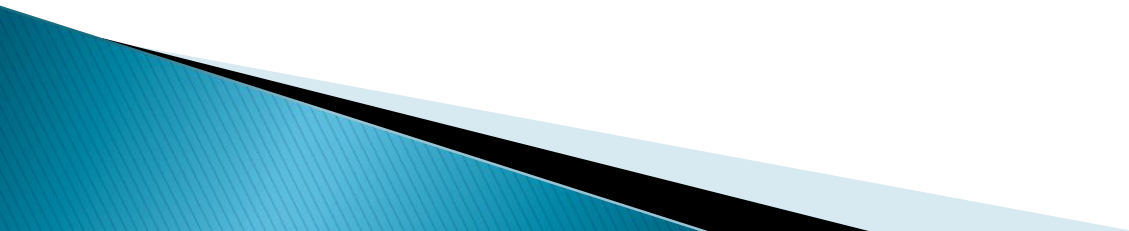


Unit 3

Common Standards and Cloud Platforms



Unit-III

Common Standards: The Open Cloud Consortium, Open Virtualization Format, Standards for Application **Developers:** Browsers (Ajax), Data (XML, JSON), Solution Stacks (LAMP and LAPP), Syndication (Atom, Atom Publishing Protocol, and RSS), Standards for Security.

Amazon web services: Compute services Storage Services Communication Services Additional services

Google AppEngine: Architecture and core concepts, Application life cycle, Cost model

Microsoft Azure: Azure core concepts, SQL Azure, Windows Azure platform appliance

Introduction

- ▶ working group–task groups or technical advisory groups
- ▶ cooperative collaboration of researchers working on new research activities
- ▶ Open Cloud Consortium (OCC)–to support the development of standards for cloud computing and to develop a framework for interoperability among various clouds

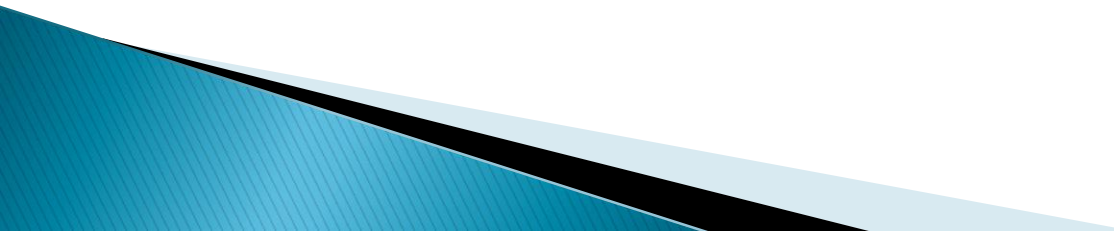
Open Cloud Consortium

- ▶ The Open Cloud Consortium (OCC) is
 - Not for profit
 - Manages and operates cloud computing infrastructure to support scientific, medical, health care and environmental research
- ▶ OCC members span the globe and include over 10 universities, over 15 companies, and over 5 government agencies and national laboratories.
- ▶ The OCC is organized into several different working groups.-Standards and Interoperability for Clouds, Wide Area Clouds and the Impact of Network Protocols on Clouds

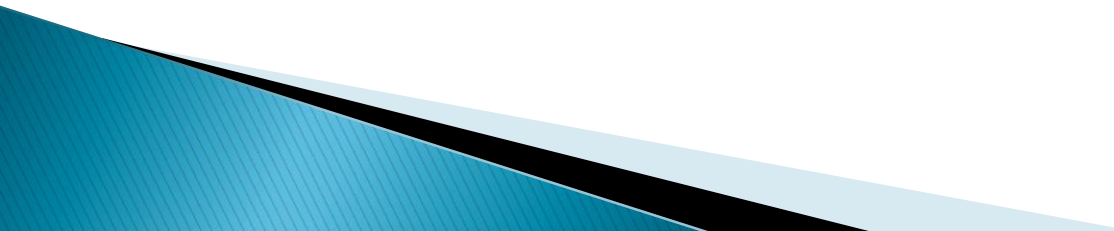
Open Cloud Consortium

- ▶ Support the development of standards for cloud computing and to develop a framework for interoperability among various clouds.
- ▶ The OCC supports the development of benchmarks for cloud computing
- ▶ OCC manages a **testing platform and a test-bed** for cloud computing called the Open Cloud Test-bed. -to improve cloud computing software and services
- ▶ Develops reference implementations, benchmarks and standards, such as the MalStone Benchmark, to improve the state of the art of cloud computing
- ▶ Sponsors workshops and other events related to cloud computing.

Open Cloud Consortium

- ▶ Open Cloud Computing Interface (OCCI) is a set of open standards and specifications developed by the Open Grid Forum (OGF) that defines how various cloud service providers can provision their resources and services to end users.
 - ▶ OCCI's set of features includes implementation, protocol and API stack, all of which provide management-level functionalities for the cloud service.
- 

Open Cloud Consortium

- ▶ www.opencloudconsortium.org / <https://www.occ-data.org/>
 - ▶ Non profit corporation
 - ▶ Supports for the development of standards and reference implementations
 - ▶ Develops benchmarks
 - ▶ Manages testbeds
 - ▶ Manages cloud infrastructure
- 

Open Cloud Consortium

- **Working Group on Standards and Interoperability for Clouds**
 - Provide On-Demand Computing Capacity focuses on **developing standards for interoperating clouds that provide on demand computing capacity.**
 - One architecture for clouds that was popularized by a series of Google technical reports describes a **storage cloud** providing a **distributed file system**, a **compute cloud** supporting MapReduce, and a **data cloud** supporting table services. The open source Hadoop system follows this architecture. These types of cloud architectures support the concept of on demand computing capacity.

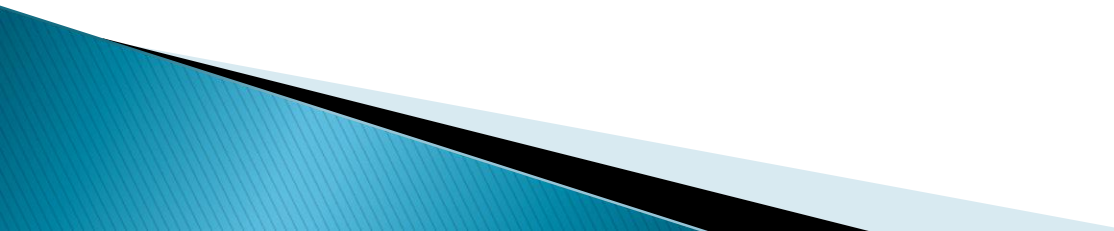
Open Cloud Consortium

- ▶ **Working Group on Wide Area Clouds and the Impact of Network Protocols on Clouds.**
 - The focus of this working group is on developing technology for wide area clouds, including creation of methodologies and benchmarks to be used for evaluating wide area clouds.
 - This working group is tasked to study the **applicability of variants of TCP (Transmission Control Protocol) and the use of other network protocols for clouds.**

Open Cloud Consortium

- **Open Cloud Test-bed**
- -allows researchers to test and evaluate cloud architectures, network protocols, and distributed computing technologies under real-world conditions.
 - uses Cisco C-Wave and the UIC Teraflow Network for its network connections.
 - **C-Wave** makes network resources available to researchers to conduct networking and applications research.
 - no cost to researchers and allows them access to 10G Waves (Layer-1 p2p) on a per-project allocation.
 - provides links to a 10GE (giga-bit Ethernet) switched network backbone.
 - CloudLab (USA) – A flexible testbed for building and experimenting with new cloud architectures.
 - Chameleon Cloud – Supports experiments in edge computing, AI, and cloud security.
 - GENI (Global Environment for Network Innovations) – Focuses on networking and distributed systems research.


