8 CHAPTER

Cloud Platforms and Applications

Chapter Outline

After studying this chapter, students will be able to understand the:

- Web Services
- SOAP vs. REST WEB SERVICES,
- Web Services And APIs
- Amazon Web Services
- Google Cloud Platform (GCP)
- AI And Machine Learning
- Developer Tools
- Google App Engine (Gae)
- Services Provided by App Engine Includes
- Microsoft Azure Platform (MAP)
- Apache Hadoop
- Aneka, Applications of Cloud Computing,
- Healthcare: ECG Analysis in the Cloud

Web Services

Web service refers to the software system designed to support interoperable machine-to-machine interaction over the computer network and World Wide Web. A server running on the network listens for requests at a certain port and serves web content such as HTML, JSON, XML, etc. Web services are self-contained, modular, distributed, dynamic programs that may be specified, published, located, or invoked through a network to produce products and services. These apps might be local, distributed, or web-based. Web services are client and server applications that interact using the HyperText Transfer Protocol (HTTP) over the World Wide Web (WWW).

Web Service is "a software system designed to support interoperable machine-to-machine interaction over a network". Web services, as defined by the World Wide Web Consortium (W3C), provide a common mechanism of interoperating across software applications running on various platforms and frameworks. Web services are distinguished by their high interoperability and extensibility, as well as machine-processable descriptions made possible by the use of XML.

Any program, application, or cloud technology that enables standardized web protocols (HTTP or HTTPS) to interoperate, interact, and exchange data messages – commonly XML (Extensible Markup Language) – across the internet is considered a web service. Web services are data interchange systems based on XML that use the Internet for A2A (Application-to-Application) communication and interfacing. Programs, messages, documents, and/or objects are all involved in these processes. Figure 8.1 depicts a web service model consisting of three main entities: Service provider, Service Consumer and Service Broker, each performs publish, find and service registration role respectively.

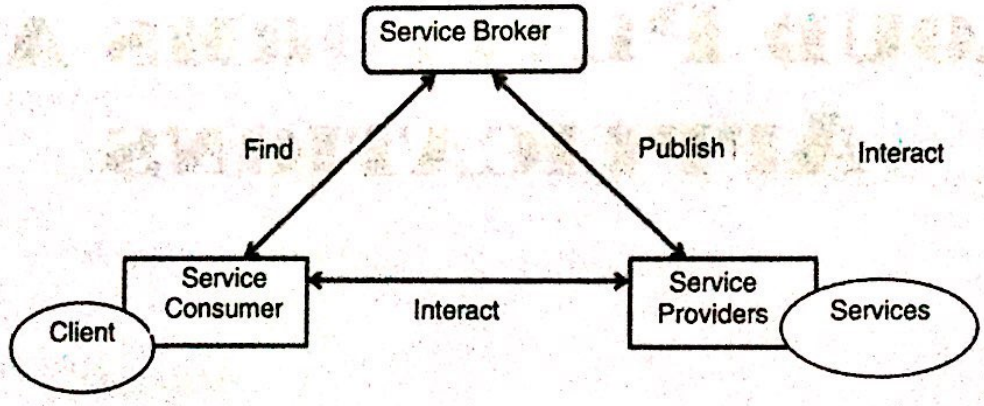

Figure 8.1: Web Services Model

A key aspect of web services is that applications developed in different languages connect by transferring data over a web service between clients and servers. A client invokes a web service by submitting an XML request, and the service responds with an XML response. Service-Oriented Architecture (SOA) is frequently related to web services. For example, a client may activate a web service by submitting an XML message and then waiting for an XML answer. Because all communication is done in XML, web services are not limited to a single operating system or programming language – Java may communicate with Perl, and Windows programs can communicate with Unix programs.

A web service must perform the following functions:

- Accessible through the Internet or intranet networks
- An XML communications protocol that is standardized
- Unconstrained by a particular operating system or programming language
- Self-description using the standard XML language
- Discoverable through a simple location method

A web service allows several programs to communicate using HTML, XML, WSDL, SOAP, and other open standards. XML tags the data, SOAP transports the message, and WSDL explains the accessibility of the service. For instance, a web service lies between two sets of Java, .Net, or PHP programs, allowing them to connect across a network. A java program, for example, communicates with Java, .Net, and PHP programs on the other end via a web service communicating in an independent language.

