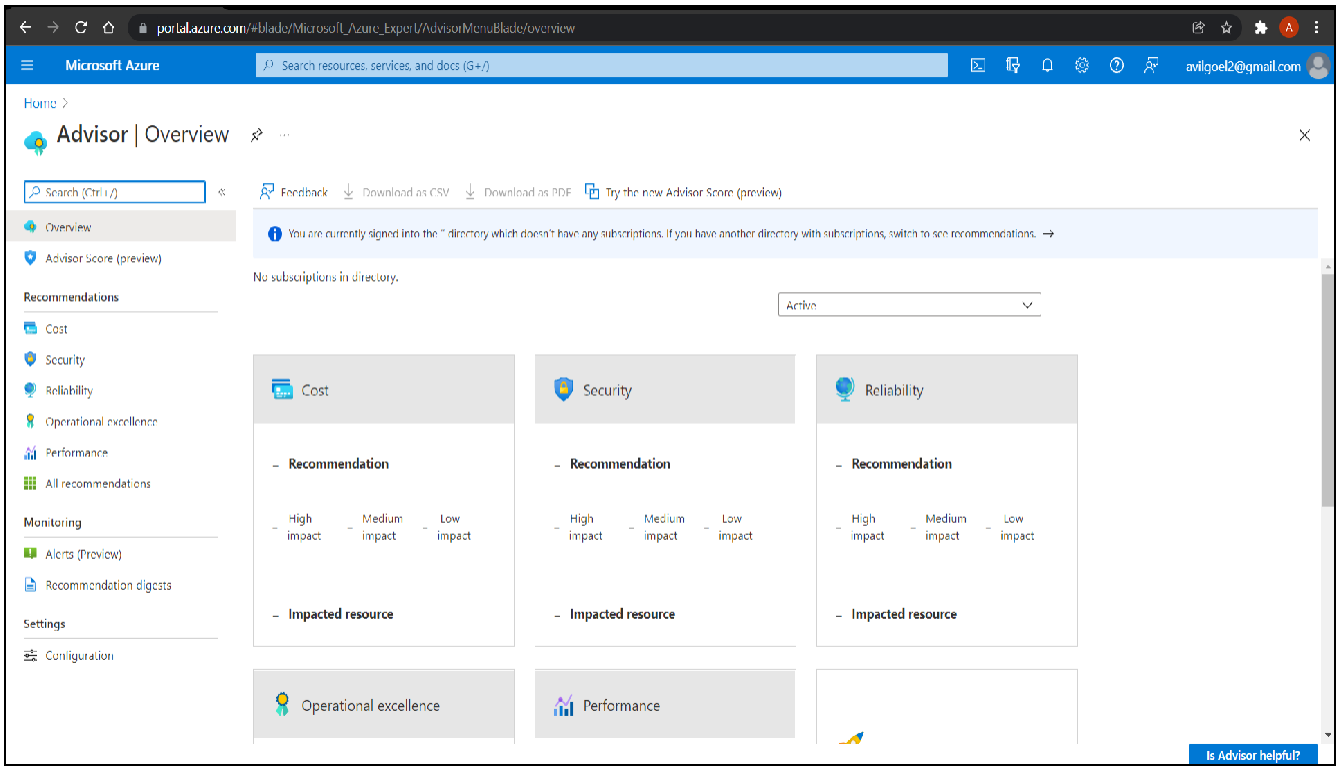
Microsoft Azure Landing Page



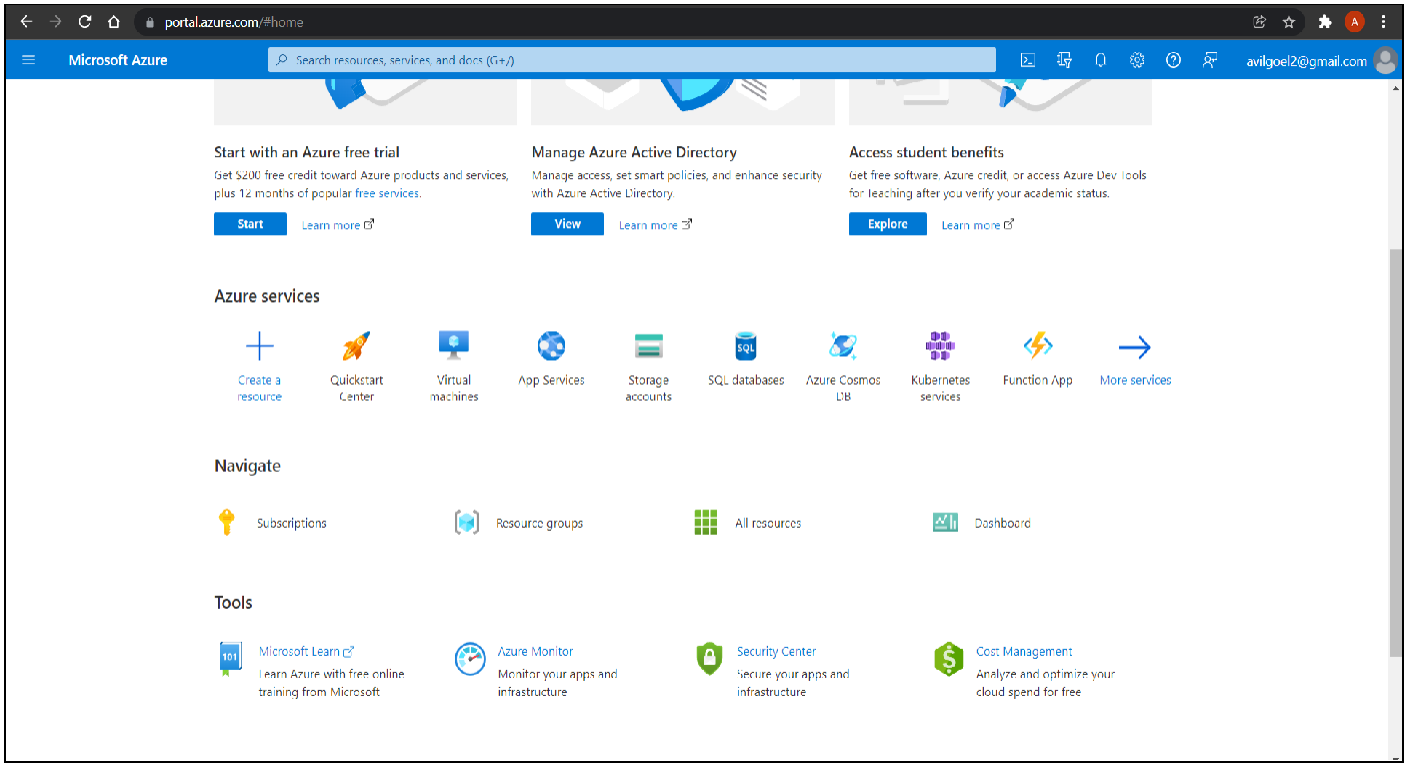
Microsoft Azure Login Page



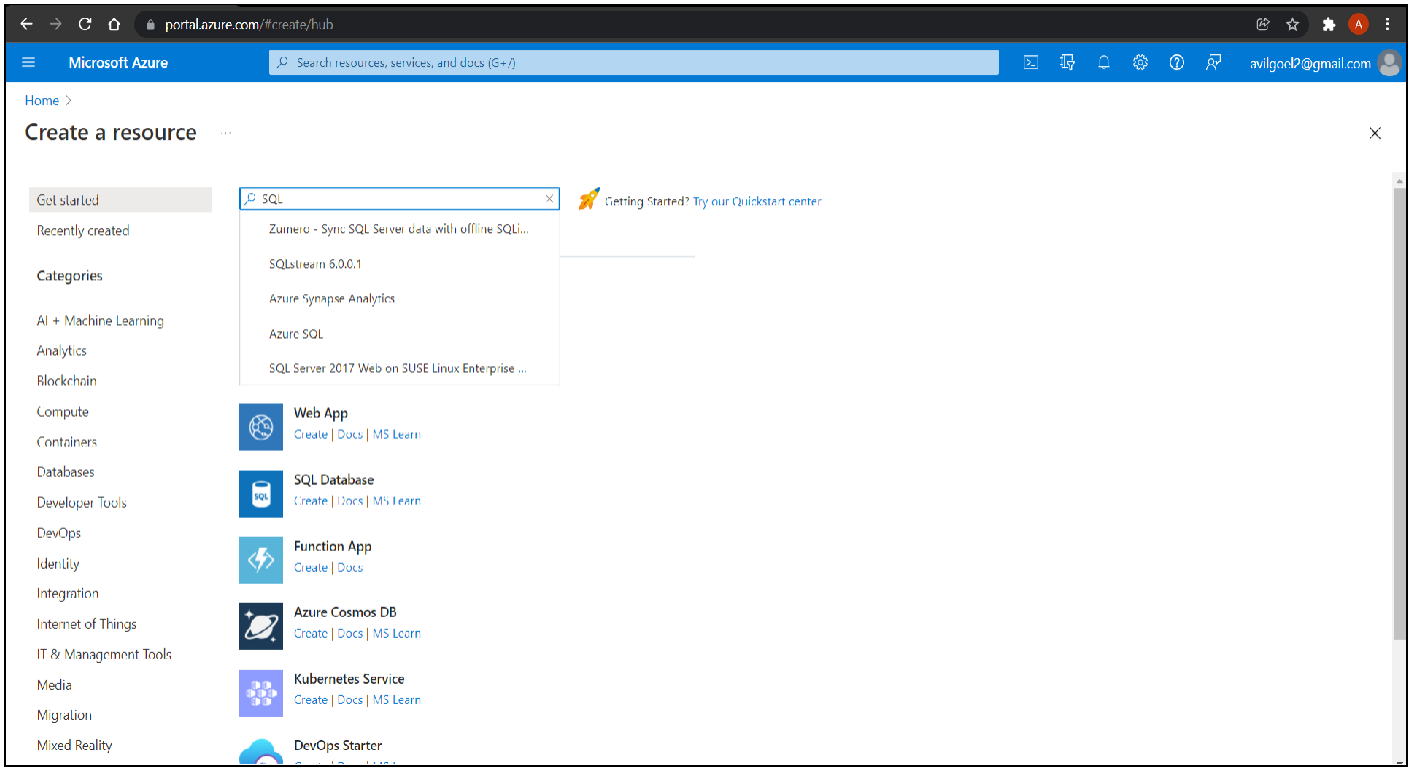
Monitoring Cloud Usage Statistics



Dashboard for Cloud Resource Management



Services offered by Microsoft Azure



Creating a Resource with Microsoft Azure

Amazon Web Services (AWS)

Introduction

AWS (Amazon Web Services) is a comprehensive, evolving cloud computing platform provided by Amazon that includes a mixture of infrastructure as a service (IaaS), platform as a service (PaaS) and packaged software as a service (SaaS) offerings. AWS services can offer an organization tools such as compute power, database storage and content delivery services.

AWS launched in 2006 from the internal infrastructure that Amazon.com built to handle its online retail operations. AWS was one of the first companies to introduce a pay-as-you-go cloud computing model that scales to provide users with compute, storage or throughput as needed.

AWS offers many different tools and solutions for enterprises and software developers that can be used in data centers in up to 190 countries. Groups such as government agencies, education institutions, nonprofits and private organizations can use AWS services.

Popular Services

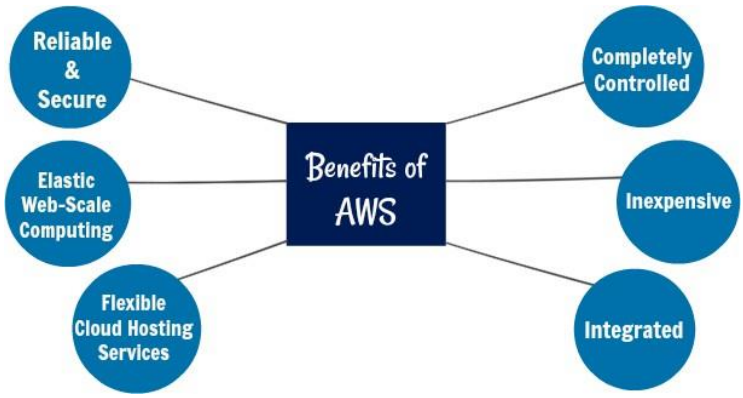
AWS, today, is undoubtedly the largest and globally renowned technology that provides cloud computing products and services. What makes AWS the most successful and profitable service is its size and presence in the computing world. AWS's existence is so large that it can be divided into two main products viz. EC2, Amazon's virtual machine service and S3, Amazon's storage system. Furthermore, some of the major services AWS provides include Amazon CloudFront, Amazon Elastic Compute Cloud (EC2), Amazon Relational Database Service (Amazon RDS), Amazon Simple Notification

Service (Amazon SNS), Amazon Simple Queue Service (Amazon SQS), Amazon Simple Storage Service (Amazon S3), Amazon SimpleDB, and Amazon Virtual Private Cloud (Amazon VPC). AWS offers some amazing services to its users that include the remote computing, servers, networking, security, storage, email, and mobile development etc. Let us take a sneak peek into the AWS services list here :

- **Storage :** Amazon provides storage services called Amazon Simple Storage Service, also known as S3. Amazon S3 offers a scalable storage for users to create their data backup for up to 5 Gigabytes. Users can store and organize their data and files in the S3 buckets.
- **Amazon Glacier :** Amazon Glacier is one of the low-cost cloud storage services for cold data storage that makes the users able to store their infrequently accessed data for long retrieval times.
- **Amazon Elastic Block Store :** Another storage provides by the Amazon includes Amazon Elastic Block Store. The Elastic Block Store service makes the users store their persistent data in the block-level storage that is highly available even when the Elastic Compute Cloud (EC2) is shut down.
- **Amazon Elastic Compute Cloud (EC2)** : Amazon Elastic Compute Cloud (EC2) is a web-based service virtual server for business to run applications on. These servers are commonly known as the Instances, which allow developers to access the compute capacity on the global AWS data centers.
- **Database Management :** The services offered by the Amazon Web Services (AWS) for the database management include the Amazon Relational Database Service. The Amazon RDS is compatible with a wide range of database engines that make the users able to migrate, recover and even take the backup of their data.
- **Data Migration :** AWS also provides its users with the ability to migrate their data, applications, servers and database on its public AWS cloud.

Users, with the help of the AWS Migration Hub, can manage the migration of their data to the cloud.

- **Networking** : With the Amazon Virtual Private Cloud (VPC), users can have the full control to use a secluded segment of the AWS cloud. Moreover, AWS also provides some productive tools to balance the network traffic.
- **Cloud Configuration and Management Tools :** AWS also provides few tools such as AWS Config and AWS Config Rules that help users deal with the cloud resource configuration. Another tool called, AWS Trusted Advisor plays an important role in selecting the best practices to help users configure cloud resource efficiently based on the cost-effectiveness, protection, error lenience, and performance enhancement.