Open Cloud Consortium

- ▶ **Teraflow Test-bed (TFT)** is an international application network for **exploring, integrating, analyzing, and detecting changes in massive and distributed data** over wide-area high performance networks.
 - ▶ The Teraflow Test-bed analyzes streaming data with the goal of developing innovative technology for data streams at very high speeds.
 - ▶ It is hoped that prototype technology can be deployed over the next decade to analyze 100-gigabit-per-second (Gbps) and 1,000-Gbps streams.
- 

Open Cloud Consortium

- ▶ C-Wave and Teraflow Test-bed products use wavelengths provided by the **National Lambda Rail (NLR)**.
- ▶ The NLR can support many distinct networks for the U.S. research community using the same core infrastructure. Experimental and productions networks exist side by side but are physically and operationally separate.
- ▶ Production networks support cutting edge applications by providing users guaranteed levels of reliability, availability, and performance.
- ▶ At the same time, experimental networks enable the deployment and testing of new networking technologies, providing researchers national scale test-beds without the limitations typically associated with production networks

Open Cloud Consortium

- ▶ The **Working Group on Information Sharing, Security, and Clouds** has a primary focus on **standards and standards-based architectures for sharing information between clouds**.
 - ▶ This is especially true for clouds belonging to different organizations and subject to possibly different authorities and policies.
 - ▶ This group is also concerned with security architectures for clouds.
 - ▶ An example is exchanging information between two clouds, each of which is HIPAA-compliant, but when each cloud is administered by a different organization.
- 

Open Cloud Consortium

- ▶ **Open Cloud Test-bed Working Group** that manages and operates the Open Cloud Test-bed.
- ▶ For more information on the Open Cloud Consortium, the reader is encouraged to visit the OCC website - <https://www.occ-data.org/>

DMTF-Distributed Management Task Force

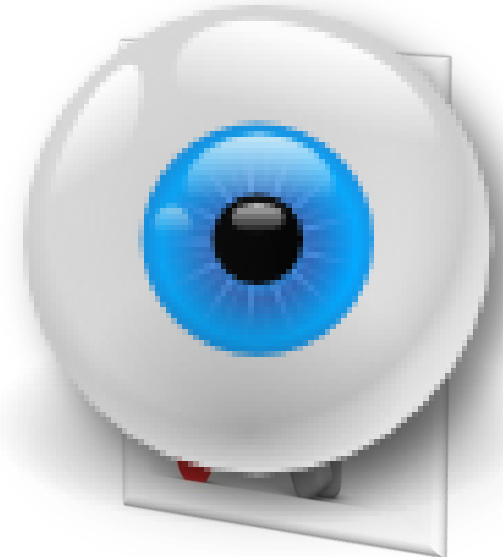
- ▶ Virtualization Management Initiative (VMAN).
- ▶ unleashes the power of virtualization by delivering broadly supported interoperability and portability standards to virtual computing environments.
 - 1. Deploy virtual computer systems
 - 2. Discover and take inventory of virtual computer systems
 - 3. Manage the life cycle of virtual computer systems
 - 4. Add/change/delete virtual resources
 - 5. Monitor virtual systems for health and performance

OVF-Open Virtualization Format

- ▶ new standard that has emerged within the VMAN Initiative
- ▶ A standard for packaging and distributing virtual appliances used in cloud and virtualization environments (e.g., VMware, VirtualBox).
- ▶ simplifies interoperability, security, and virtual machine life-cycle management
- ▶ simplified installation and deployment process.

Standards for Application Developers

- ▶ purpose of application development standards is to ensure uniform, consistent, high-quality software solutions.
- ▶ Programming standards are important to programmers
- Application developers rely on various **standards, protocols, and frameworks** to build scalable, secure, and interoperable web applications.
- AJAX
- XML
- JSON
- LAMP
- LAPP



Standards for Application Developers(Cont'd)

❖ Browsers (Ajax)

❖ Asynchronous JavaScript and XML

❖ It is a technique, not programming language

❖ group of interrelated web development techniques used to create interactive web applications or rich Internet applications

❖ enables asynchronous communication between a web browser and a server.

❖ Allows web pages to update dynamically without requiring a full reload.

❖ This greatly reduces networking bandwidth usage and page load times.

❖ Used in interactive animation on web pages.



Standards for Application Developers(Cont'd)



❖ Data (XML, JSON)

❖ XML(Extensible Markup Language)

❖ A structured, text-based format used for storing and exchanging data between different applications,diff .computer,diff. organization without needing to be converted from one to another.

- Usually combination with other standards.
- you can define the structure (schema) and content (data) separately
- **ability to reuse that content in other applications**

❖ JSON(JavaScript Object Notation)

- A lightweight computer data interchange format
- Preferred over XML in modern web development due to its simplicity and compatibility with JavaScript.
- web APIs, configurations, and databases
- Independent data format

Standards for Application Developers(Cont'd)

❖ Solution Stacks (LAMP and LAPP)

❖ LAMP

- The acronym **L**inux, **A**pache, **M**ySQL, and **P**HP (or Perl or Python)
- **Platform for development and deployment** of high-performance web applications
- Popular-Open source nature, low cost, and the wide distribution of its components
- Used to
 - Run dynamic web sites and servers.
 - Development and deployment of high-performance web applications.
 - Define a web server infrastructure.
 - Creating a programming environment for developing software.
 - Example Use Cases: ✓ WordPress, Joomla, Drupal
 - ✓ Small to-medium web apps
 - ✓ E-commerce (eBay, WooCommerce, Magento)



Standards for Application Developers(Cont'd)

❖Solution Stacks (LAMP and LAPP)

❖LAPP

- LAPP (Linux, Apache, PostgreSQL, PHP/Python/Perl)
- open source web platform that can be used to run dynamic web sites and servers.
- It is more powerful than LAMP stack

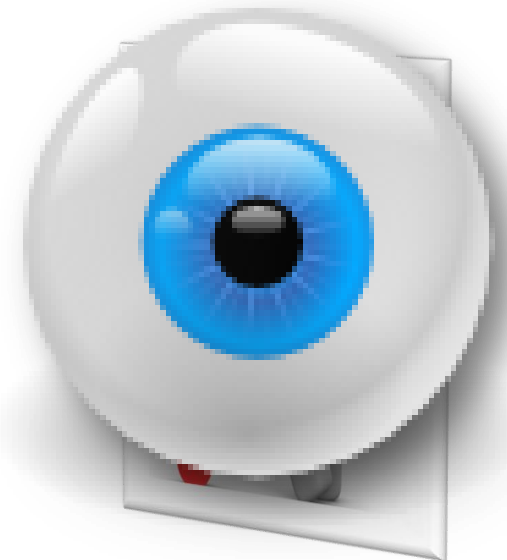
Example Use Cases: ✓ High-traffic websites