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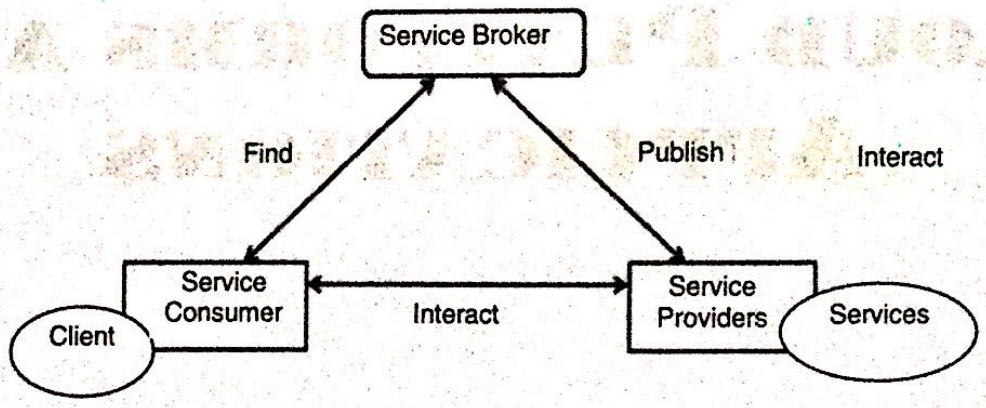

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Characteristics of Web Services

- Web services are XML-Based
- Web service is Loosely Coupled
- Web service can be Synchronous or Asynchronous
- Web service supports Remote Procedure Calls (RPCs)
- Web service supports Document Exchange

Benefits of Web Service

- By reducing development time, the technology assists IT professionals and web architects in streamlining connections.
- With this simpler infrastructure, corporate leaders are beginning to realize greater ROI
- Web services provide Interoperability – applications developed in one programming language can communicate with the application developed in other programming languages.
- Web services allow effective technology distribution over a complete network in a B2B business where both parties understand how the process works.
- Web Services interact via regular Internet technology.
- XML is used in the data representation and data transportation levels of Web Services. So it provides minimal effort communication.

Types of Web Services

XML-RPC, UDDI, SOAP, and REST are important to web services.

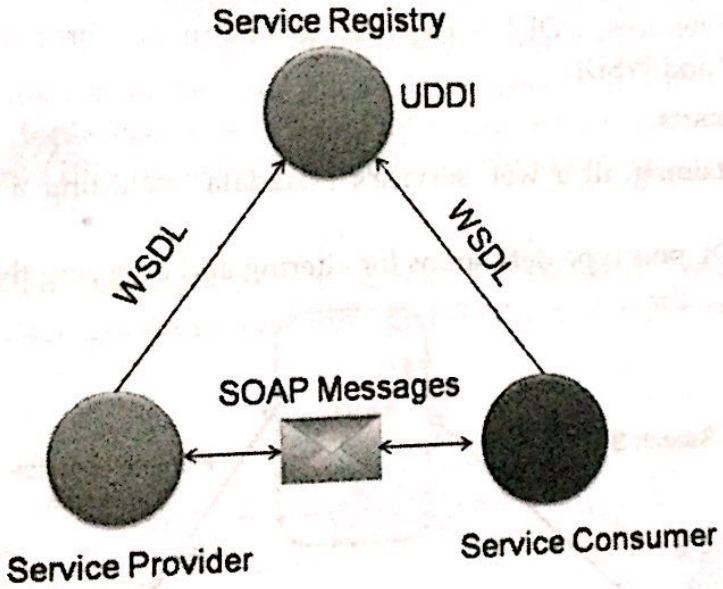

Figure 8.2: Web Services

XML-RPC

XML-RPC (Remote Procedure Call) is the most fundamental XML protocol for exchanging data across a wide range of network devices, which allows applications to invoke functions or procedures across a network. XML-RPC performs RPCs using XML messages. In the XML request, the XML-RPC client gives a procedure name and arguments, and the server delivers either a fault or a response in the XML response. This platform-independent web service uses HTTP to transmit data and communicate other information from the client to the server in a timely and efficient manner. The body of the HTTP response contains XML replies. XML-RPC enables the communication between many programs so that a Java client application can communicate with a Perl server application.