- **Security :** AWS Identity and Access Management (IAM) are such services provided by the AWS that help manage access over to cloud resources. Moreover, AWS provides its users with the ability to create and control custom policies for multiple accounts as well.
- **Amazon Messaging Services :** AWS owns some of the greatest Messaging services called Amazon Simple Queue Service (Amazon SQS), Amazon Simple Notification Service (Amazon SNS), and Amazon Simple Email Service (Amazon SES). While Amazon SQS is a quick, powerful and trustworthy message queuing service that sends, receives and stores messages, Amazon SNS is quick and flexible push notification service that makes the users enable to send messages to single or multiple users at one go.
- **AWS Development Tools :** Notably, AWS SDKs support number of platforms and computer languages including Android and iOS, C++, Java, NodeJS, PHP, Python, and Ruby as well. Additionally, AWS users also have the option to use AWS Tools for Powershell, AWS Serverless Application Model, Amazon API Gateway, and many more other tools and services.

Advantages and Disadvantages

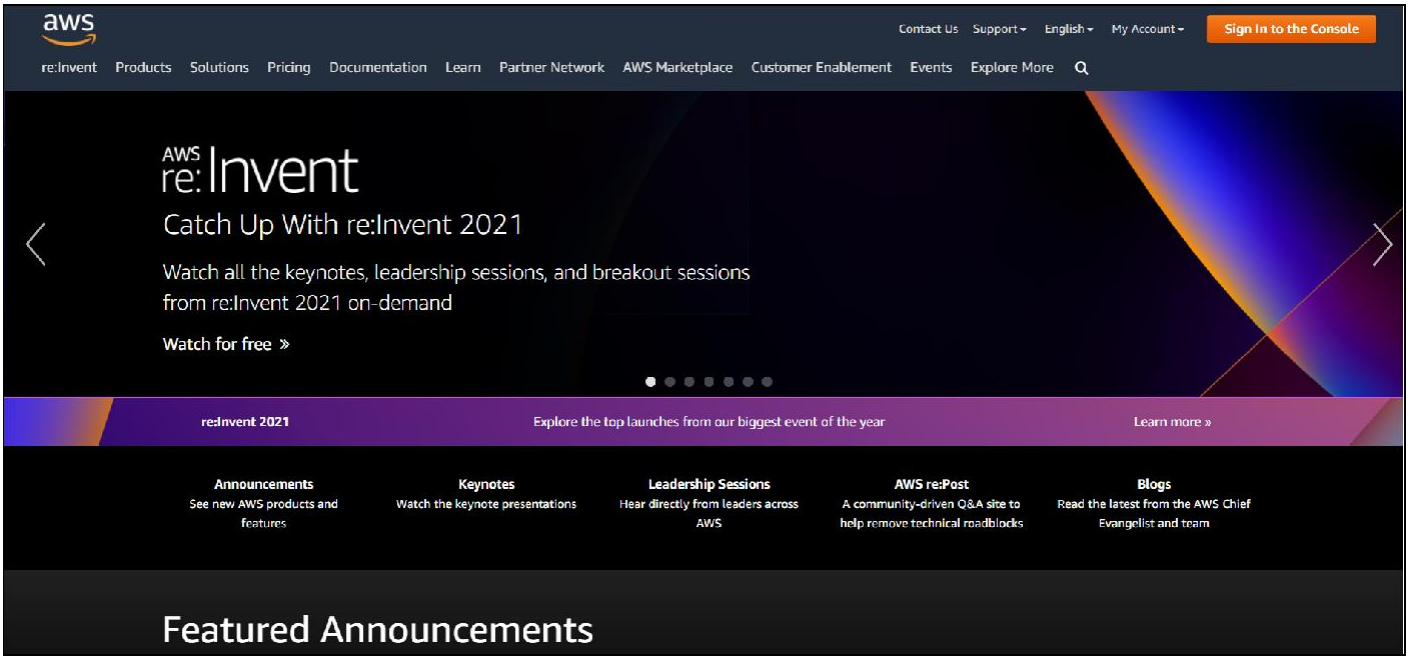
The advantages of using AWS are as follows :

- ➔ AWS enables organizations to use programming models, operating systems, databases, and architectures which are already known to its user.
- ➔ Amazon Web Services can be very cost-efficient as the individual who is using the cloud services will have to pay only for what you use.
- ➔ Expenses for creating, implementing, and maintaining data centers is not required while using AWS.
- ➔ Users are facilitated with scale-up and down the allocated resources as per the demand for the resources.
- ➔ AWS offers fast deployment which allows individuals to obtain optimum user satisfaction.
- ➔ AWS allows us to deploy the application in different regions with just a few clicks.

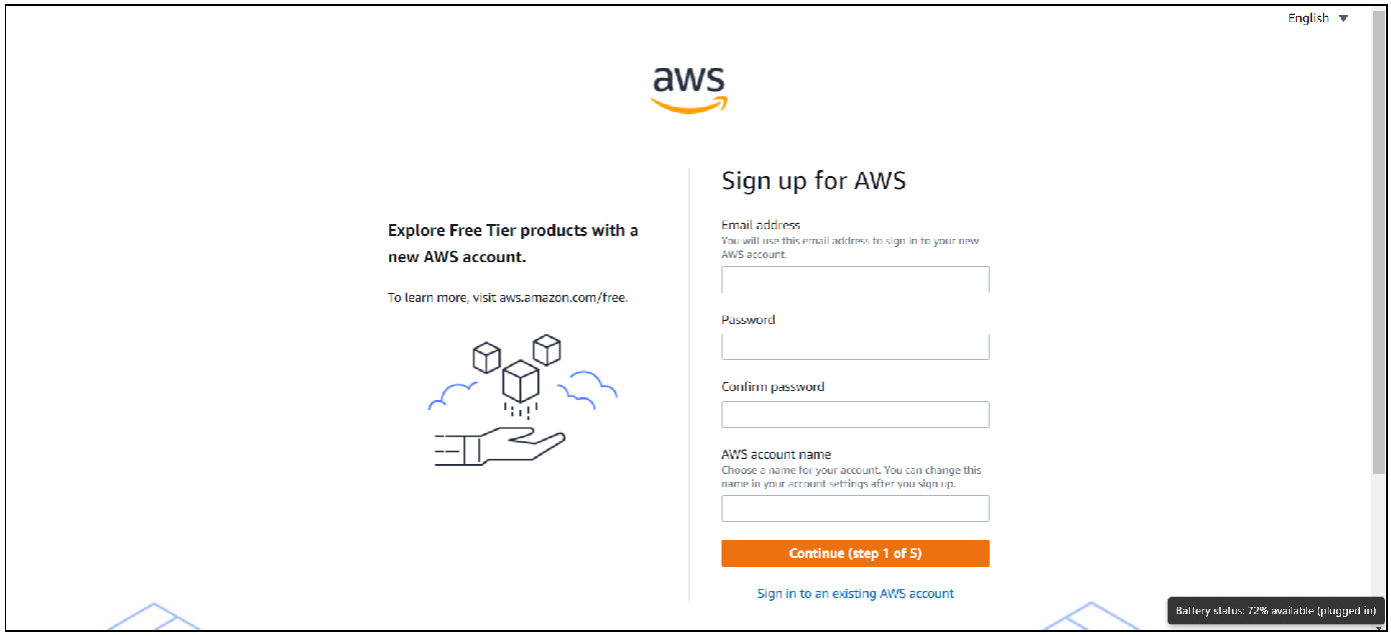
The disadvantages of using AWS are as follows :

- ➔ While using the services of AWS, an individual is required to pay for obtaining immediate assistance.
- ➔ The resources of AWS can differ from region to region as all the services of AWS are not provided to all the regions.
- ➔ Some issues such as files vanishing and the problem of server not syncing may arise while working with AWS.
- ➔ Without internet access, the data present in the cloud cannot be accessed.