✓ Enterprise applications

✓ Geographic Information Systems (GIS)

Standards for Messaging (Cont'd)

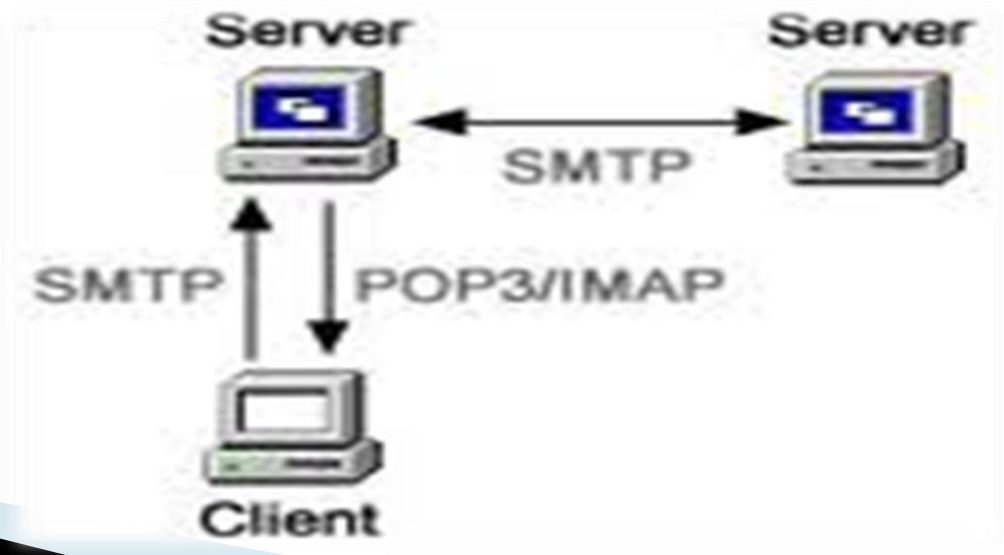
- Messaging protocols play a crucial role in cloud computing, enabling communication between users, systems, and services
- ▶ *Message* is a unit of information that is moved from one place to another.
- SMTP-Simple Message transfer protocol
- POP-Post Office Protocol
- IMAP
- RSS
- Atom & Atom Publishing Protocol
- HTTP, SIMPLE, and XMPP



Standards for Messaging (Cont'd)

❖ Simple Message Transfer Protocol (SMTP)

- FTP-to transmit files as mail/messages,
- so it did not provide any means for recipients to identify the sender
OR VICE ERSA
- SMTP is usually used for:
 - Sending a message from a workstation to a mail server.
 - Or communications between mail servers.
- Client must have a constant connection to the host to receive SMTP messages.



Standards for Messaging (Cont'd)

❖ **SMTP**-Client must have a constant connection to the host to receive SMTP messages.

❖ **Post Office Protocol (POP)**

- Purpose is to download messages from a server.
- This allows a server to store messages until a client connects and requests them.
- Once the client connects, POP servers begin to download the messages and subsequently delete them from the server
 - emails can be accessed offline on the client device.
- Not suitable for multi-device access
- if users move from computer to computer or use mobile networking, since their messages do not automatically move where they go.

❖ **Internet Messaging Access Protocol (IMAP)**-to overcome POP limitation

- IMAP allows messages to be kept on the server.
- But viewed as though they were stored locally.
- **synchronizes them across all connected devices.**



Standards for Messaging (Cont'd)

❖ Syndication (Atom & Atom Publishing Protocol, and RSS)

❖ distributing content (such as news, blogs, and podcasts) to multiple platforms automatically.

❖ RSS

- The acronym “Really Simple Syndication” or “Rich Site Summary”.
- Used to publish frequently updated works—such as news headlines, blogposts
- RSS is a family of web feed formats



❖ Atom & Atom Publishing Protocol

- The Atom format was developed as an alternative to RSS
- designed for creating and editing content (such as blog posts, articles, or files) on a web server.
- APP-HTTP-based protocol that allows creating, updating, and deleting content remotely. It is commonly used in blogging platforms, CMS, and APIs.

Standards for Messaging (Cont'd)

❖ Communications (HTTP, SIMPLE, and XMPP)

❖ HTTP

- The acronym “Hypertext Transfer Protocol.”
- HTTP is a request/response standard between a client and a server
- Stateless
- For distributed, collaborative, hypermedia information systems.
- Not suitable for real time communication

❖ XMPP(Extensible Messaging and Presence Protocol)

- XML-based protocol
- Used for near-real-time, extensible instant messaging and presence information, voice & video calls
- XMPP remains the core protocol of the Jabber Instant Messaging and Presence technology

Standards for Messaging (Cont'd)

❖ Communications (HTTP, SIMPLE, and XMPP)

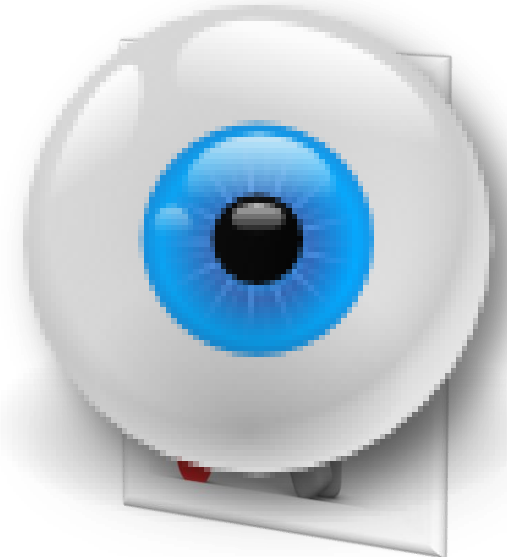
❖ SIMPLE

- Session Initiation Protocol for Instant Messaging and Presence Leveraging Extensions
- Extension of SIP (Session Initiation Protocol)
- XMPP, SIMPLE is an open standard
- For registering for presence information and receiving notifications.
- It is also used for sending short messages and managing a session of real time messages between two or more participants.
- subscriptions, notifications, and publications.



Standards for Security(Cont'd)

- Security in cloud computing is critical to ensure data confidentiality, integrity, and availability.
- Several standards have been developed to help organizations secure their cloud environments, and these standards address various aspects such as data protection, access control, compliance, and risk management.
 - SAML
 - OAuth
 - OpenID
 - SSL / TLS



Standards for Security(Cont'd)

❖SAML

- Security assertion Markup language
- Standard for communicating authentication, authorization, and attribute information among online partners.
- online partners (e.g., identity providers and service providers).
- It allows businesses to securely send assertions between partners.
- widely used for Single Sign-On (SSO), where users can authenticate once and gain access to multiple services without needing to re-enter credentials for each service.
- SAML protocol refers to what is transmitted, not how it is transmitted.
- Three types of statements are provided by SAML:
 - authentication statements,- a user was authenticated at a specific time and by a particular method.(MFA)
 - attribute statements-provides additional user attributes or data that the identity provider knows about the user, like their email, role, or group memberships.
 - authorization decision statements-whether the user is authorized to perform a certain action or access a resource. It is often based on some decision-making process by the identity provider.