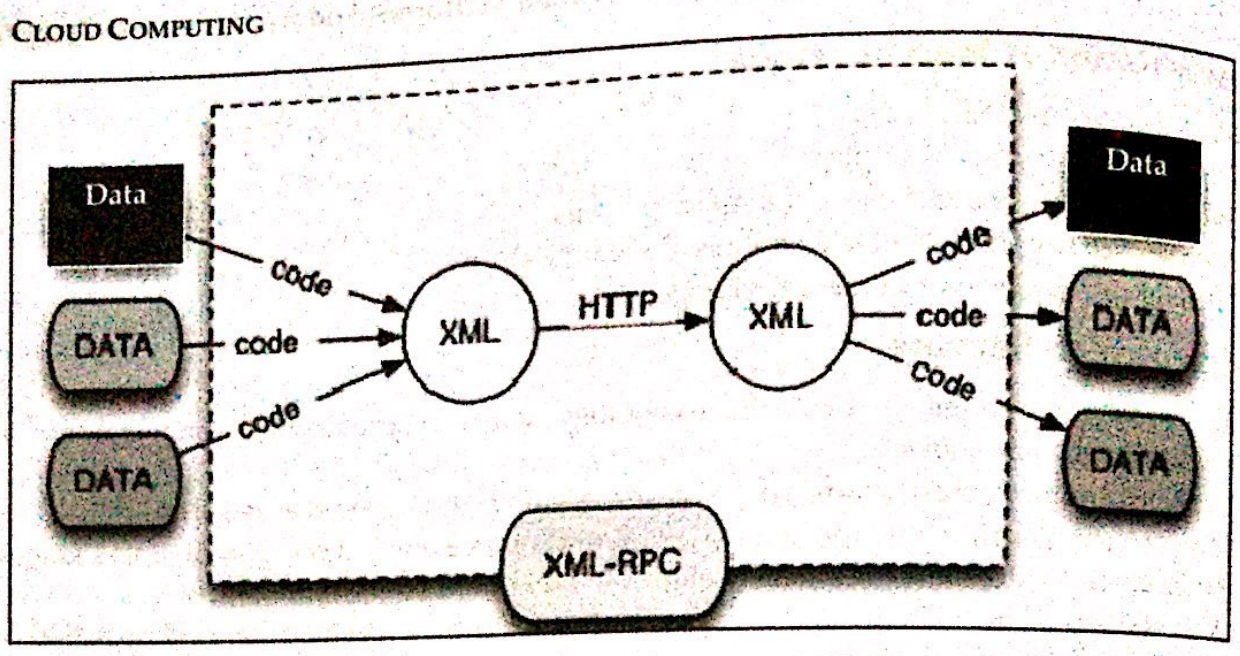

Figure 8.3: XML-RPC

UDDI

UDDI (Universal Description, Discovery, and Integration) is an XML-based standard used to describe, publish, and discover web services. UDDI is a specification for a distributed web service registry, which is a platform-independent and open framework. It essentially serves as an online register for firms all across the world. The major purpose is to improve the efficiency of digital transactions and e-commerce across enterprise platforms.UDDI communicates via SOAP, CORBA, and the Java RMI Protocol and uses WSDL to describe web service interfaces. UDDI is regarded as one of the three foundation standards of web services, along with SOAP and WSDL.

UDDI is divided into two parts:

- A registration containing all a web service's metadata, including a link to the service's WSDL description.
- A collection of WSDL port type definitions for altering and querying the register.

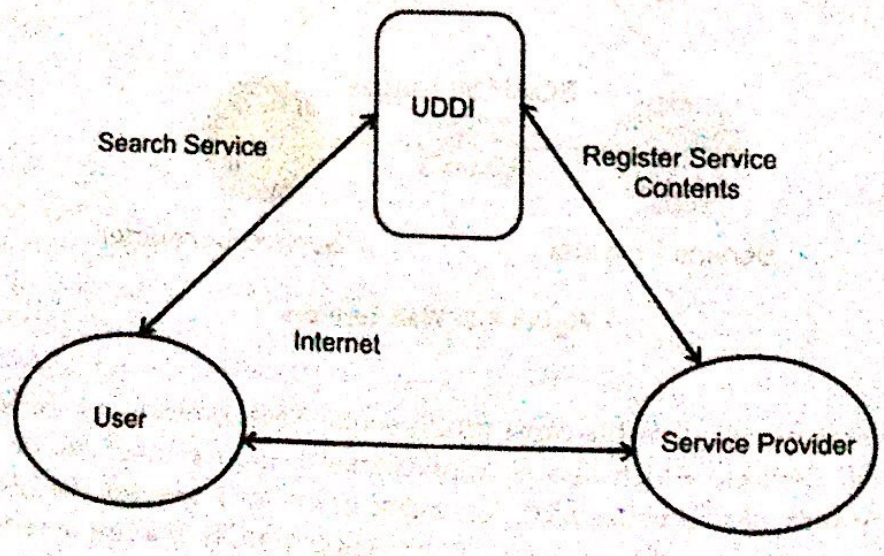

Figure 8.4: UDDI

A UDDI registry may be used by any firm to store three categories of information. These are as follows:

1. **White Pages:** White pages contain basic information on the company and its operations such as the name of the firm, address, phone number, and basic information about the firm.
2. **Yellow Pages:** Yellow pages contain more information about the firm, such as the types of electronic capabilities that the firm provides to anybody who wants to do business with it. It accepts corporations based on their industry type, product codes, business identity codes, and industry code, making it easier for businesses to navigate through the listings and get precisely what they are looking for.