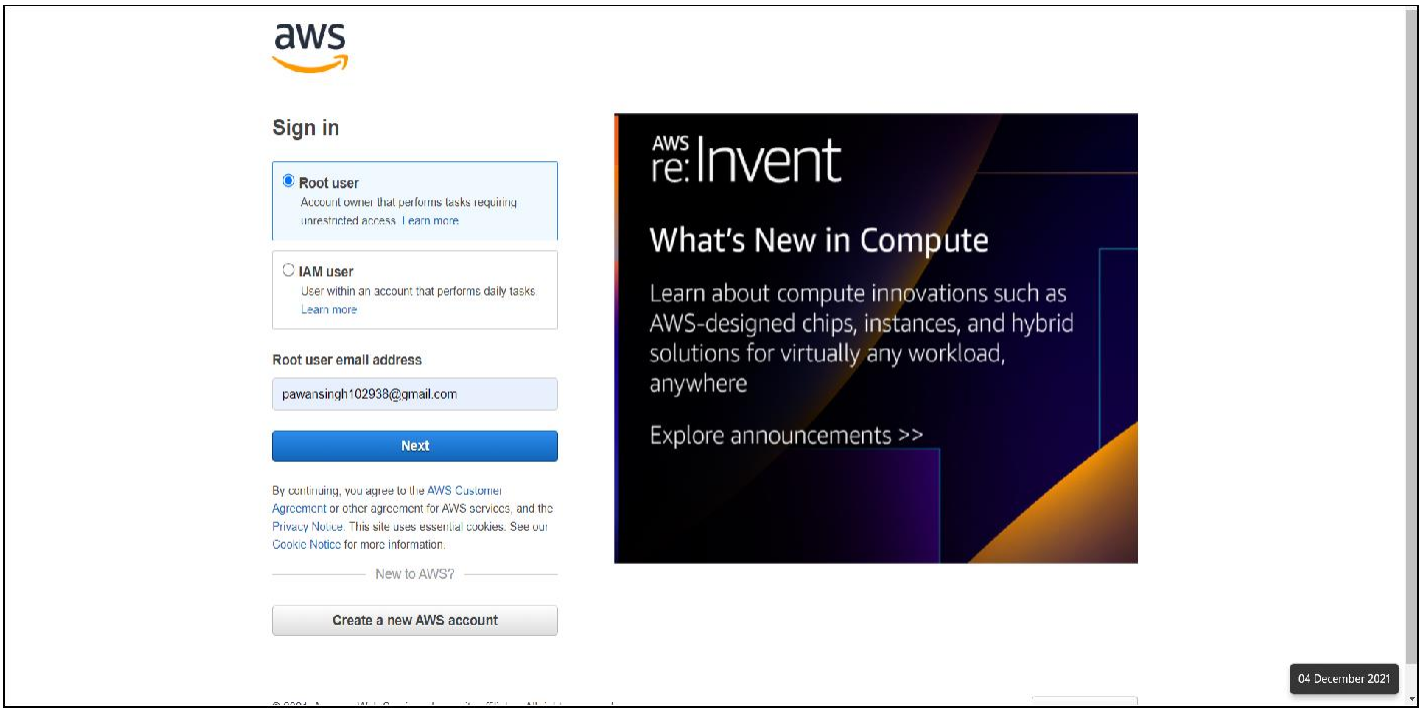
Hands-On Experience



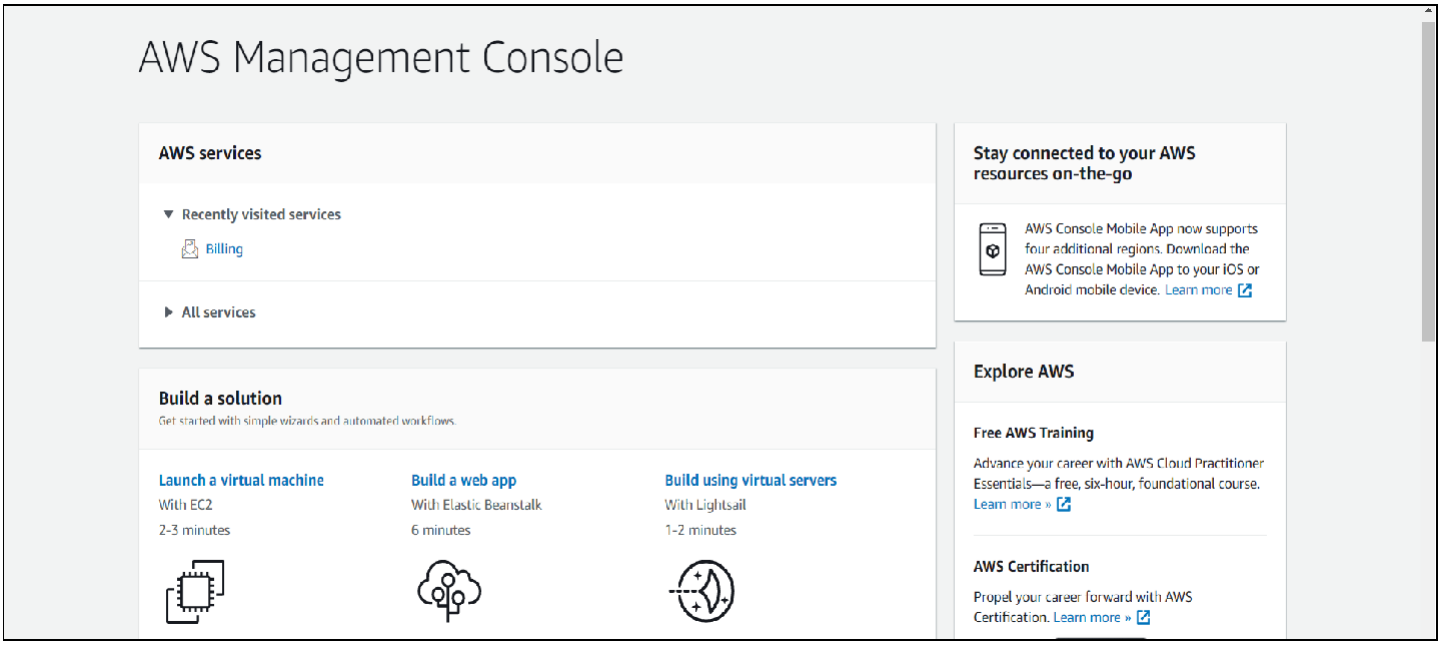
AWS Homepage



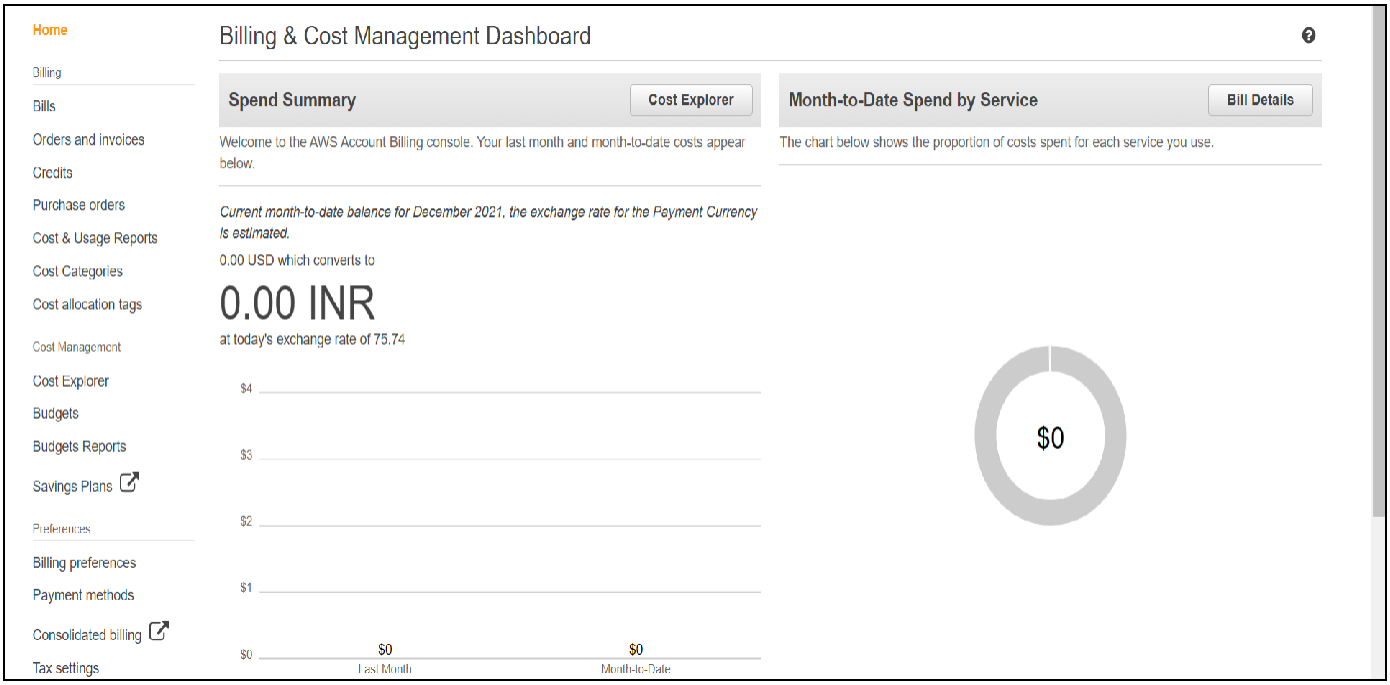
AWS register new user page



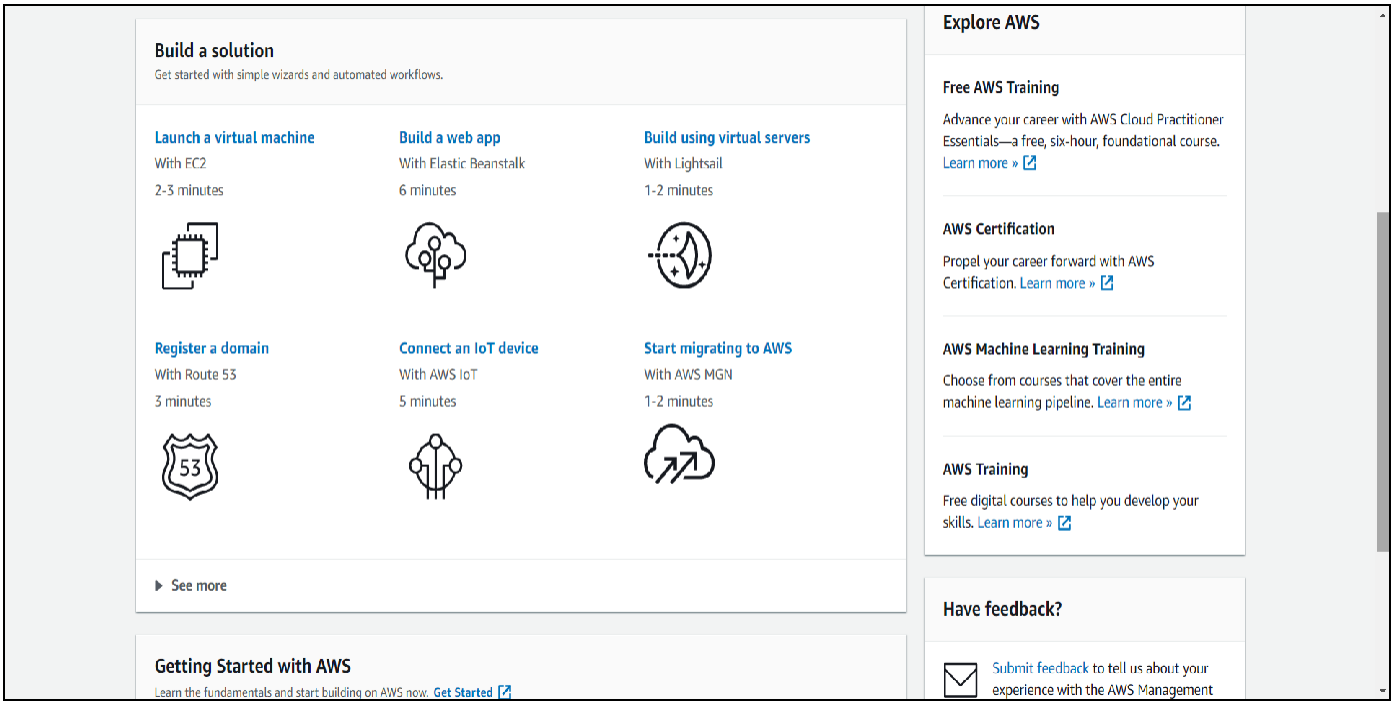
AWS Sign in page



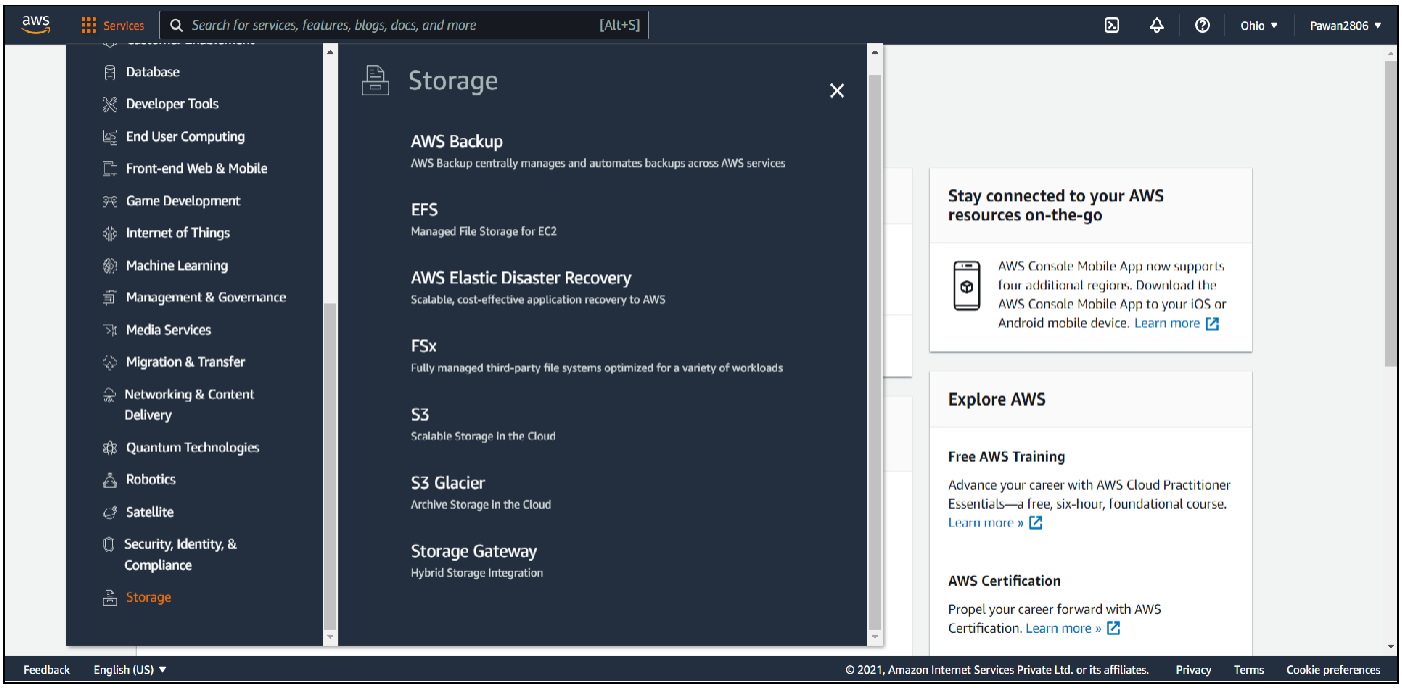
AWS Console



AWS Billing Dashboard(pay-as-you-go)



AWS Applications



AWS Services offered

G Suite (Google Workspace)

Introduction

G Suite is a suite of productivity solutions developed by Google that offers a wide array of web-based applications and services designed to help organizations communicate, collaborate, and store data.

G Suite is one of the most popular cloud based suite of applications currently available and most professionals and consumers alike are already very familiar with many of its core offerings like Gmail, Hangouts, Calendar, Drive, Docs, and Sheets to name a few. Most of these core services are free for consumers. However, G Suite does offer enterprise grade solutions to suit just about every business need.

Today, G Suite offers solutions for the vast majority of a typical organization's productivity needs. These solutions have made it possible for many organizations to eliminate the need for on-prem infrastructure at large. The benefits for organizations include reduced cost, maintenance and implementation, and management overhead.

However, while G Suite certainly checks the boxes for most of an organization's needs, it doesn't check all of them. This is particularly true when it comes to the core directory service.

G Suite has become such a comprehensive platform that Google is starting to follow Microsoft's lock-in strategy. This is most evident with their creation of Google Cloud Identity, which effectively detached G Suite user identities from

working only with G Suite. Those identities now work across a wider range of Google services.

Popular Services

The following apps are available as part of the core offering for most editions of Google Workspace. For more details about each app, click the link name to go to the corresponding Google Workspace page.

One important aspect of Workspace apps is speed. Google offers new shortcuts, which, when entered in a modern browser's URL box, create a new item of the type indicated. For example, cal.new creates a new Google Calendar event, while doc.new creates a new Google Doc.

- **Gmail**: The world's most widely used email service
- **Calendar**: Scheduling solution (cal.new)
- **Meet/Meet hardware :** Group video and audio conferencing (meet.new)
- **Chat and Spaces**: Team conversations and project places
- **Drive**: Private cloud storage that also allows shared drives and files
- **Docs**: Collaborative documents (doc.new)
- **Sheets**: Collaborative spreadsheets (sheet.new)
- **Slides**: Collaborative presentations (slide.new)
- **Forms**: Customizable forms and surveys (form.new)
- **Keep**: Collaborative notes (note.new or keep.new)
- **Sites**: Collaborative web-sites (site.new)
- **Currents**: Enterprise social networking and engagement

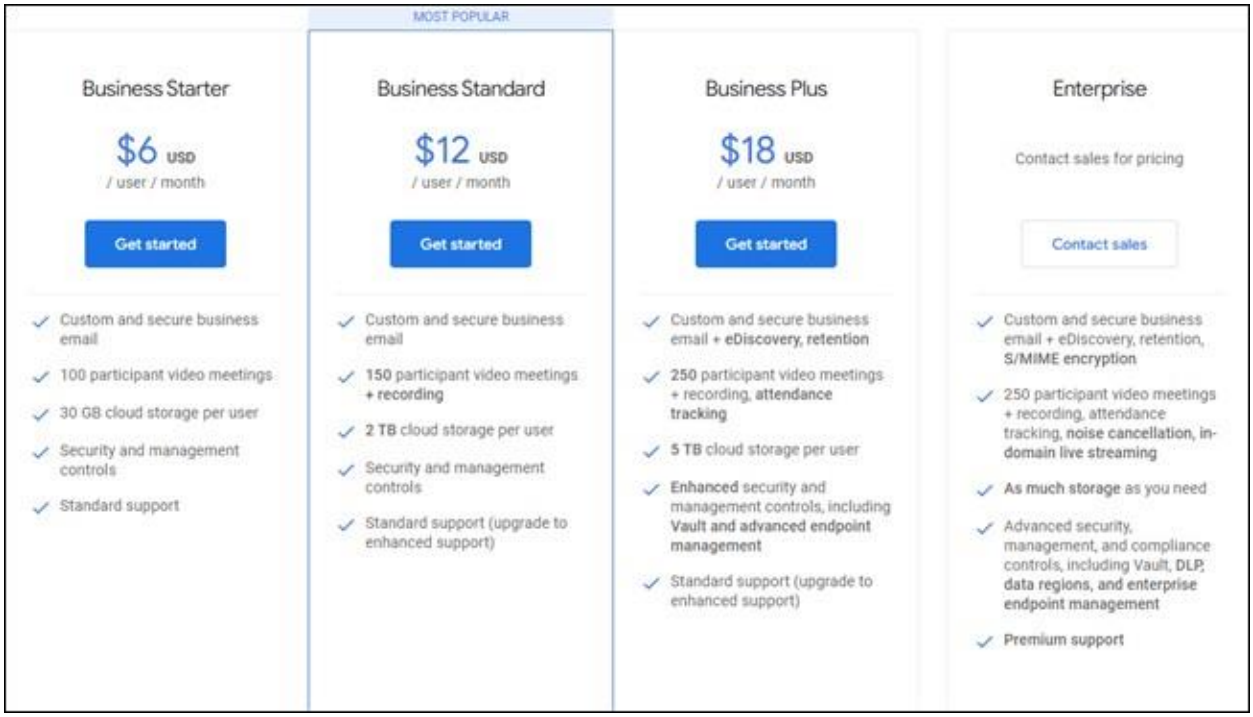
The following offerings are not prominently featured as core Workspace apps, but are often available, depending on the edition of Google Workspace you use. In some cases, these require additional purchases.

- **Groups and Groups for Business**: Email lists and access management
- **Cloud Search**: Search across your Google Workspace
- **Vault**: Data retention and eDiscovery
- **Jamboard/Jamboard hardware**: Collaborative visual board (jam.new)

- **Voice**/**Voice hardware**: Virtual phone system
- **Apps Script**: Business process automation
- **AppSheet**: No-code application development
- **Classroom**: Structured learning spaces for teachers and students
- **Domains**: Domain registration with integrated Google Workspace sign-up and configuration

Costing

Google Workspace is not a free service, though all the tools available in Workspace do have free consumer versions. There are a few different pricing tiers to match the needs of your organization. At the time of writing, the pricing breaks down as follows:



At the bare minimum, everyone in the Workspace gets a custom and secure business email address, video meetings, cloud storage, and support. From there, it depends on how large your organization is and what advanced features you want.