Standards for Security(Cont'd)



❖ OAuth(Open Authentication)

- OAuth is a method for publishing and interacting with protected data.
- If you've ever received a message such as, "Sign in with Facebook?" or "Allow this application to access your account?" you've seen OAuth in action.
- For developers, OAuth provides users access to their data .
- OAuth by itself provides no privacy at all and depends on other protocols such as SSL .
- Eq. Giving an app permission to access your Google Drive.
- "Allow Spotify to access your Google Drive"

Standards for Security(Cont'd)

❖ OpenID

- OpenID is an open, decentralized standard for user authentication.
- And allows users to log on to many services using the same digital identity.
- It is a single-sign-on (SSO) method of access control.
- OpenID Connect (OIDC) is actually built on OAuth 2.0.
- OAuth is for authorization, while OpenID is for authentication.
- Eq.Login to google

-

Standards for Security(Cont'd)

❖SSL/TLS (Secure Sockets Layer / Transport Layer Security)

- cryptographic protocols that provide secure communication over the internet.
- TLS is the successor to SSL and is more secure.
- key security properties:
 - Encryption – Protects data from being intercepted.
 - Authentication – Verifies that the website is genuine.
 - Data Integrity – Ensures data is not altered during transmission.
- Always use HTTPS for security!
- They are used to protect sensitive data like passwords, payment information, and other personal information.

Standards Groups (Cont'd)

Standards Organisations	Members
Open Grid Forum	Microsoft, Sun, Intel, HP, AT&T, eBay etc
Cloud Computing Interoperability Forum	Cisco, Intel, Thomson Reuters, Orange, Sun, IBM, RSA etc
Distributed Management Task Force	IBM, Microsoft, Novell, Oracle, Sun, Vmware, EMC etc
Open Cloud Consortium	Cisco, MIT Lincoln Labs, Yahoo, various colleges including University of Illinois etc
Cloud Security Alliance	eBay, ING, Qualys, PGP, zScaler etc
Storage Networking Industry Association	Dell, EMC, Oracle, Juniper Networks, Qlogic, HP, Vmware, Hitachi, NetApp

Standards Groups (Cont'd)

- ▶ Cloud Security Alliance (CSA)
- ▶ Distributed Management Task Force (DMTF)
- ▶ Storage Networking Industry Association (SNIA)
- ▶ Open Grid Forum (OGF)
- ▶ Open Cloud Consortium (OCC)
- ▶ Organization for the Advancement of Structured Information Standards (OASIS)
- ▶ TM Forum
- ▶ Internet Engineering Task Force (IETF)
- ▶ International Telecommunications Union (ITU)
- ▶ European Telecommunications Standards Institute (ETSI)
- ▶ Object Management Group (OMG)

Standards Groups (Cont'd)

Which Organizations doing What?

	SaaS	PaaS	IaaS	DaaS
Provisioning			OGF/DMTF	SNIA
Metering and Billing				SNIA
Security			OGF/DMTF/ CSA	SNIA (IETF)
Privacy				
Quality of Service			DMTF	SNIA
Identity		OASIS		

Standards Groups (Cont'd)

Which Organizations doing What?

	SaaS	PaaS	IaaS	DaaS
Client Application Interface				
Development Platform				
Virtual Machine Interface			DMTF	
Data Storage Interface				SNIA

Some Activities in Cloud Computing Standardization (Cont'd)

❖ **European Telecommunications Standards Institute (ETSI)**

- Looks at commercial trend towards cloud computing with particular emphasis on ubiquitous network access to scalable computing storage resource and IaaS delivery model

❖ **National Institute of Standards and Technology (NIST)**

- Developed a working definition of cloud computing

❖ **Object Management Group (OMG)**

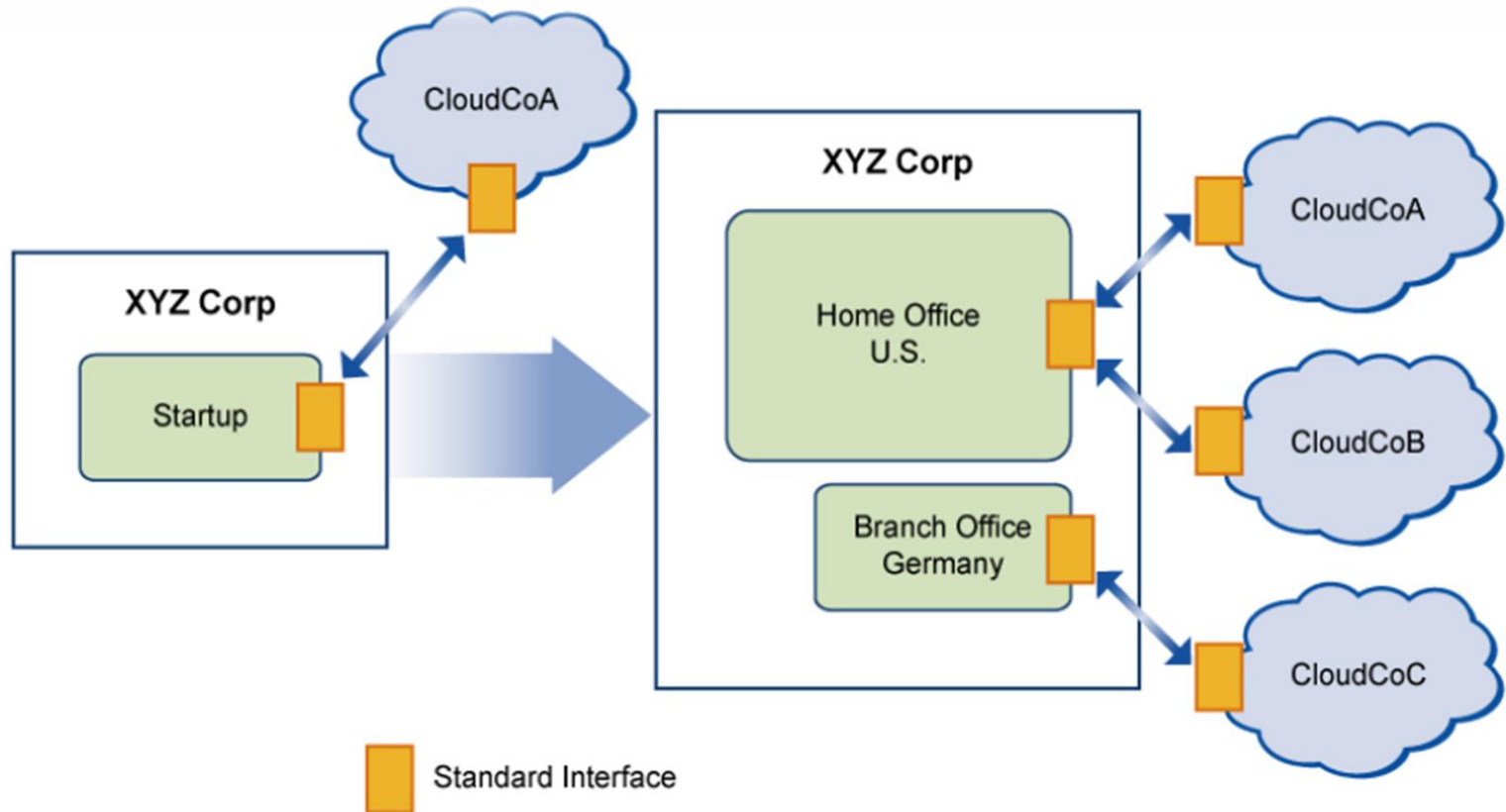
- Focus on modeling deployment of applications & services on cloud for portability, interoperability & reuse