3. ***Green Pages:*** Green pages contain technical details about a web service. It allows someone to bind to a Web service after it has been found. It includes various interfaces, URLs, and discovery information, and similar data required to find and run the Web service.

The technical architecture of UDDI comprises three parts:

- UDDI Data Model (Schema)
- UDDI API Specification
- UDDI Cloud Services
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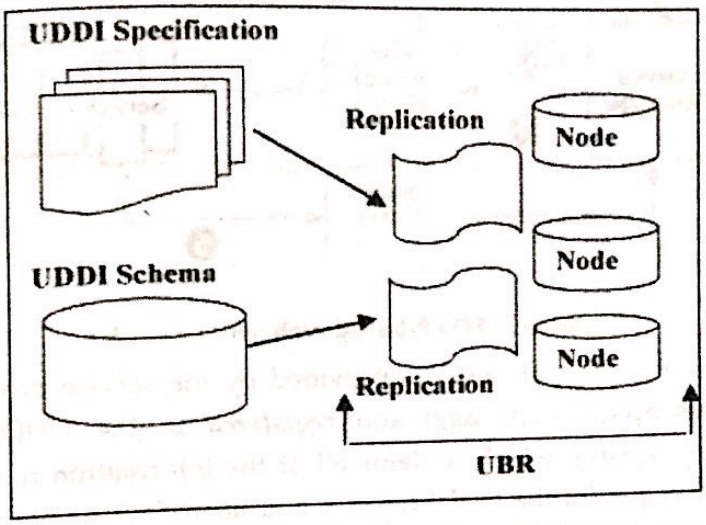

Figure 8.5: Technical architecture of UDDI

The UDDI Business Registry (UBR) is the Public Cloud, which is conceptually a single system composed of several nodes whose data is synchronized through replication. The present cloud services provide a directory that is conceptually centralized but physically dispersed. It implies that data provided to one root node is immediately duplicated to all other root nodes. At the moment, data replication happens every 24 hours. Microsoft and IBM presently provide UDDI cloud services.

SOAP

SOAP that stands for Simple Object Access Protocol, is a W3C standard, XML-based Web service protocol for exchanging structured data and documents through HTTP or SMTP (Simple Mail Transfer Protocol).

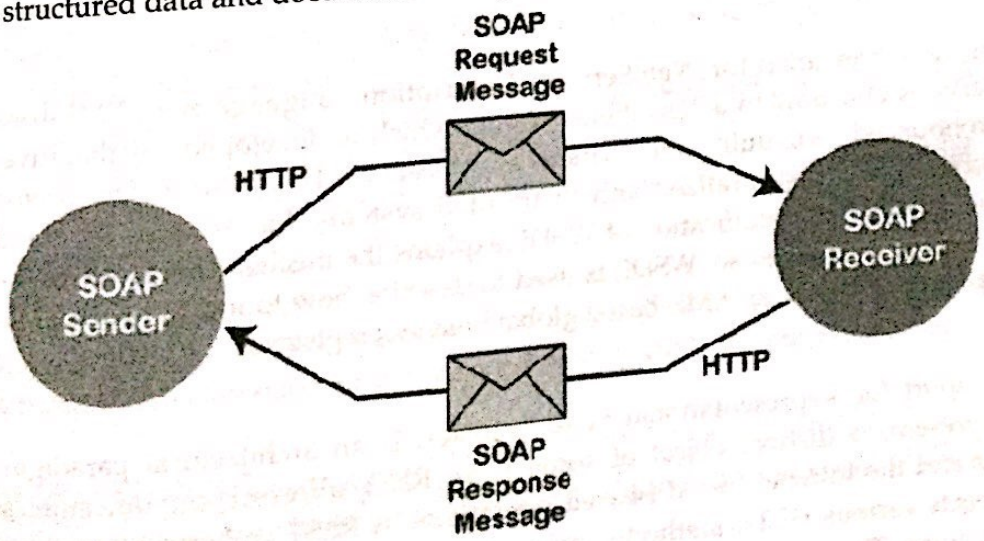

Figure 8.6: Basics of SOAP Communication

As it is language-independent, it enables separate programs running on different platforms to communicate using XML. It is a platform-independent format for sending messages. SOAP also uses a web service description model using WSDL (Web Services Description Language) documents. This defines the appearance of SOAP requests (client-side) and responses (server-side). SOAP web services also include security and addressing requirements.