Advantages and Disadvantages

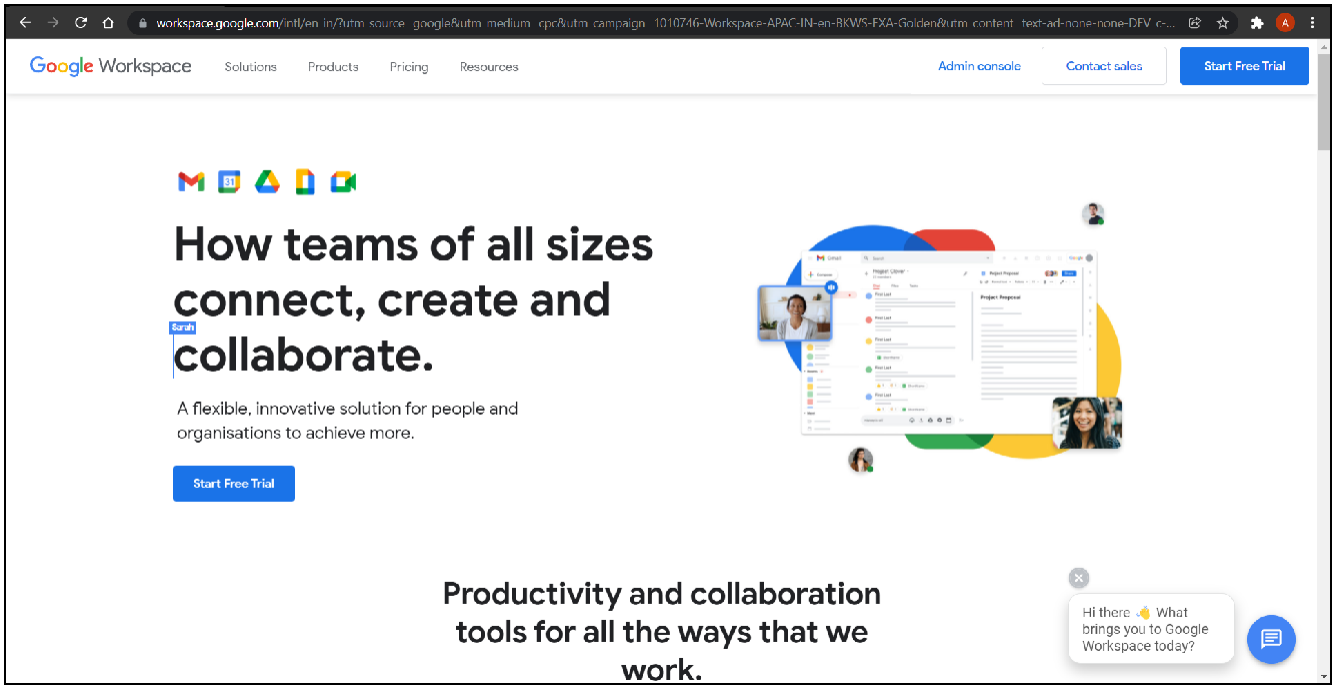
The advantages of using G-Suite are as follows :

- ➔ Sites: A nice side feature is Google Sites, an in-built website creation tool for G Suite. Users can leverage Sites to create their own web portals, whether an internal corporate website or a front-facing normal site.
- ➔ Familiarity and Ease of Use: Most people are familiar with at least one Google app. One of the best things the company has done is use a clean universal UI design language throughout its tools. This design ethos is based on making usability as seamless for the user as possible. G Suite is probably the easiest productivity platform to get to grips with.
- ➔ Uptime: It's hard to argue with a service that always has a connection. G Suite's uptime is well known amongst businesses as one of the most reliable productivity tools on the market. Google promises a 99.9% uptime Service Level Agreement (SLA) and often surpasses that commitment.
- ➔ Affordability: G Suite is available across three price tiers and each is competitive against rivals like Office 365. It's also worth remembering most G Suite apps are available to use for free, without some business-centric abilities.
- ➔ G Suite users have at their disposal an array of Google's apps. Some of these, such as Gmail, Calendar, Drive, Search, and Maps are simply the best versions in their areas.
- ➔ G Suite's always connected nature means working on projects is a dream. As mentioned, the ability to use Google Drive to tap into content across an organization makes collaboration extra efficient.
- ➔ In many ways, G Suite feels like it was built to be a dream for companies that want deep collaboration. It is based on the cloud and is constantly connected to Drive, Google's cloud storage and file sharing platform. This means there is no downtime and team members can tap into work and share it at any time.
- ➔ Gmail needs little introduction. It is the world's most popular email client and backs up its market position with excellent security tools, an easy-to-use UI, and plenty of features that make it a great choice for business and personal use.

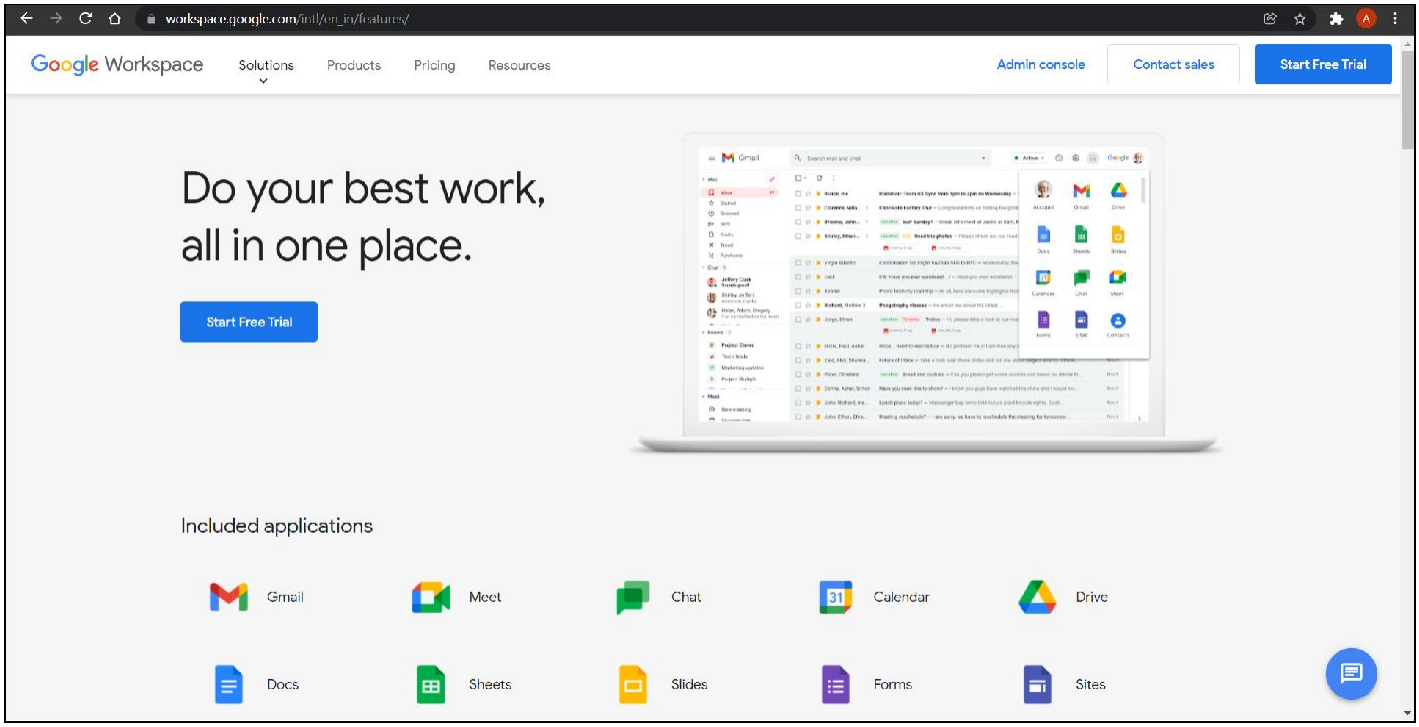
The disadvantages of using G-Suite are as follows :

- ➔ Google Meet is an immensely popular video communication and collaboration tool that more than 100 million people use. Let's be clear, Meet is an amazing tool and G Suite users are hardly going to be disappointed by it. That said, it is still not quite as robust as some rivals.
- ➔ G Suite is also not quite as friendly to third party apps for collaboration as it could be.
- ➔ Google has made updates to improve the offline functionality of G Suite's apps, but Microsoft Office remains ahead in their offline capabilities since it was originally developed for offline work saved to your PC.
- ➔ It would be wholly unfair to call any G Suite apps bad. In fact, all of them are excellent to outstanding. That said, there are some tools where Microsoft Office remains arguably the better option. For example, Microsoft Word, Excel, and PowerPoint are still better than G Suite's Docs, Sheets, and Slides tools. However, these are fine margins.