❖ **Storage Networking Industry Association (SNIA)**

- Cloud Data Management Interface, an architecture standard that allows for interoperable cloud storage implementation from cloud service providers and storage vendors

Some Activities in Cloud Computing Standardization (Cont'd)

DMTF Open Cloud Standards Incubator



▶ **DMTF (Distributed Management Task Force)**

- ❑ **Cloud Management Standards** – Enables **interoperability** across cloud platforms.
- ❑ **Virtualization Management** – Defines how virtual machines (VMs) and hypervisors interact.
- ❑ **Security & Networking** – Provides security frameworks for remote management.
- ❑ **System Management** – Creates protocols for managing enterprise hardware & software.

Open Source Cloud Computing System

- ▶ A cloud is a collection of networked resources configured such that users can request scalable resources (VMs, platforms, software services) deployed across a variety of physical resources.
- ▶ Most cloud computing systems are proprietary and rely upon infrastructure that is invisible to the end users.

Cloud Vs Grid

▶ Cloud

- Users get small fraction of resources.
- No support for federation.
- Resources are hidden.

▶ Grid

- Users get higher resources.
- Federation is supported.
- Resources are visible.

Open Source Clouds

- ▶ Commercial cloud service providers charge CPU time and bandwidth.
- ▶ For large organizations, it's more cost effective to purchase the hardware and create own cloud.
- ▶ Researchers and academia need open standards.
- ▶ More secure and flexible.
- ▶ No vendor lock in.

Common features of Cloud Providers

Development Environment:
IDE, SDK, Plugins

Production Environment

Simple storage

Table Store
<key, value>

Drives

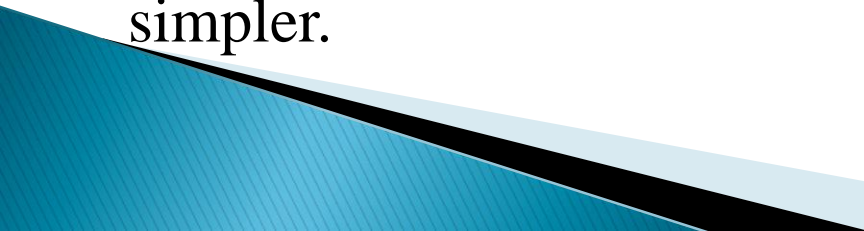
Accessible through
Web services

Management Console and Monitoring tools
& multi-level security

Windows Azure

- ▶ Enterprise-level on-demand capacity builder
- ▶ Fabric of cycles and storage available on-request for a cost
- ▶ You have to use Azure API to work with the infrastructure offered by Microsoft
- ▶ Significant features: web role, worker role , blob storage, table and drive-storage

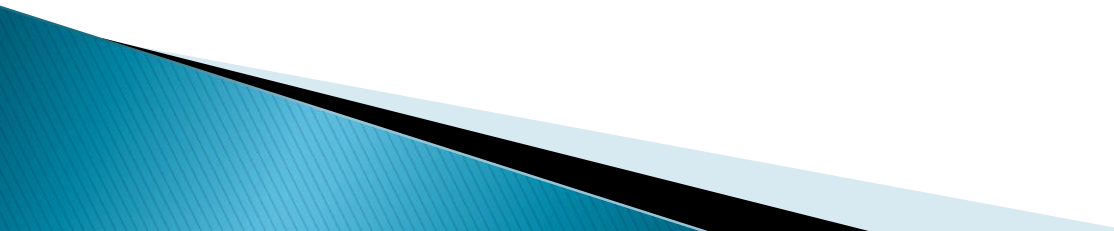
Windows Azure

- ▶ offering Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS)
 - ▶ provides on-demand computing resources such as virtual machines, databases, storage, networking, AI services, and security.
 - ▶ Generally, it is a platform through which we can use Microsoft's resource.
 - ▶ For example, to set up a huge server, we will require huge investment, effort, physical space and so on. In such situations, Microsoft Azure comes to our rescue.
 - ▶ It will provide us with virtual machines, fast processing of data, analytical and monitoring tools and so on to make our work simpler.
- 

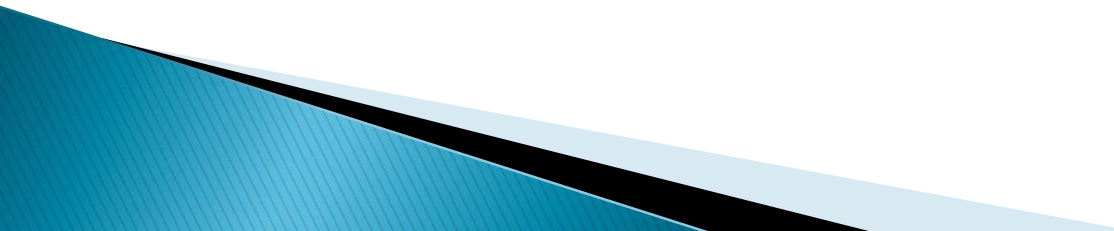
History - Windows Azure

- ▶ Microsoft unveiled Windows Azure in early October 2008 but it went to live after February 2010. Later in 2014, Microsoft changed its name from Windows Azure to Microsoft Azure. Azure provided a service platform for .NET services, SQL Services, and many Live Services. Many people were still very skeptical about “the cloud”.
- ▶ It has two releases as of now. It's famous version **Microsoft Azure v1** and later **Microsoft Azure v2**. Microsoft Azure v1 was more like JSON script driven then the new version v2, which has interactive UI for simplification and easy learning.