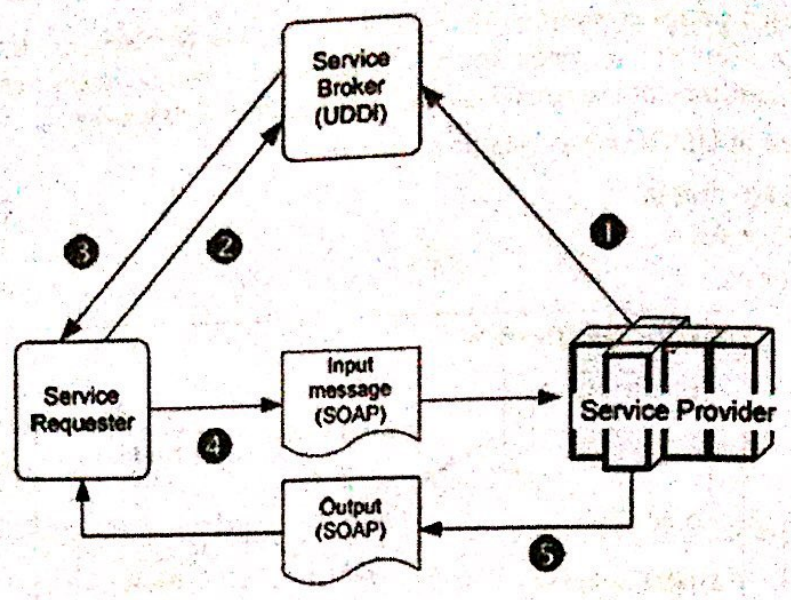

Figure 8.7: SOAP-based web service model

As illustrated in the figure 8.7, the web services provided by the service provider are described using WSDL (Web Services Description Language) and ***registered*** in the UDDI (Universal Description, Discovery, and Integration) registry, which contains all of the information required to identify the web service. After a requestor has ***queried*** the UDDI registry and ***identified*** the needed service, the WSDL file for that service may be ***retrieved*** from the registry and ***consumed*** via SOAP message.

Advantages

- Usually easier to consume,
- More standards available (such as WSDL)
- Distributed computing

Disadvantages

- Difficult set-up
- Complicated coding

WSDL

WSDL, which is an abbreviation for Web Services Description Language is an XML-based language for defining web services and how to access them. WSDL, which is developed collaboratively by Microsoft and IBM is pronounced 'wiz-dull' and written as 'W-S-D-L. This XML-based protocol is used for exchanging information in decentralized and distributed systems that are also the standard format for describing a web service. The specification of WSDL explains the mechanisms to access a web service and the actions that will be performed so, WSDL is used to describe how to interact with XML-based services. WSDL is a component of UDDI, an XML-based global business registry.

REST

REST, which is short for Representational State Transfer, is an architectural paradigm in which each unique URL represents a distinct object of some type. REST allows communication and connections between devices and the Internet for API-based operations. A REST web service communicates through HTTP and supports various HTTP methods, including GET, POST, PUT, and DELETE. It also provides basic CRUD functions. The original RESTful architecture was established by Roy Fielding, one of the key authors of HTTP.

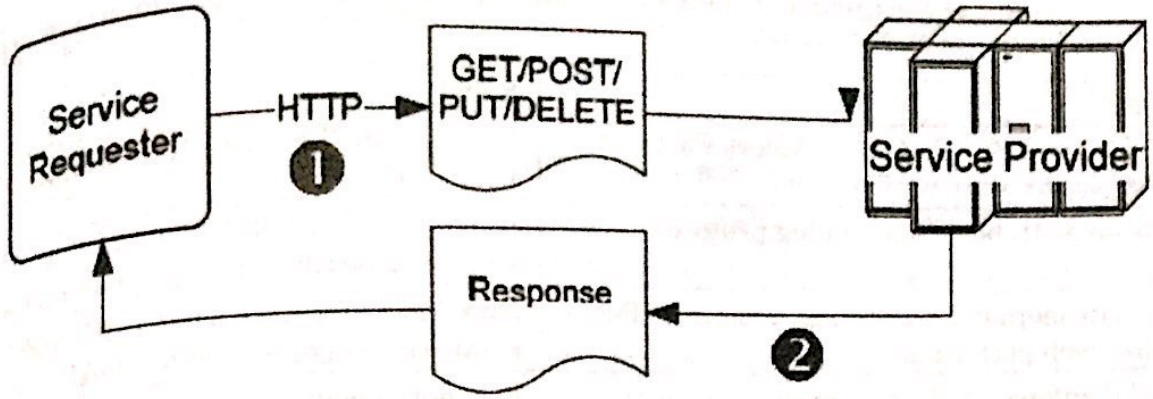

Figure 8.8: RESTful Web Services Model (Request & Response)

Advantages

- Lightweight
- Human readable
- Easier to build

Disadvantages

- Point-to-point communication,
- Lack of standards

Think about a simple account management and order processing system. The accounting personnel uses a client application built with JSP to create new accounts and enter new customer orders. The processing logic for this system is written in Java and resides on a Solaris machine, which also interacts with a database to store information.