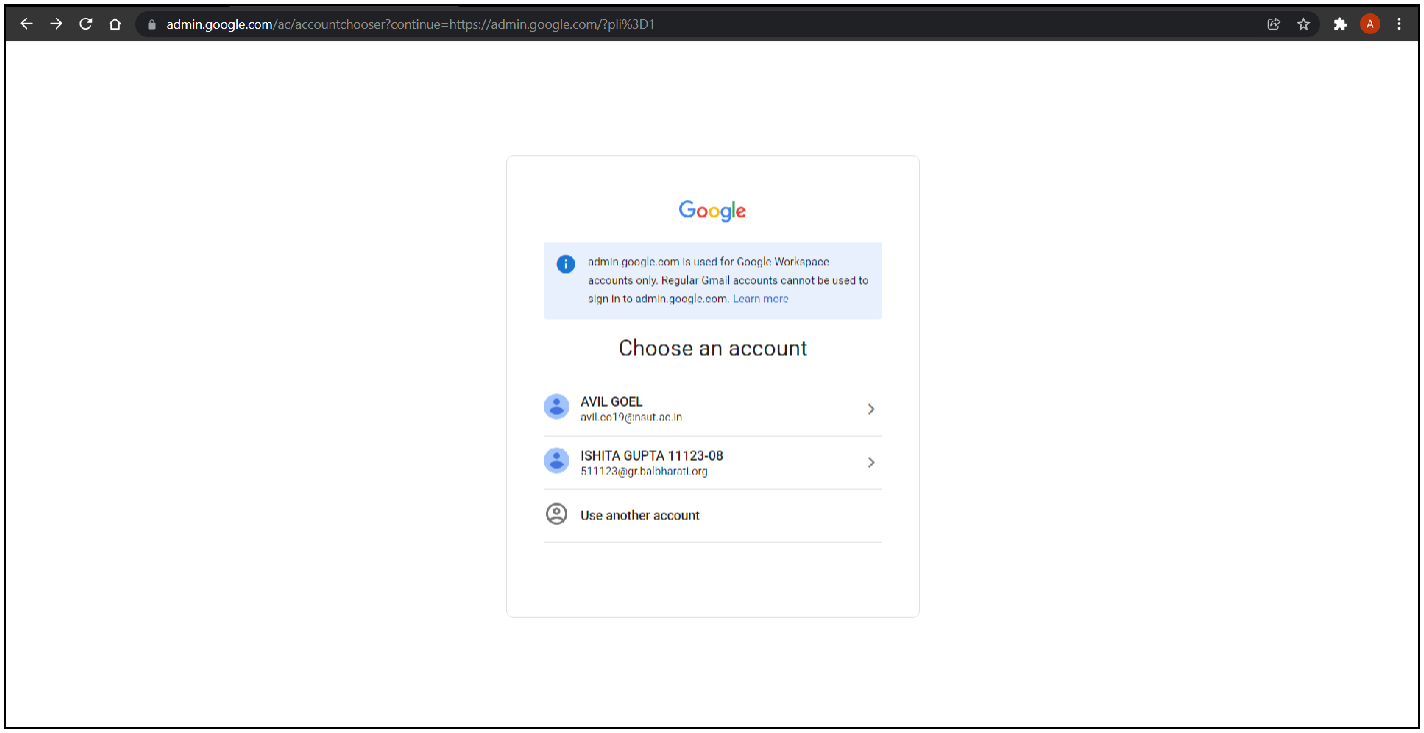
Hands-On Experience



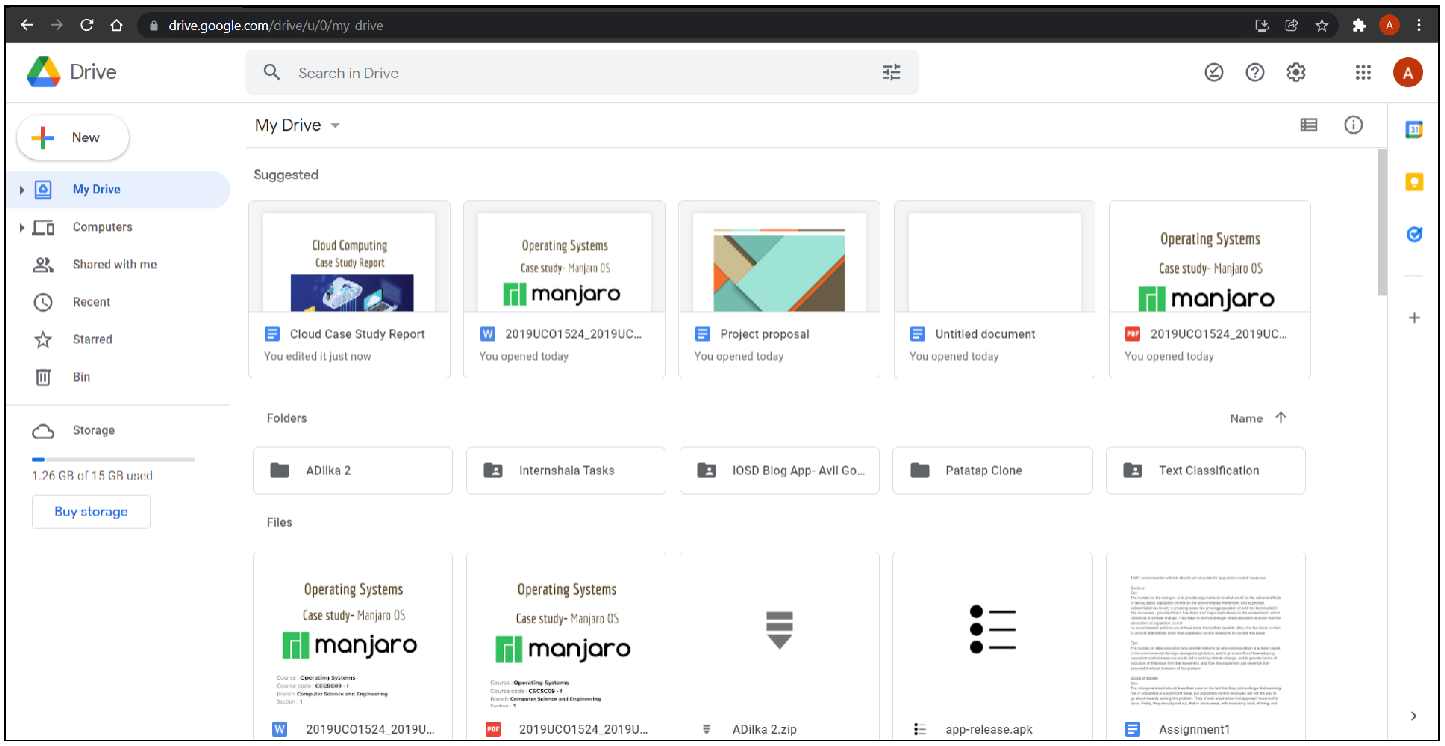
G Suite Landing Page



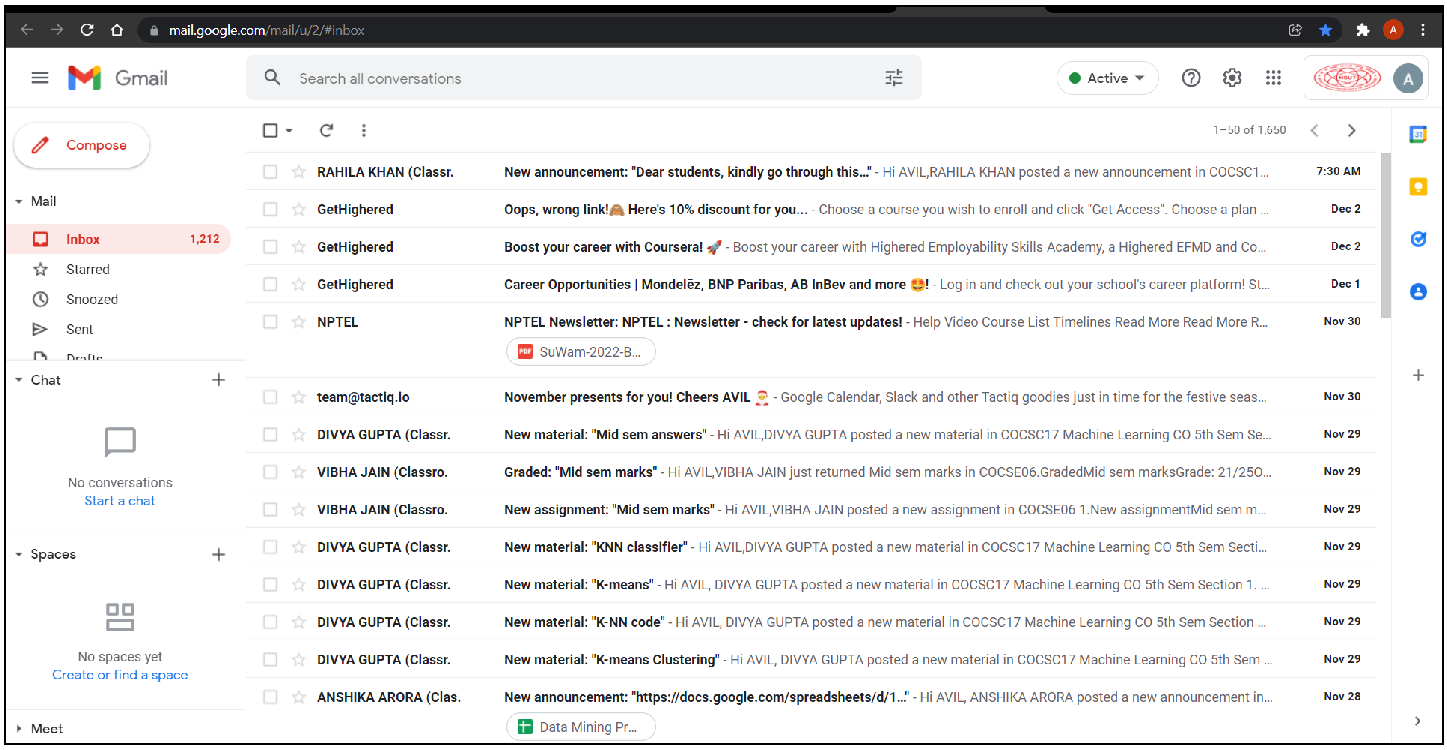
Services offered by G Suite



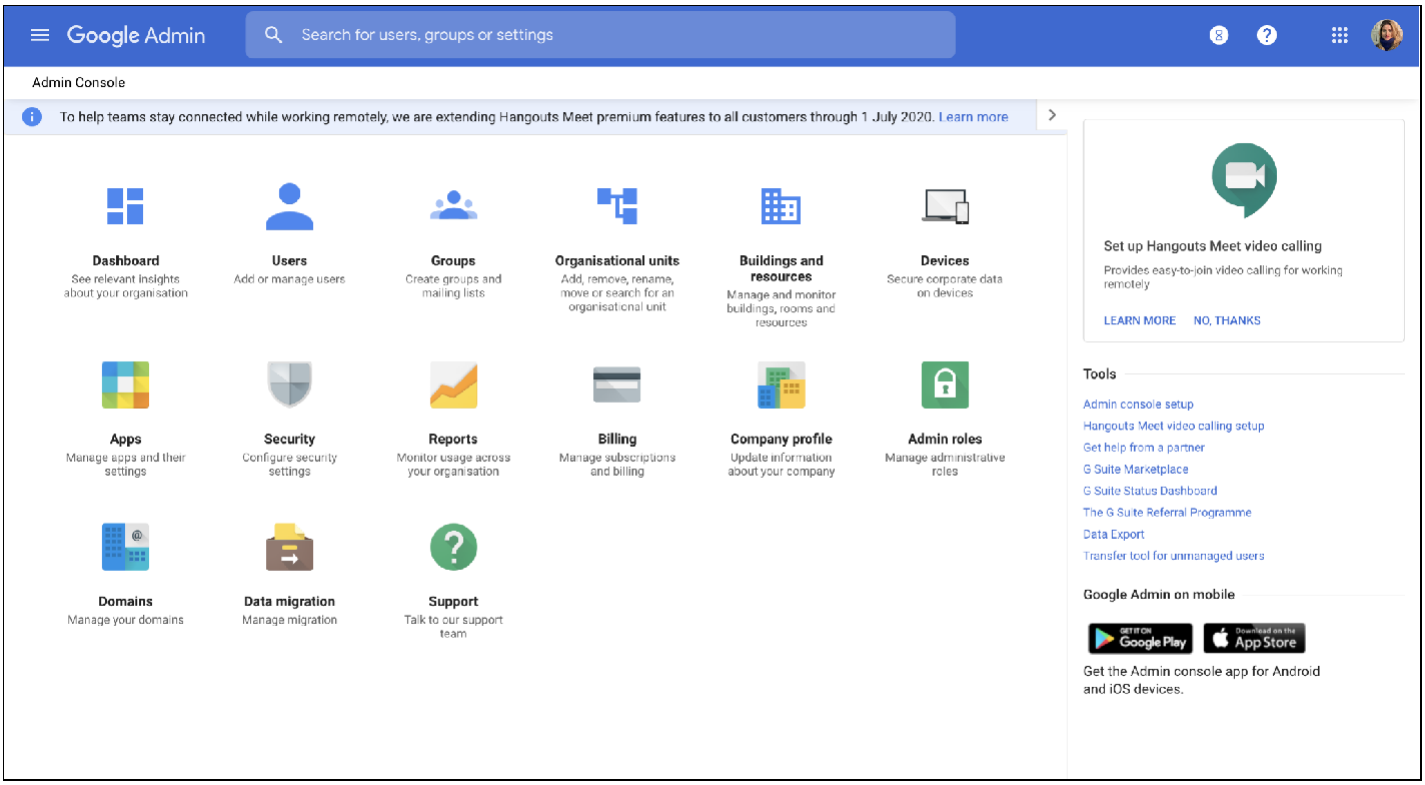
G Suite Login Page



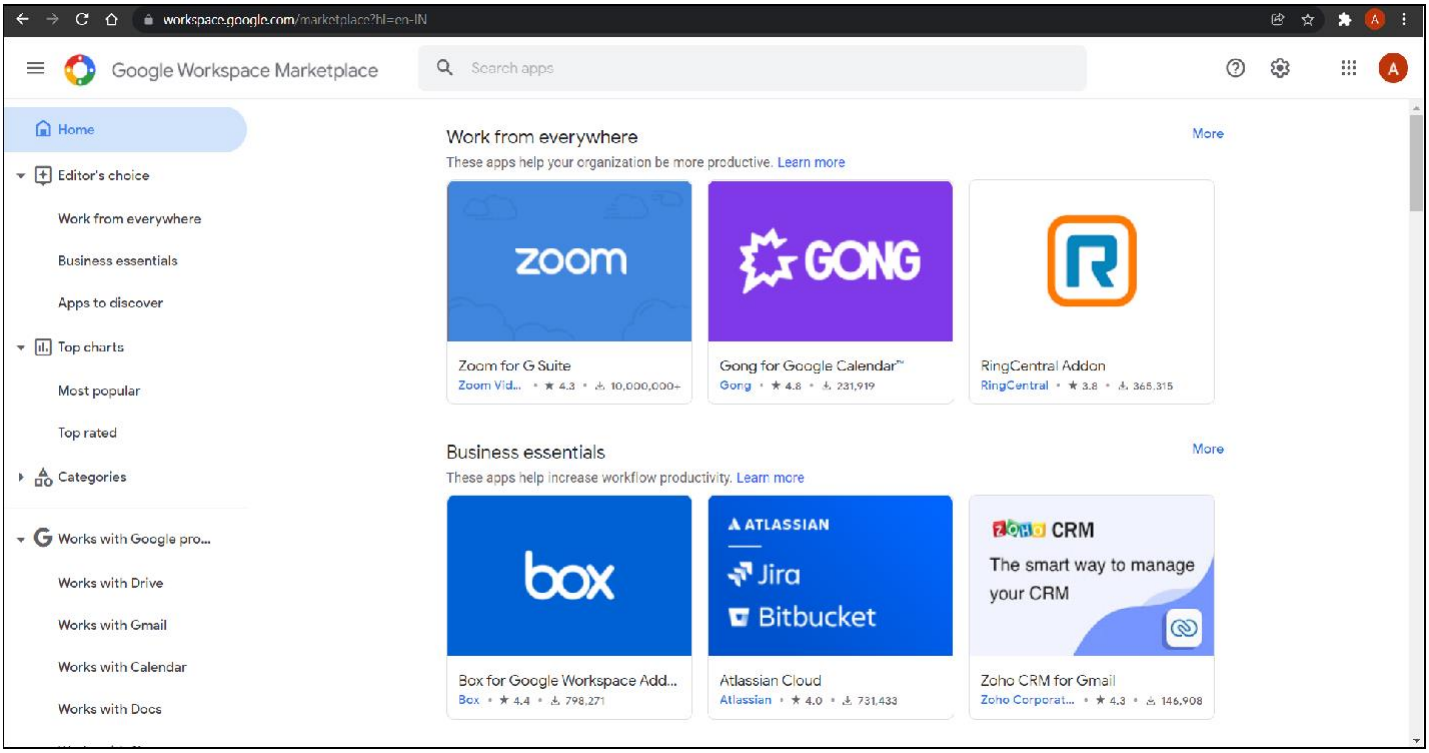
Google Drive- The Storage Service offered by G Suite



Gmail- The Email Service offered by G Suite



Admin Console for G Suite



Marketplace offered by Google Workplace

VMware

Introduction

The VMware Cloud Provider Program is a global network of approximately 4,000 service providers who have built their cloud and hosting services on VMware software. These service providers deliver world-class cloud and hosting services to their customers across the globe, offering value-add and differentiated services that support a wide choice of compliance requirements, performance, scale, market coverage, functional features, and so on. In this way, service providers give existing and new VMware enterprise customers many options when they choose to build out their unified hybrid cloud strategy.

The intended audience includes the following roles:

- Service Providers of VMware powered cloud services.
- Architects and planners responsible for driving architecture-level decisions.
- Technical decision makers who have business requirements that need IT support.
- Consultants, partners, and IT personnel who need to know how to create a service definition for their VMware powered cloud services.

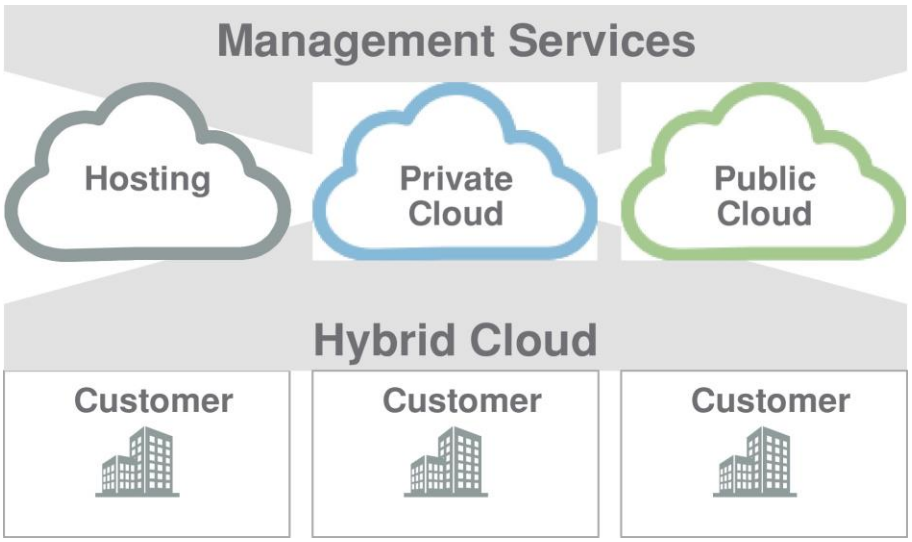
A VMware Powered Public Cloud Is typically built with the following core principles:

- The cloud service must be built with VMware vSphere and VMware vCloud Director at its core.
- The vCloud APIs must be exposed to the cloud tenants.
- Cloud tenants must be able to upload and download virtual workloads packaged with the Open Virtualization Format (OVF) version 1.0.

Deployment Model

Service providers typically have three different cloud deployment models that they can offer to their customers:

- **Hosting (managed or unmanaged)** – VMware Cloud Provider Program Powered Hosting Services offer all the benefits of a dedicated software-defined data center and are engineered on VMware vSphere to be fully compatible with customers' on-premises vSphere environments. This offers a unified hybrid cloud experience with the same advantages of improved availability, recoverability, performance and scalability to run your business critical applications with confidence. The hosting solution can either be managed by the provider or self-managed.



- **Private Cloud (managed or unmanaged)** – VMware Cloud Provider Program Powered Private Cloud Services are engineered on VMware vRealize® Suite, and is fully compatible with customers' on-premises vSphere environments. This provides a unified hybrid cloud experience and dedicated software-defined data centers, offering the required self-service consumption, availability, performance, and scalability to run your business critical applications in the cloud. The private cloud solution can either be managed by the provider or self-managed.
- **Public Cloud** – VMware Cloud Provider Program Powered Public Cloud Services are engineered on VMware vCloud Suite with vSphere and VMware vCloud Director at the core. This unique combination provides complete multi-level security and a multi-tenant architecture that reduces complexity and supports policy implementation that can be consistent with your internal data center and vCloud Air, offering a unified hybrid cloud experience to the consumers.