Advantages - Windows Azure

- ▶ Capitaless
 - ▶ Less Operational Cost
 - ▶ Cost Effective
 - ▶ Easy Back Up and Recovery options
 - ▶ Easy to implement
 - ▶ Better Security
 - ▶ Increased collaboration
-
- ▶ Azure has 200+ data centers across 60+ regions worldwide.
 - ▶ Provides 99.95% uptime SLA for high availability.
- 

Azure SQL

- ▶ SQL Server on an Azure Virtual Machine is known as **IaaS** or **Infrastructure as a Service**.
 - ▶ As we move towards Azure SQL Database and Azure SQL Managed Instance, we moved towards the territory of **Platform as a Service** or **PaaS** type of offerings.
 - ▶ The one big difference before we get started is that in IaaS or in this case, SQL Server on Azure Virtual Machine, there are a lot of things that you can configure yourself, just like in SQL Server, but with PaaS, there's a lot of automation and help that Azure provides.
- 

Category	Azure Services	Description
Compute	Azure Virtual Machines (VMs)	Deploy Linux & Windows VMs
Containers	Azure Kubernetes Service (AKS)	Manage Kubernetes workloads
Serverless	Azure Functions	Event-driven, serverless computing
Storage	Azure Blob Storage	Store unstructured data (images, videos)
Databases	Azure SQL Database	Managed SQL database
AI & ML	Azure Machine Learning	Train and deploy AI models
Networking	Azure Virtual Network (VNet)	Private network for cloud resources
Security	Azure Security Center	Threat protection & monitoring
Hybrid & Edge	Azure Arc	Manage cloud and on-prem infrastructure

Category

Compute

Networking

Storage

Databases

AI & ML

Security

DevOps

Analytics & Big Data

Internet of Things (IoT)

Hybrid & Multi-Cloud

Identity & Access Management

Popular Azure Services

Azure Virtual Machines (VMs), Azure Kubernetes Service (AKS), Azure Functions

Azure Virtual Network, Load Balancer, Azure Firewall

Azure Blob Storage, Azure Files, Azure Disk Storage

Azure SQL Database, Cosmos DB, PostgreSQL, MySQL

Azure Machine Learning, Cognitive Services, Bot Service

Azure Security Center, Key Vault, DDoS Protection

Azure DevOps, GitHub Actions, Azure Monitor

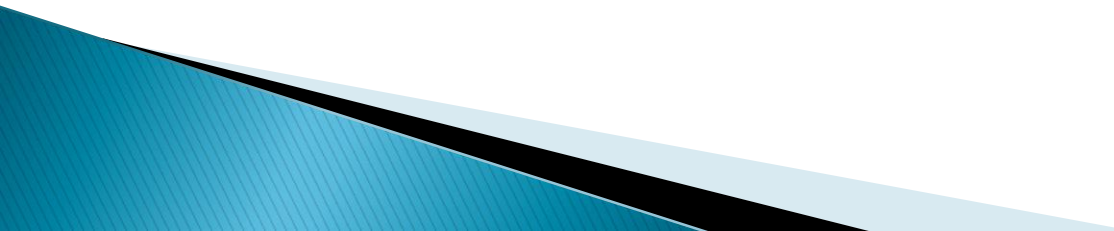
Azure Synapse Analytics, Azure Data Lake, HDInsight

Azure IoT Hub, Azure IoT Edge

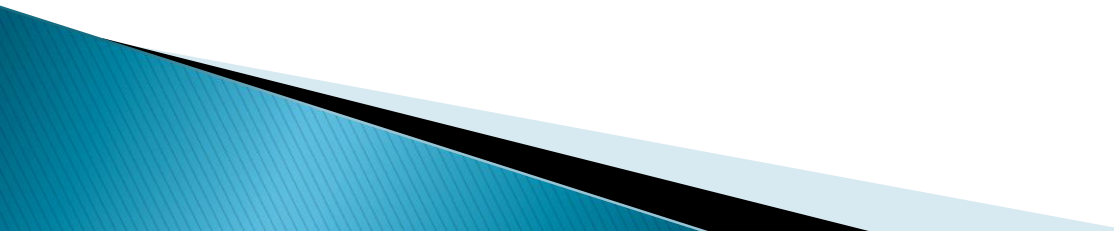
Azure Arc, Azure Stack

Azure Active Directory (AAD), Multi-Factor Authentication (MFA)

Amazon EC2

- ▶ Amazon EC2 is one large complex web service.
 - ▶ provides resizable, scalable virtual machines (VMs) on demand.
 - ▶ EC2 provided an API for instantiating computing instances with any of the operating systems supported.
 - ▶ It can facilitate computations through Amazon Machine Images (AMIs) for various other models.
 - ▶ Signature features: S3, Cloud Management Console, MapReduce Cloud, Amazon Machine Image (AMI)
 - ▶ Excellent distribution, load balancing, cloud monitoring tools
- 

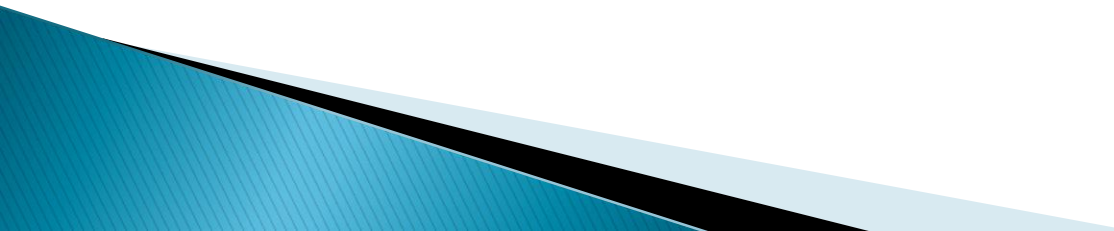
Amazon EC2

- ▶ Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, resizable compute capacity in the cloud.
 - ▶ You can select from a variety of operating systems and resource configurations like memory, CPU, storage that is required for your application.
 - ▶ Amazon EC2 enables you to obtain and configure capacity within minutes. You can use one or hundreds or even thousands of server instances simultaneously. Some of the considerations for estimating Amazon EC2 cost are Operating systems, Clock hours of server time, Pricing Model, Instance type and Number of instances.
- 

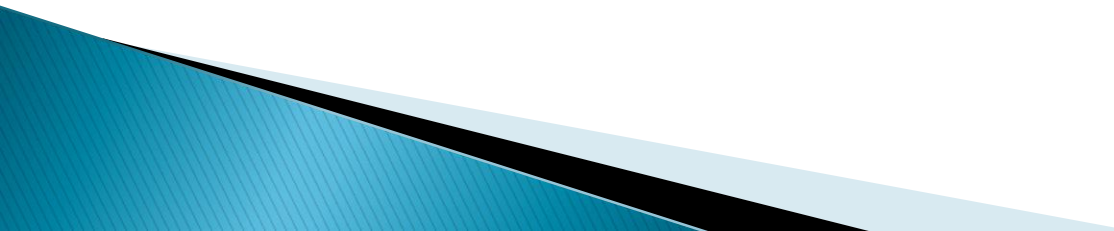
Pricing models for Amazon EC2:

- ▶ There are four pricing models for Amazon EC2 instances:
 - On-Demand Instances,
 - Reserved Instances,
 - Spot Instances, and
 - Dedicated Hosts.