The steps to perform this operation are as follows:

- The client program bundles the account registration information into a SOAP message.
- This SOAP message is sent to the web service as the body of an HTTP POST request.
- The web service unpacks the SOAP request and converts it into a command that the application can understand.
- The application processes the information as required and responds with a new unique account number for that customer.
- Next, the web service packages the response into another SOAP message, which it sends back to the client program in response to its HTTP request.
- The client program unpacks the SOAP message to obtain the results of the account registration process.

Web template, JSON-RPC, JSON-WSP, Web Services Description Language (WSDL), Web Services Conversation Language (WSCL), Web Services Flow Language (WSFL), Web Services Metadata Exchange (WS-MetadataExchange), XML Interface for Network Services (XINS), etc. are some more examples of web services.

SOAP vs. REST Web Services

RESTful web services and SOAP both have their own set of advantages and disadvantages. A REST web service, for example, is often a superior choice when time is of the essence, while SOAP triumphs when designing a service with various, non-CRUD methods. Unless otherwise specified by the Web Service provider, the type of web service implemented by a partner is determined by the company's requirements.Amazon and eBay both employ web services for REST and SOAP. And, as more firms

become service-focused and experiment with new features, they will be forced to accommodate both types.

#	SOAP	REST
1.	It stands for Simple Object Access Protocol.	It stands for Representational State Transfer.
2.	It is an XML-based messaging protocol.	It is not a protocol. It is an architectural style for distributed hypermedia systems.
3.	It needs more bandwidth and resources for better web performance.	REST requires less bandwidth and resources as compared to SOAP.
4.	SOAP enforces XML as a message format.	It is not specifically applied that the message format must be XML or JSON, etc.
5.	It has not great performance as compared to REST.	It has better performance as compared to SOAP, less CPU intensive, lesser code, etc.
6.	SOAP defines its security.	REST inherits security measures from the underlying transport.
7.	It does not support error handling.	It has built-in error handling.
8.	SOAP is a heavyweight XML protocol that requires more coding to send a message.	It is lightweight, scalable, and maintainable.
9.	It cannot be cached.	It can be cached.
10.	SOAP messages are wrapped in an envelope and sent to any transport mechanism such as SMTP, FTP, HTTP, or any protocol.	It relies on the HTTP protocol for communication between two machines.

Web Services and APIs

Web services and APIs can be frequently mistaken for one another. Most online services include an API, which is used to get data using a set of commands and functions. Web services and APIs are accessed through HTTP/HTTPS to enable communication between services providers and customers and they both call a function, process data, and receive a response. API is a lightweight architecture which is suitable for devices with low bandwidth such as smartphone and as SOAP is required to send and receive network data, web services are not lightweight. APIs can use any form of communication, but a Web service only uses SOAP, REST, and XML-RPC. APIs support URL, request/response headers, caching, versioning, content formats however web services only support HTTP. One important thing to consider is that all web services may be APIs, but not all APIs can be web services.

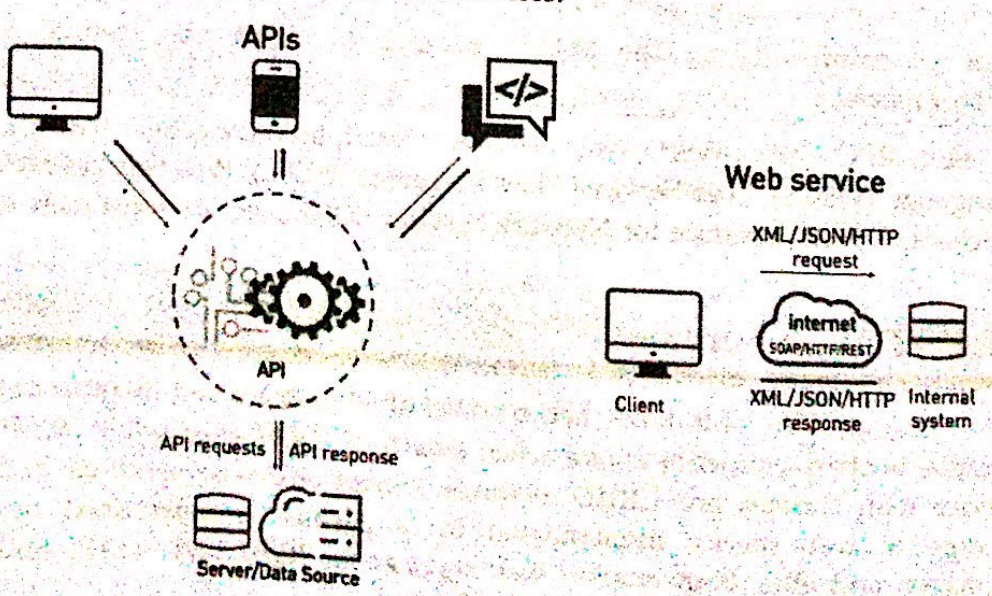

Figure 8.9: APIs and Web Services

For instance, Twitter provides an API that allows developers to read tweets from a server and gather data in JSON format.