All three models can be complimented with associated management services. The service provider can offer managed services on top of their core IaaS, PaaS, or SaaS offerings, such as:

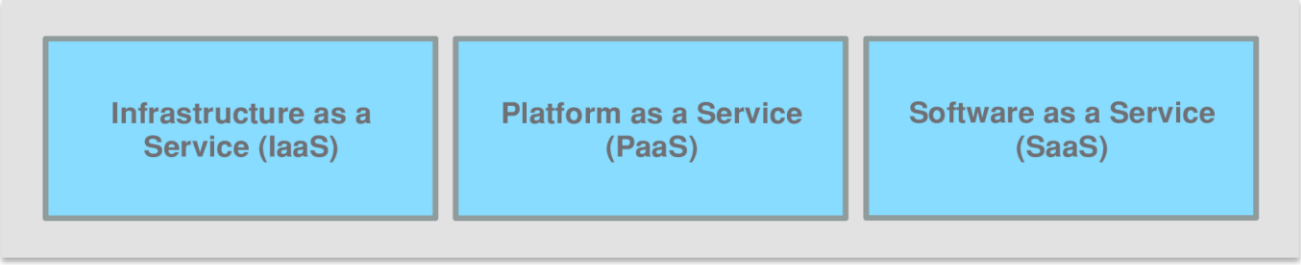
- Professional services (managed creation)

- Patching
- SLAs
- Recoverability options
- Monitoring capabilities

Service Model

Based on the hybrid model above, public cloud service can offer a multitude of services to customers. Typically, services can fall under one of three service models. VMware defines these service layers as:

- **Infrastructure as a Service (IaaS)** – Infrastructure containers are presented to consumers to provide agility, automation, and delivery of components.
- **Software as a Service (SaaS)** – Business-focused services are presented directly to the consumer from a service catalog.
- **Platform as a Service (PaaS)** – Technology-focused services are presented for application development and deployment to application developers from a service catalog.



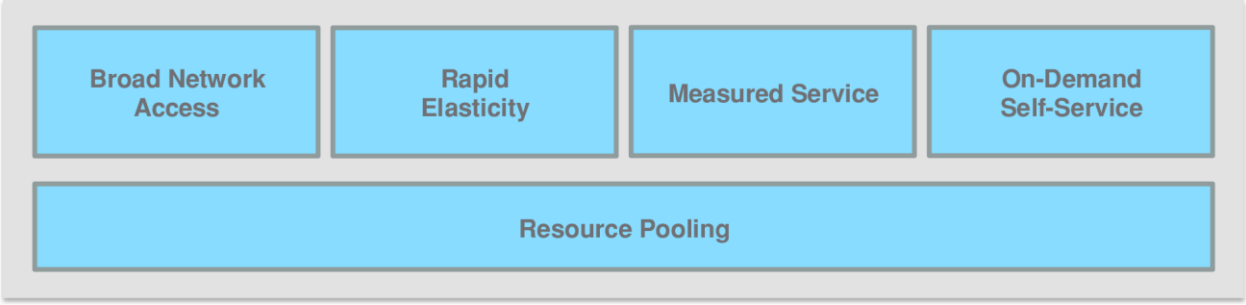
This service definition primarily focuses on Infrastructure as a Service. A service provider can, however, include additional "as a Service" offerings on top of the core cloud platform.

Services Characteristin

The NIST defines the following essential cloud service characteristics:

- **Broad network access** – Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin-client or thick-client platforms.

- **Rapid elasticity** – Capabilities can be provisioned to scale out quickly and to be released rapidly, in some cases, automatically. Rapid elasticity enables resources to both scale out and scale in quickly. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.
- **Measured service** – Cloud systems automatically control and optimize resource usage by leveraging a metering capability at a level of abstraction appropriate to the type of service. Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and the consumer of the utilized service.
- **On-demand self-service** – A consumer can unilaterally automatically provision computing capabilities as needed without requiring human interaction with each service's provider.
- **Resource pooling** – The provider's computing resources are pooled to serve multiple consumers, using a multi-tenant model with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. A sense of location independence results because the subscriber generally has no knowledge of or control over the exact location of the provided resources, but the subscriber might be able to specify location at a higher level of abstraction.



To deliver business solutions using VMware public cloud services, the cloud infrastructure must have the following additional essential characteristics:

- **Standardized** – Homogeneous infrastructure delivered as software services across pools of standard x86 hardware. Homogeneity eliminates unnecessary complexity caused by operating system silos and the redundant tools and skill sets associated with them. It also eliminates costly, special-purpose hardware and enables a single, scalable approach to backup and recovery.
- **Holistic** – A platform optimized for the entire data center fabric, providing comprehensive infrastructure services capable of supporting

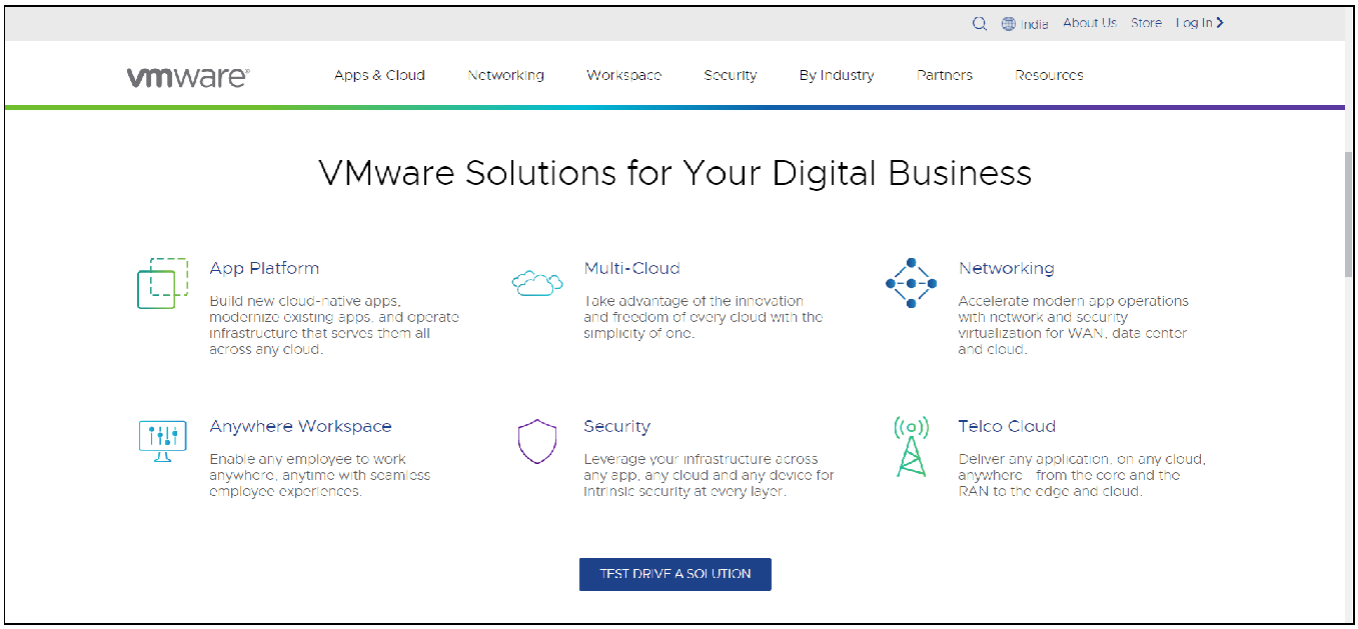
any and all applications. A holistic infrastructure can support any workload, with complete flexibility to balance the collective application demands, eliminating the need for diverse technology stacks.

- **Adaptive** – Infrastructure services are provided on demand, unconstrained by physical topology and dynamically adapting to application scale and location. The infrastructure platform configures and reconfigures the environment dynamically, based on collective application workload demands, enabling maximum throughput, agility, and efficiency.
- **Automated** – Built-in intelligence automates provisioning, placement, configuration, and control, based on defined policies. Intelligent infrastructure eliminates complex, brittle management scripts. Less manual intervention equates to scalability, speed, and cost savings. Intelligence in the infrastructure supports cloud scale operations.
- **Resilient** – A software-based architecture and approach compensates for failing hardware, providing failover, redundancy, and fault tolerance to critical operations. Intelligent automation provides resiliency without the need for manual intervention.

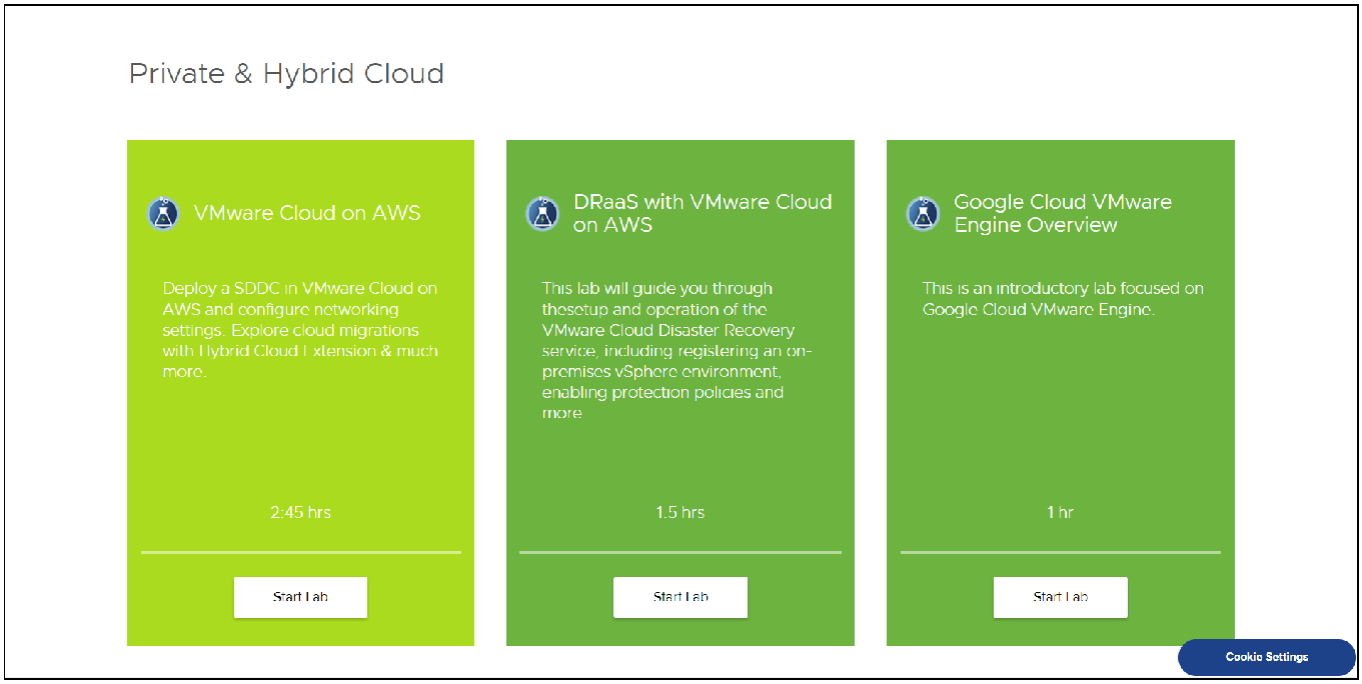
Service Type	Service Description
Operating systems	Microsoft Windows server
	RHEL
	CentOS
	SUSE Linux Enterprise Server (SLES)
	Ubuntu server

Infrastructure services	Databases
	Microsoft SQL
	Oracle databases
	MySQL
	Distributed data management: VMware vFabric® GemFire®
	Web application servers
	Microsoft IIS
	VMware vFabric tc Server
	Apache Tomcat
	IBM WebSphere application server
	Tiered applications:
	2 / 3 tier applications (web, application, database with networking and security)
	Networking services
	Edge routers, NAT, FW, routing, and so on
	Load-balancing services (VMware NSX or third party)
	Horizon DaaS
	DR services
	DRaaS
Application frameworks	Tomcat/Spring
	JBoss
	Cloudera/Hadoop
Business applications	Microsoft SharePoint
	Microsoft Exchange
Professional Services	Architecture and Design
	Configuration Services
	Integration Services