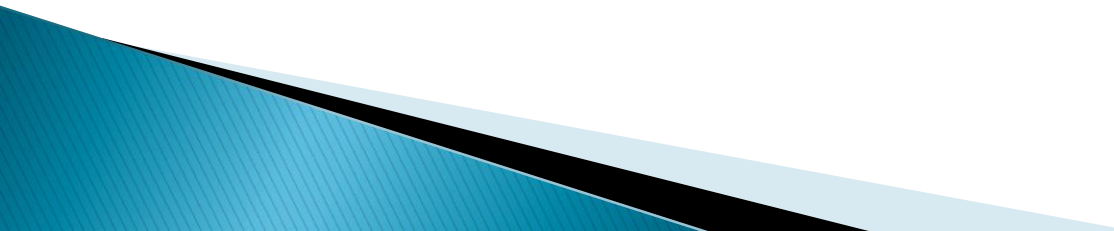
On-Demand Instances

- ▶ In this model, based on the instances you choose, you pay for compute capacity per hour or per second (only for Linux Instances) and no upfront payments are needed.
 - ▶ You can increase or decrease your compute capacity to meet the demands of your application and only pay for the instance you use.
 - ▶ This model is suitable for developing/testing application with short-term or unpredictable workloads. On-Demand Instances is recommended for users who prefer low cost and flexible EC2 Instances without upfront payments or long-term commitments.
- 

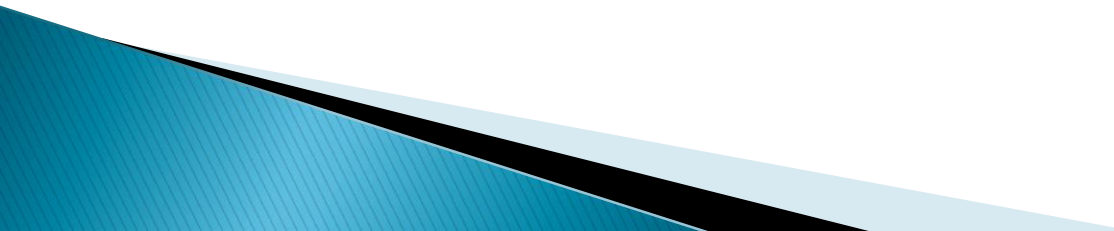
Spot Instances

- ▶ Amazon EC2 Spot Instances is unused EC2 capacity in the AWS cloud. Spot Instances are available at up to a 90% discount compared to On-Demand prices.
 - ▶ The Spot price of Amazon EC2 spot Instances fluctuates periodically based on supply and demand.
 - ▶ It supports both per hour and per second (only for Linux Instances) billing schemes . Applications that have flexible start and end times and users with urgent computing needs for large scale dynamic workload can choose Amazon EC2 spot Instances.
- 

Reserved Instances

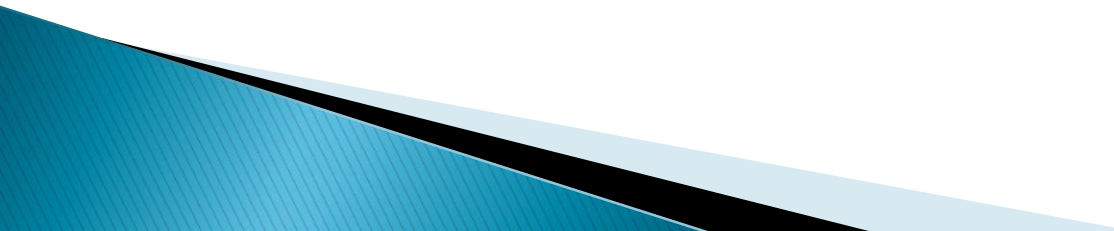
- ▶ Amazon EC2 Reserved Instances provide you with a discount up to 75% compared to On-Demand Instance pricing. It also provides capacity reservation when used in specific Availability Zone.
 - ▶ For applications that have predictable workload, Reserved Instances can provide sufficient savings compared to On-Demand Instances.
 - ▶ The predictability of usage ensures compute capacity is available when needed. Customers can commit to using EC2 over a 1- or 3-year term to reduce their total computing costs.
- 

Dedicated Hosts

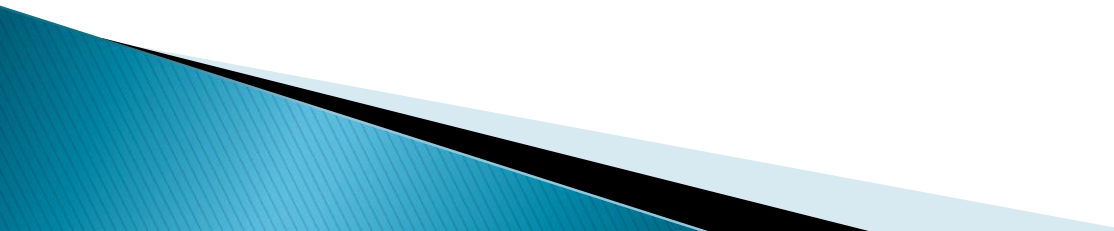
- ▶ A Dedicated Host is a physical EC2 server dedicated for your use.
 - ▶ Dedicated Hosts can help you reduce costs by allowing you to use your existing server-bound software licenses like Windows server, SQL server etc and also helps you to meet the compliance requirements .
 - ▶ Customers who choose Dedicated Hosts have to pay the On-Demand price for every hour the host is active in the account. It supports only per-hour billing and does not support per-second billing scheme.
- 

Pricing Model	Description	Best For
On-Demand	Pay per hour/second, no commitment	Short-term workloads
Reserved Instances (RI)	1-3 year commitment, up to 72% savings	Long-term applications
Spot Instances	90% cheaper, bid-based	Batch jobs, AI training
Savings Plans	Flexible pricing, up to 66% savings	Predictable workloads
Dedicated Hosts	Entire physical server for compliance	Government, Large Enterprises

Google App Engine

- ▶ This is more a web interface for a development environment that offers a one stop facility for design, development and deployment Java and Python-based applications in Java, Go and Python.
 - ▶ Google offers the same reliability, availability and scalability at par with Google's own applications
 - ▶ Interface is software programming based
 - ▶ Comprehensive programming platform irrespective of the size (small or large)
 - ▶ Signature features: templates and appspot, excellent monitoring and management console
- 

Google App Engine

- ▶ **Google App Engine (GAE)** is a Platform as a Service (PaaS) cloud computing platform for developing and hosting web applications in Google-managed data centers.
 - ▶ Google App Engine lets you run web applications on Google's infrastructure.
 - ▶ Easy to build.
 - ▶ Easy to maintain.
 - ▶ Easy to scale as the traffic and storage needs grow.
- 

Google App Engine (PL Support)

▶ **Java:**

- App Engine runs JAVA apps on a JAVA 7 virtual machine
- Uses JAVA Servlet standard for web applications:
 - WAR (Web Applications Archive) directory structure.
 - Servlet classes
 - Java Server Pages (JSP)
 - Static and data files
 - Deployment descriptor (web.xml)
 - Other configuration files

Google App Engine (PL Support)

▶ **Python:**

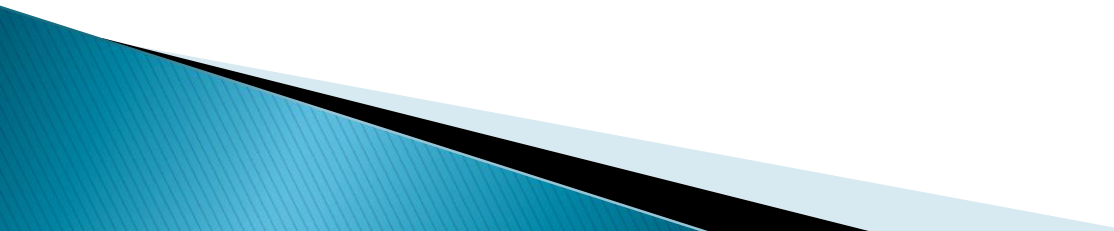
- Uses WSGI (Web Server Gateway Interface) standard.
- Python applications can be written using:
 - Webapp2 framework
 - Django framework
 - Any python code that uses the CGI (Common Gateway Interface) standard.