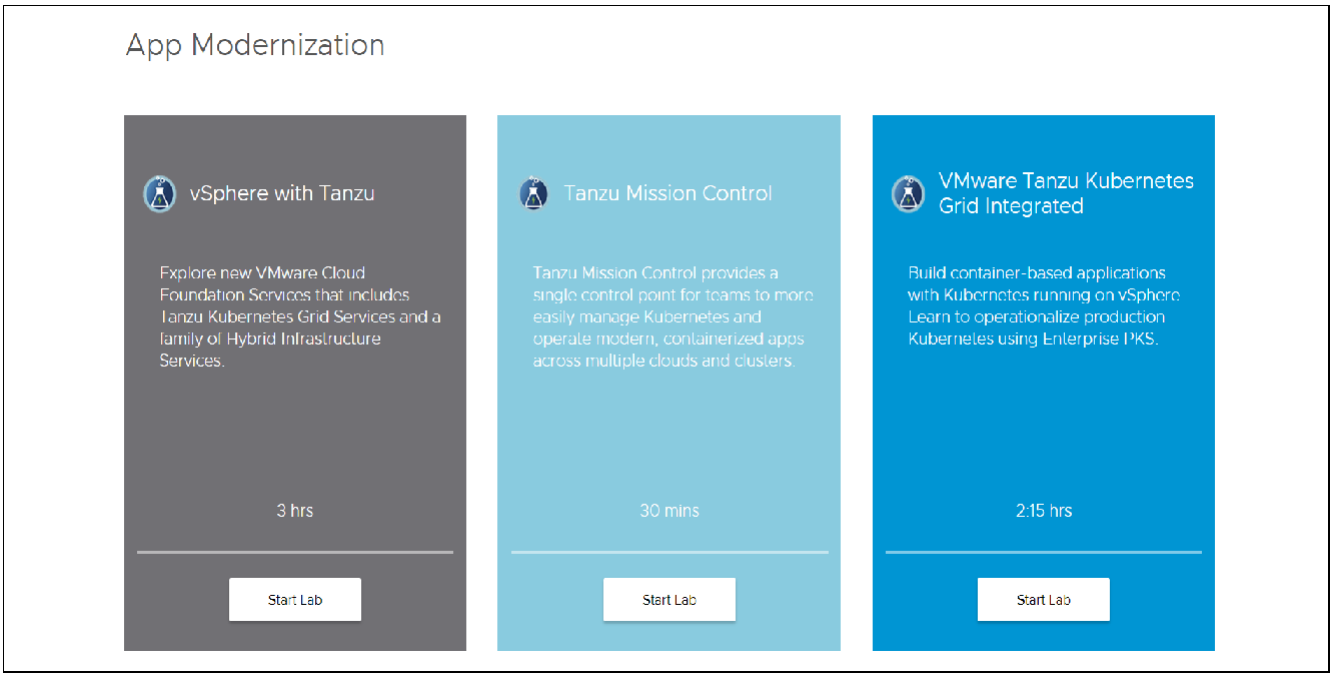
Hands-On Experience



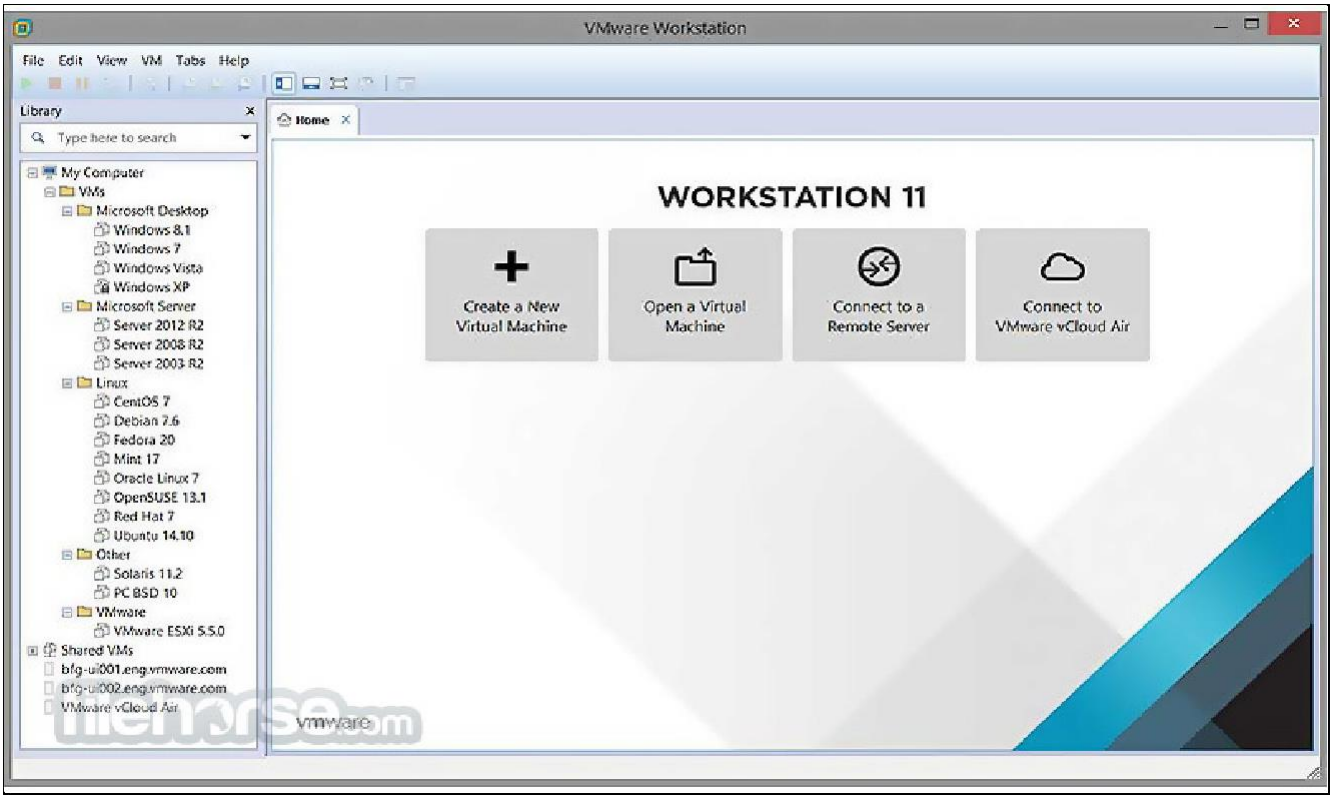
VMware Landing Page



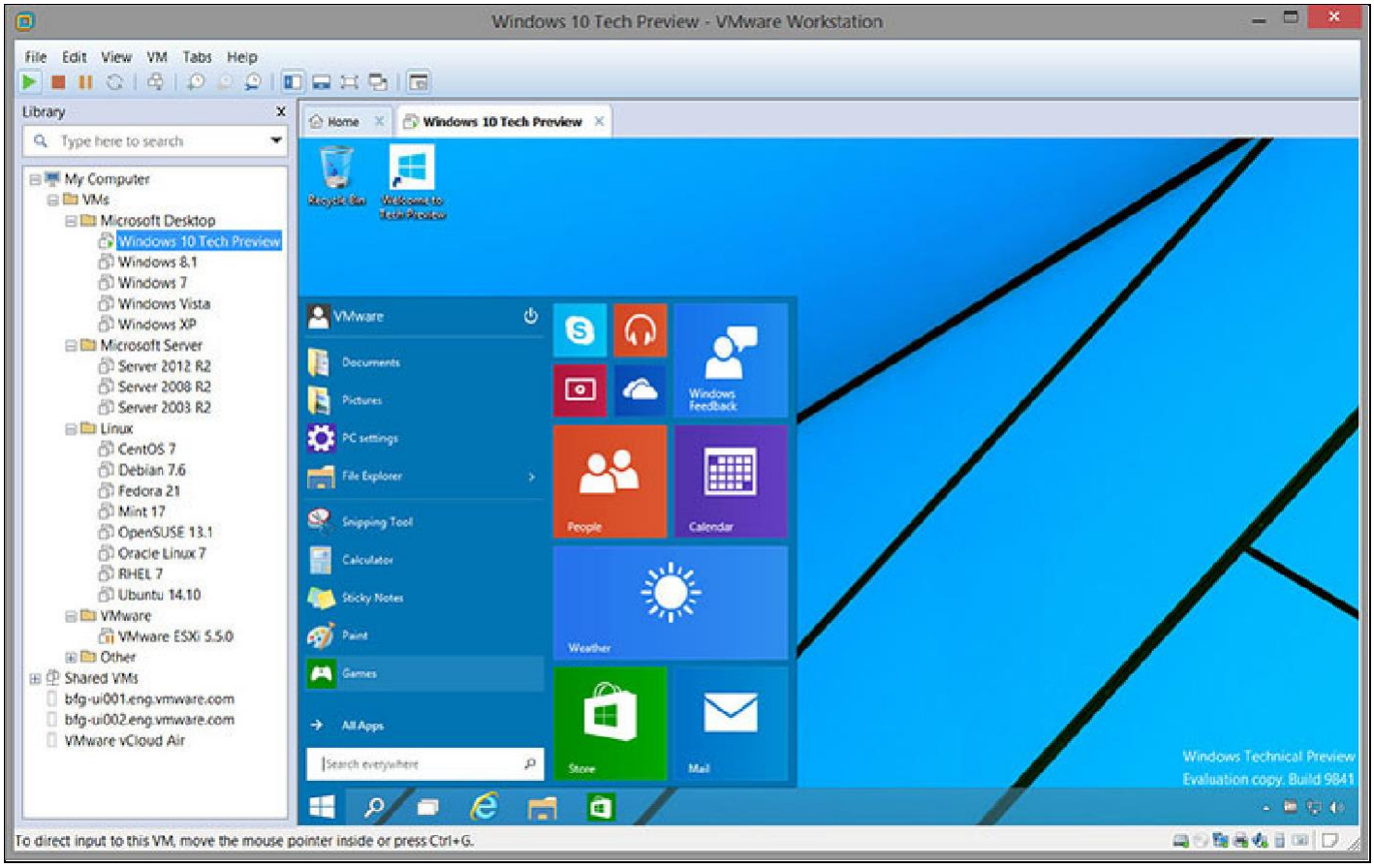
Services Offered by VMware



Additional Services Offered by VMware



Workstation in VMware



Windows 10 running in VMware virtual machine

Meghraj

Introduction

Meghraj is the cloud service provided by the Government of India through National Informatics Centre Services (NICS) under its GI cloud (Government of India Cloud) initiative. It was developed with the aim of providing cloud services through a common platform to all the government officials and departments at every level of government, from the central to the local level, so that the push towards e-governance under Digital India initiative is facilitated. A common cloud platform can enable local governments and it's instrumentalities to adopt e-Governance for rendering better citizen services, without requiring the setting up of significant IT infrastructure.

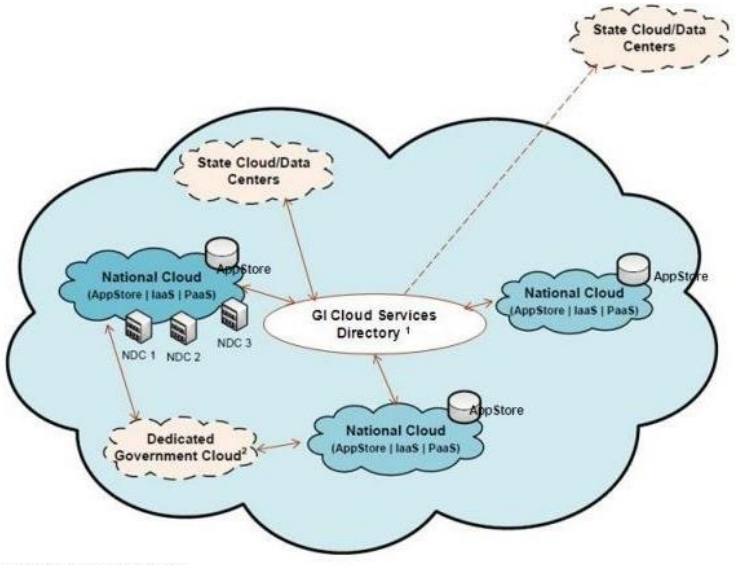
The National Cloud Initiative also presents an opportunity for India's Information Technology (IT) & IT Enabled Services (ITeS) sector by opening up a new avenue of providing Cloud-based services to global organizations ranging from Software as a Service (SaaS) based application services, providing remote testing and prototyping services in addition to remote application hosting services such as Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

Since it was researched upon about its cost benefits, challenges and feasibility by TRAI in 2012, envisioned in 2013 through two papers by the GOI (*GI Cloud (Meghraj) Strategic Direction Paper* and *GI Cloud (Meghraj) Adoption and Implementation Roadmap*) and launched in 2014, it is still growing and being worked upon actively under the Department of Electronics and Information Technology (DeitY). So far, NIC has set up Data

Centres at Delhi, Hyderabad, Pune and is in the process of setting up a National Data Centre at Bhubaneswar. Besides this, mini Data Centres are operational in all NIC State Centres to cater to the e-Governance requirements at the state level. These Data Centres provide round-the-clock operations and management of systems with onsite skilled personnel. Currently, there are 11 CSPs empanelled with the GoI for providing cloud computing services to government departments which include Microsoft Corporation, Hewlett Packard, IBM India, Tata Communications, Bharat Sanchar Nigam Limited (BSNL), Net Magic IT Services, Sify Technologies and CtrlS Data Centers. As of December 16, 2017, Amazon Web Services (AWS) has already been empanelled, while Microsoft and IBM were added by the third week of December (2017). Bharti Airtel and Reliance Jio — the other two companies are in the process of getting empanelled with the government as CSPs.

Deployment Model

Meghraj is primarily a community cloud deployment with the resources in the data centers on premises owned either by NICS - the cloud service provider - or some other 3rd party whose existing infrastructure has been incorporated into the program to be used for provisioning through the cloud. Access to the cloud resources is available through a secured Virtual Private Network and multi-location cloud based on nodes setup all across india. All the cloud service users (CSUs) - government entities - broadly share a common security policy and guidelines for operation and work towards a shared objective following a set of common protocols and standards.



While new (augmented) infrastructure is being added, primarily, the GI cloud is envisioned to consist of multiple National and State Clouds. The agencies responsible for operating and managing the National and State Clouds may engage Managed Service Providers (MSPs) for managing the respective cloud computing environments. These data centers, adapted for the cloud through infrastructure virtualization, will be connected through existing network infrastructure such as SWAN (State Wide-Area-Network) and National Knowledge Network (NKN), as well as the internet. Based on demand assessment and taking into account security-related considerations, the government may also engage the services of private cloud service providers (CSPs). These allowances and architecture along with the fact that it is hoped in future, cloud services can be provided to global organizations makes it a Hybrid or on the way to Hybrid cloud.

Offered Cloud Services

Platform as a Service (PaaS) :
PaaS provides pre-installed web and database servers so that users can publish and run web applications without worrying about server setup. The servers are pre configured ready with basic security hardening. PaaS services quickly deploying servers and publishing web applications. The OS & Application Software licenses are provided by the cloud service provider (CSP) as part of offering.

Infrastructure as a Service (IaaS) :
IaaS provides users with basic virtual compute infrastructure resources like CPU, Memory, Disk Storage attached to blank VMs allowing installations of OS, using ISOs, from scratch and customizations. However users have to use their own licenses for OS and Application software (if any).

Software as a Service (SaaS) :
This provides on demand software service. SaaS is a software delivery model where users are not responsible for supporting the application or any of the components. The server infrastructure, OS and software is being managed by cloud services. If clients have a web application and want to distribute it to users, using this cloud service allows them to deliver it through Software as a Service.

Storage as a Service (STaaS):
This provides clients with on demand storage of various types including file storage and block storage etc. File and Block storage are methods to store data on NAS and SAN storage systems. Each storage volume can be treated as an independent disk drive and it can be controlled by an external server operating system.

Load Balancer as a Service :
Load balancing Service allows clients to efficiently get incoming network traffic requests distributed across a group of back-end servers (e.g. server farm / server pool). This service is available on demand for critical applications requiring high availability and easy workload manageability.

Resource Monitoring as a Service :
This service helps users monitor the cloud resources utilization and its availability by allowing the analysis of the utilization trends for critical server resources like CPU, Memory, Network I/O etc. This helps them for better capacity planning and providing a better end-user experience.

Vulnerability Assessment Service :
This service helps clients to assess their servers and networks for identifying any security vulnerabilities i.e. threats and risks they pose. A vulnerability assessment process detects and classifies system weaknesses in servers, networks and communications equipment and predicts the effectiveness of countermeasures.

Backup Service :
This service allows clients to backup the data and application code lying inside the cloud servers based on various parameters like frequency, retention period etc.

Application Performance Management (APM) Service :
Application Performance Management (APM) provides the monitoring and management of performance, availability and user experience of software applications. APM strives to detect and diagnose complex application performance problems to maintain an expected level of service.

Data Analytics (DA) as a Service :

Data Analytics as a service (DA-SaaS) refers to the provision of analytics software and operations through web-delivered technologies. These types of solutions offer businesses an alternative to developing internal hardware setups just to perform business analytics.

Agile as a Service :

Agile development is a combination of frameworks, tools and software practices adopted by self-organizing teams for delivering fast paced user centric software solutions. Practices and frameworks touch upon all the aspects of software development from planning (Scrum) to deployment and monitoring (DevOps).

Load Testing as a Service :

Load Testing helps in validating the application design and server infrastructure for expected concurrent user load wherein the system's response is tested under varying load conditions simulating concurrent virtual users accessing the application under test.