Google App Engine (PL Support)

▶ **PHP :**

- Local development servers are available to anyone for developing and testing local applications.

▶ **Google's Go:**

- Go is an Google's open source programming environment.
 - Tightly coupled with Google App Engine.
 - Applications can be written using App Engine's Go SDK.
- 

Google App Engine (Data Store)

▶ App Engine Datastore:

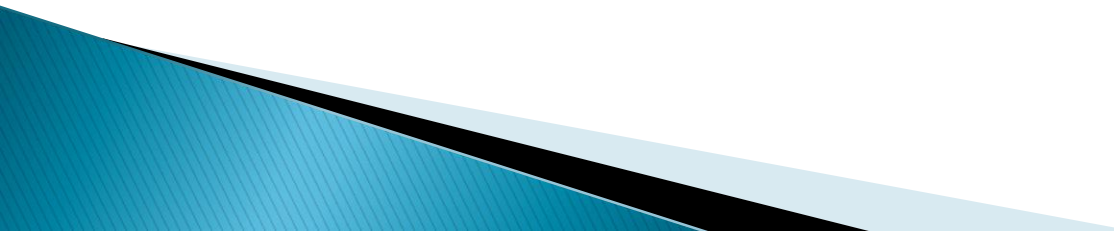
- NoSQL schema-less object based data storage, with a query engine and atomic transactions.
- Data object is called a “Entity” that has a kind (~ table name) and a set of properties (~ column names). JAVA JDO/ JPA interfaces and Python datastore interfaces.

▶ Google cloud SQL:

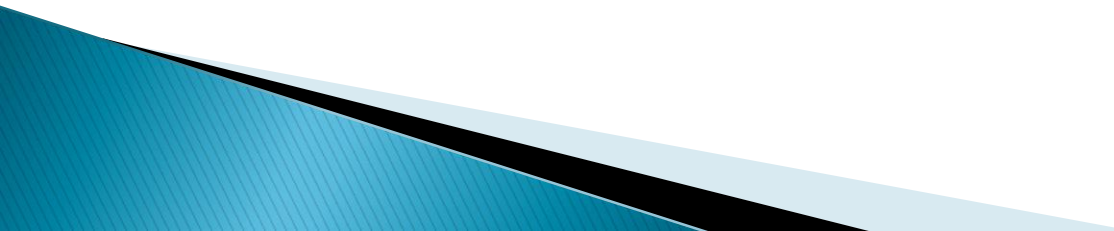
- Provides a relational SQL database service.
 - Similar to MySQL RDBMS.
- 

Google App Engine (Data Store)

▶ Google cloud store:

- RESTful service for storing and querying data.
 - Fast, scalable and highly available solution.
 - Provides Multiple layers of redundancy. All data is replicated to multiple data centers.
 - Provides different levels of access control.
 - HTTP based APIs.
- 

Google App Engine (App Engine Services)

- ▶ App Engine also provides a variety of services to perform common operations when managing your application.
 - **URL Fetch:** Facilitates the application's access to resources on the internet, such as web services or data.
 - **Mail:** Facilitates the application to send e-mail messages using Google infrastructure.
 - **Memcache:** High performance in-memory key-value storage. Can be used to store temporary data which doesn't need to be persisted.
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Google App Engine (Security)

▶ **The sandbox:**

- All hosted applications run in a secure environment that provides limited access to the underlying operating system.
- Sandbox isolates the application in its own secure, reliable environment that is independent of hardware, operating system and physical location of a web server.

Stage	Description	Tools Used
1 Development	Writing and testing code locally	VS Code, IntelliJ, PyCharm, Google Cloud SDK
2 Deployment	Deploying the application to GAE	<code>gcloud app deploy</code> , Cloud Build
3 Scaling & Load Balancing	GAE automatically scales based on demand	Auto-scaling, Load balancing
4 Monitoring & Logging	Checking app performance and errors	Cloud Logging, Stackdriver, Cloud Monitoring
5 Updating & Versioning	Deploying new versions without downtime	Traffic Splitting, Blue-Green Deployment
6 Maintenance & Debugging	Debugging and optimizing performance	Cloud Debugger, Error Reporting
7 Decommissioning	Removing or archiving the app	<code>gcloud app services delete</code>

E-Resources

	AWS	Google Cloud	Azure
Technology	EC2 (Elastic Compute Cloud)	Google Compute Engine (GCE)	VHD (Virtual Hard Disk)
Databases Supported	AWS fully supports relational and NoSQL databases and Big Data.	Technologies pioneered by Google, like Big Query, Big Table, and Hadoop, are naturally fully supported.	Azure supports both relational and NoSQL databases, and Big Data, through Windows Azure Table and HDInsight.
Pricing	Per hour – rounded up	Per minute – rounded up (minimum 10 minutes)	Per minute – rounded up commitments (pre-paid or monthly)
Models	On demand, reserved, spot	On demand – sustained use	On demand – short term commitments (pre-paid or monthly)
Difficulties	Many enterprises find it difficult to understand the company's cost structure	Fewer features and services.	Less “enterprise-ready”
Storage Services	<ul style="list-style-type: none"> • Simple Storage Service (S3) • Elastic Block Storage (EBS) • Elastic Block Storage (EBS) 	<ul style="list-style-type: none"> • Blob Storage • Queue Storage • File Storage • Disk Storage • Data Lake Store 	<ul style="list-style-type: none"> • Cloud Storage • Persistent Disk • Transfer Appliance
Machine Learning	<ul style="list-style-type: none"> • Sage Maker • Lex • Polly • And many more 	<ul style="list-style-type: none"> • Machine Learning • Azure Bot Service • Cognitive Service 	<ul style="list-style-type: none"> • Cloud Speech API • Cloud Video Intelligence • Cloud Machine Learning Engine • And many more.

E-Resources

- ▶ 1. Thomas Erl, ZaighamMahmood and Ricardo Puttini, Cloud Computing: Concepts, Technology & Architecture, Pearson, ISBN :978 9332535923, 9332535922, 1 st Edition
- ▶ 2. Anthony T. Velte Toby J. Velte, Robert Elsenpeter, “Cloud Computing: A Practical Approach”, 2010, The McGraw–Hill.

THANK YOU!