Artificial Intelligence as a Service :

Artificial Intelligence (AI) is the simulation of human cognitive processes by machines. For this machine learns from data, both structured and unstructured. AI models can be built using supervised learning, or semi-supervised learning, where the system can be used to search for patterns in the data and cluster them, and in the next stage use such classes for further model training. However, usually users don't have the necessary resources to harness AI because data crunching is a computationally intensive job. This service aims to ease this burden by running these costly computations on the cloud infrastructure.

S3WaaS: Website as a Service :

Website as a Service (WaaS) provides website design, development, hosting, maintenance and updates services through S3WaaS. S3WaaS – Secure, Scalable and Sugamya Website as a Service is aimed at providing GIGW compliant, intuitive, user friendly, high quality, and customizable websites to Government entities. The SaaS model has been developed to Create, Deploy,

Configure and Manage Accessible websites without much effort and technical knowhow. The S3WaaS framework has been deployed on the infrastructure provided by the NIC Cloud.

Public IP Service :
A public IP address is an IP address that can be allocated to any application accessible over the Internet. Users don't have to worry about booking a public IP when using Meghraj as it provides a public IP through its public IP service.

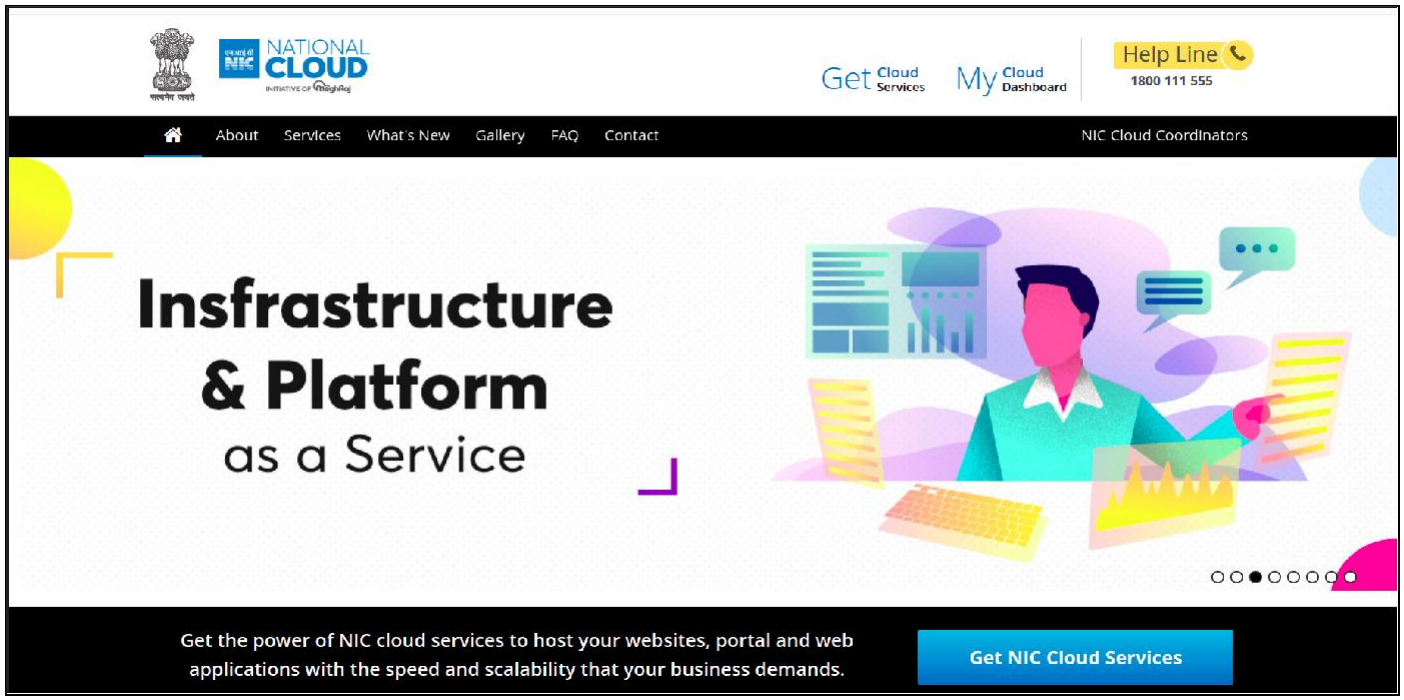
Anti-virus Service :
Virus protection is an important part of keeping the systems, applications and data in a cloud environment safe from viruses, spyware and other malware threats. Antivirus service is made available to cloud users as Managed Service.

Web Application Firewall (WAF) Service :
Web Application Firewall helps give extra protection for HTTP / web based applications by having applied a set of rules to an HTTP conversation and cover common attacks such as cross-site scripting (XSS) and SQL injection.

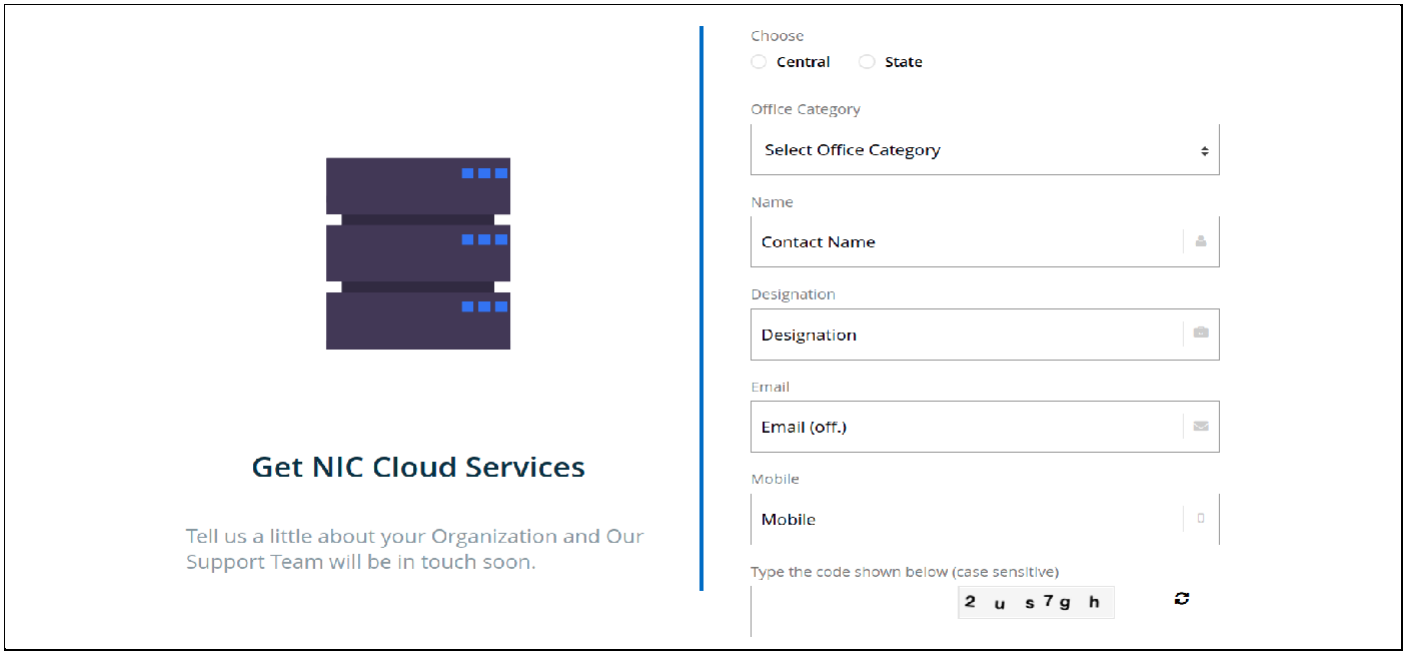
Recently Hosted e-Gov Applications on NIC Cloud

- PM-Kisan Samman Nidhi (Department of Agriculture and Farmer Welfare)
- Sakhi Dashboard (Ministry of Women and Child Development)
- eHRMS (Human Resources Management System, GOI)
- Ministry of Micro, Small and Medium Enterprises Website
- Armed Forces Medical Services Website
- Department of Science and Technology Website

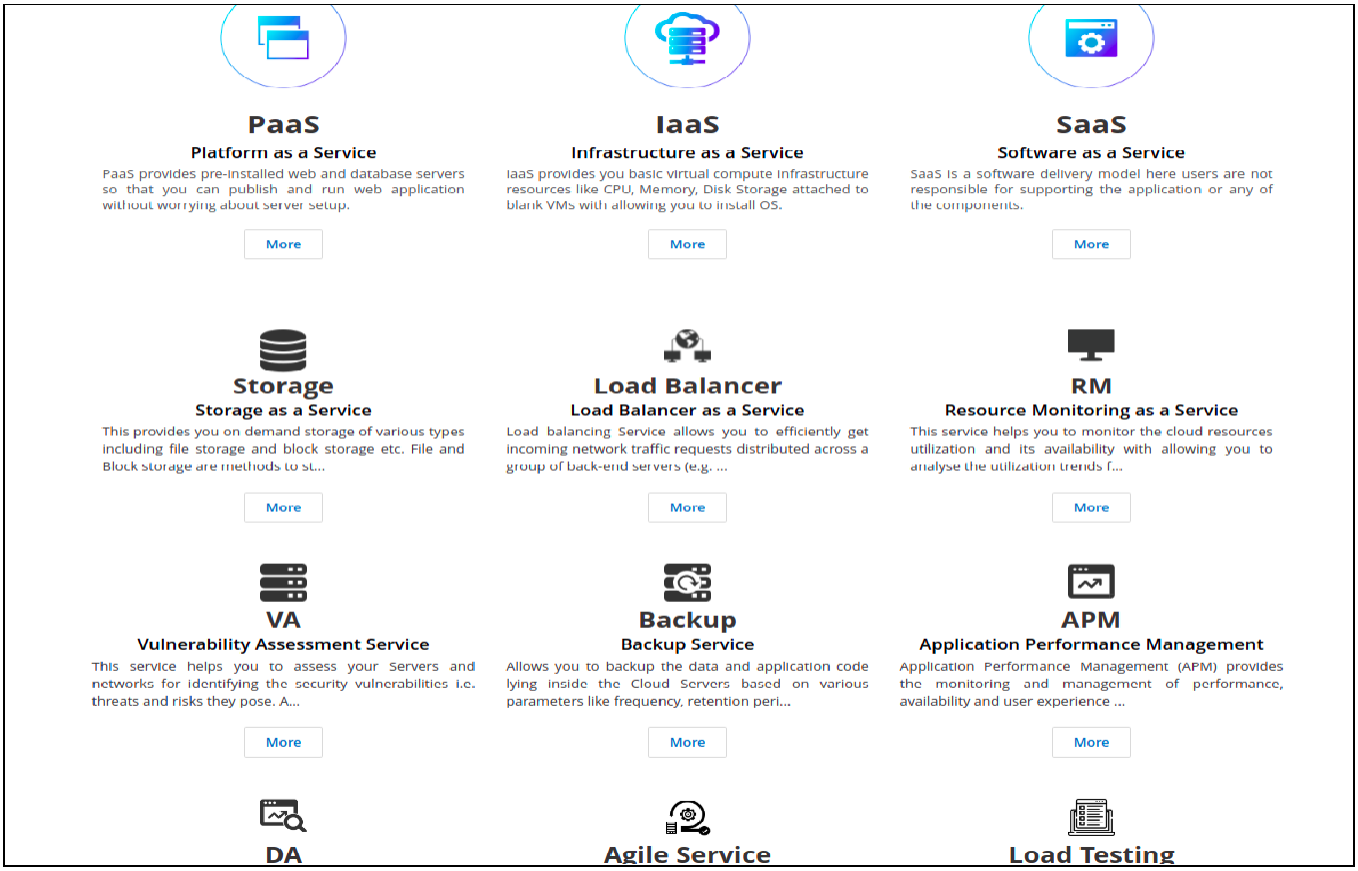
Hands-On Experience



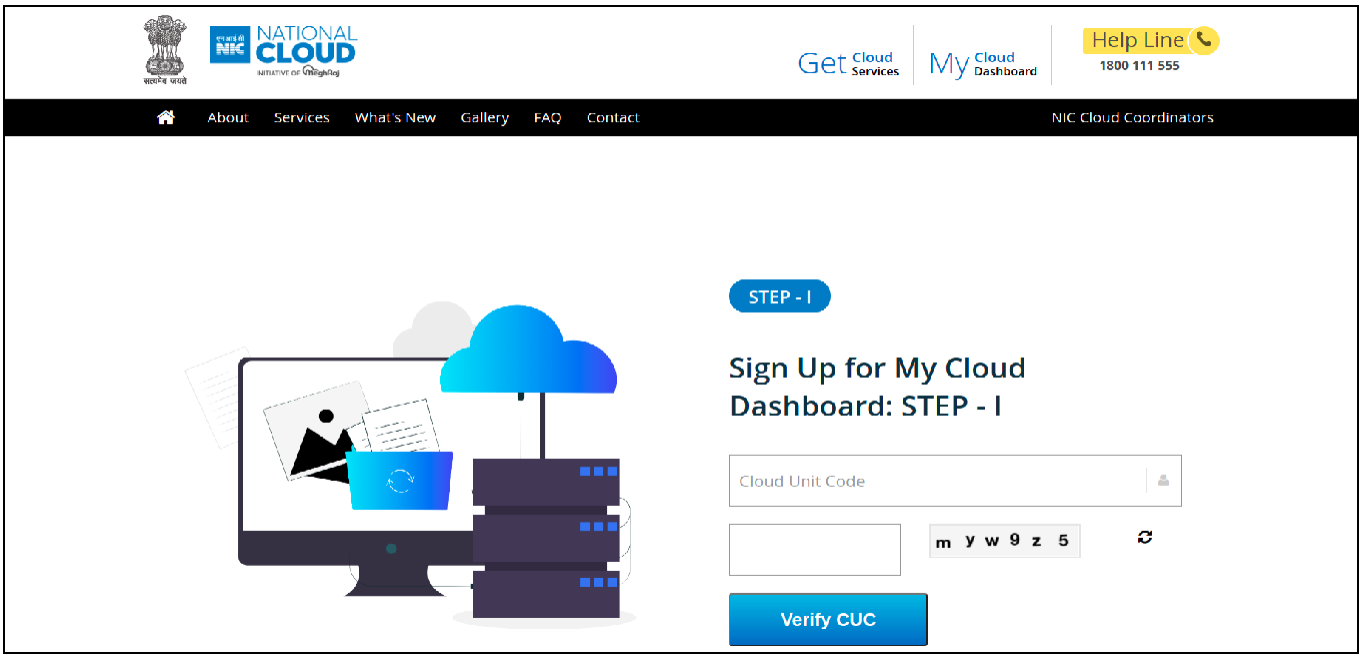
Homepage of cloud.gov.in



Registration page for creating an account on Meghraj for Government Officials and Offices



Services provided by Meghraj



Sign in page for logging into Meghraj