Amazon Web Services

Amazon Web Services (AWS) is an Amazon company that offers on-demand cloud computing platforms and APIs to people, businesses, and governments on a pay-as-you-go basis. AWS is a comprehensive, ever-evolving cloud computing platform offered by Amazon that comprises infrastructure as a service (IaaS), platform as a service (PaaS), and packaged software as a service (SaaS) product. AWS services may provide a company with tools like computation power, database storage, and content delivery services.

These cloud computing web services offer a wide range of fundamental abstract technological infrastructure and distributed computing building blocks and tools. One of these services is Amazon Elastic Compute Cloud (EC2), which provides customers with a virtual cluster of computers that is always available through the Internet. AWS's version of virtual computers emulates most of the characteristics of a real computer, including hardware central processing units (CPUs) and graphics processing units (GPUs) for processing; local/RAM; hard disk/SSD storage; a choice of operating systems; networking; and pre-loaded application software such as web servers, databases, and customer relationship management (CRM).

AWS was founded in 2006 as an extension of the internal infrastructure established by Amazon.com to manage its online retail activities. AWS was among the first firms to provide a pay-as-you-go cloud computing model. AWS provides a wide range of tools and solutions for businesses and software developers that may be utilized in data centers in over 190 countries. AWS services are available to government agencies, educational institutions, charities, and commercial organizations.

The AWS technology is used in server farms all around the world and is maintained by an Amazon subsidiary. Fees are calculated following a "Pay-as-you-go" model, which is based on the hardware, operating system, software, or networking characteristics selected by the subscriber, as well as availability, redundancy, security, and service choices. Subscribers have the option of paying for a single virtual AWS machine, a dedicated physical computer, or clusters of both. Amazon offers security for members' systems as part of the subscription agreement. AWS operates from a variety of geographical locations across the world.

How Has AWS Become so Successful?

- **Security:** AWS provides a secure and durable platform that provides end-to-end security and storage.
- **Experience:** The skills and infrastructure management born from Amazon's many years of experience can be very valuable.
- Flexibility: It allows users to select the operating systems, language, database, and other services as per their requirements.
- Easy to use: AWS lets you host your applications quickly and securely, regardless of whether it is an existing or new application.
- Scalable: The applications you use can be scaled up or down, depending on your requirements.
- Cost savings: You only pay for the compute power, storage, and other resources that you use, without any long-term commitments.
- Scheduling: This enables you to start and stop AWS services at predetermined times.
- Reliability: AWS takes multiple backups at servers at multiple physical locations.

Amazon has many services for cloud applications; some of the services and products under that service is briefly explained here:

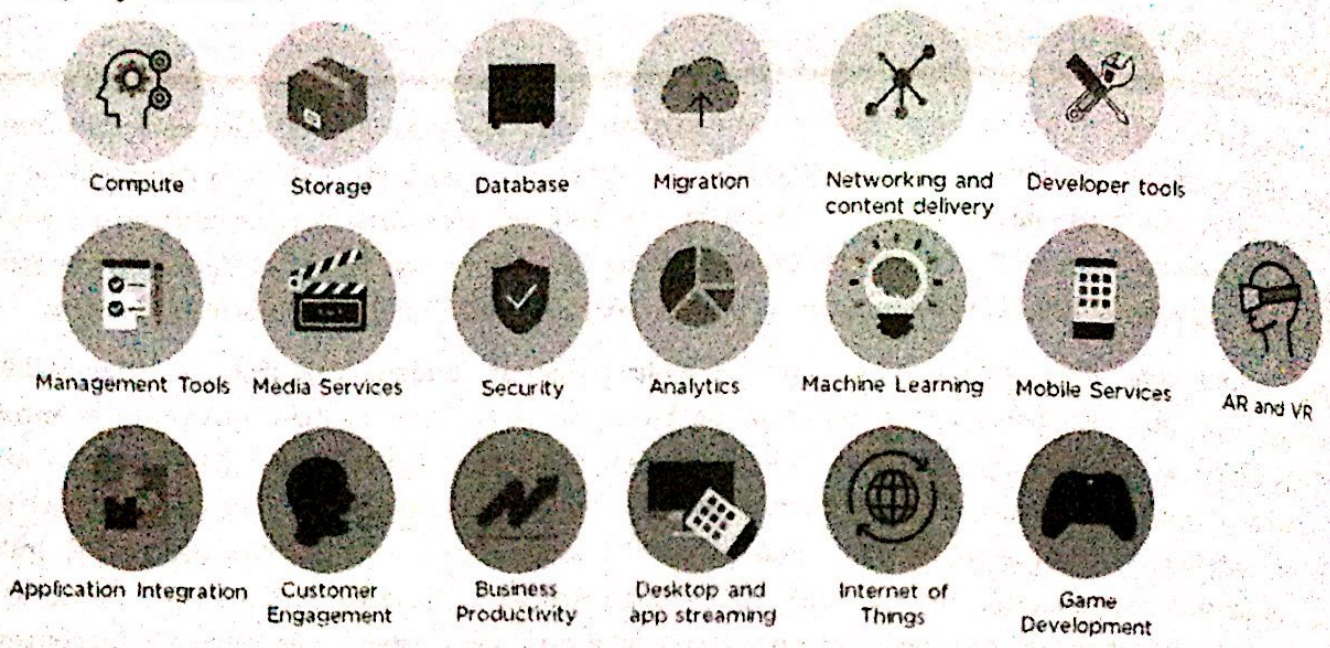

Figure 8.10: Various service domains of AWS

Compute services help developers build, deploy, and scale an application in the cloud platform.

1. **AWS EC2:** It is a web service that allows developers to rent virtual machines and automatically scales the compute capacity when required. AWS EC2 offers various instance types to developers so that they can choose required resources such as CPU, memory, storage, and networking capacity based on their application requirements.
2. **Amazon Elastic Beanstalk**Helps to scale and deploy web applications made with several programming languages like java, python, ruby, and .NET. EBS handles the deployment of the code as soon as it is uploaded.
3. **Amazon Lightsail:** Enables a virtual private server (VPS) to be launched and managed with ease. It includes everything required by developers who want to start their projects quickly on a virtual machine.
4. AWS Lambda: It is a serverless compute service that is also responsible for executing code for applications. AWS Lambda helps you execute a program without the hassle of managing servers.

AWS provides web data **storage** service for archiving data and also helps with disaster data recovery with high durability.

1. **Amazon S3:** It is an open cloud-based storage service that is utilized for online data backup. Amazon S3 provides storage through a web services interface and is designed for developers where web-scale computing can be easier for them.
2. **Amazon Glacier:** Amazon Glacier is a cloud storage service that is used for archiving data and long-term backup. The glacier is used for data archiving and long-term backup.
3. **Amazon EBS:** It provides a high availability storage volume for persistent data. It is mainly used by Amazon EC2 instances. EBS volumes are used explicitly for primary storage such as file storage, database storage, and block-level storage.
4. **Amazon Elastic File System:** Amazon EFS provides elastic file storage, which can be used with AWS Cloud Services and resources that are on-premises. It is easy to use and offers a simple interface that allows you to create and configure file systems quickly and easily.

AWS **database** domain service offers cost-efficient, highly secure, and scalable database instances in the cloud.

1. **DynamoDB:** It is a flexible NoSQL database service that offers fast and reliable performance with no scalability issues. It is a multi-region and durable database with instant built-in security, backup and restores features.

2. **Amazon RDS:** It is a managed distributed relational database cloud service that helps developers to operate and simply scale a database. This was launched to simplify the setup, operation, and scaling process for developers while accessing a relational database.
3. **Amazon Redshift:** Amazon Redshift is a data warehouse that enables users to analyze their data using SQL and other BI tools. It is a fast, fully managed data warehouse. It also allows users to run complex analytical queries against structured data using sophisticated query optimizations.

Networking and Delivery of Content offers a highly secure cloud platform and connects your physical network to your private virtual network with a high transfer speed.

1. **VPC:** It helps a developer to deploy AWS resources, such as Amazon EC2 instances into a private virtual cloud. It gives you control over the complete cloud network environment, including the section of your IP address range, subnets, route table configuration, and network gateways. With this, developers can use both IPv4 and IPv6 at a time for your resources in a highly secure environment.
2. **Amazon Route 53:** It is a web service with a highly available Domain Name System (DNS) that helps users to route software by translating the text into an IP address. We launched it for developers to provide them a cost-effective method of routing end users to cloud applications.
3. **Elastic Load Balancing:** Elastic Load Balancing automatically diverts incoming traffic into multiple targets.

Developer Tools helps a user build, deploy, and run an application source code automatically. It also updates the server and instance on the workload.

1. **CodeStar:** It is a service designed to manage application development in a single place. Here, developers can quickly develop, build, and deploy applications on AWS.
2. **Code Build:**This service removes the hassle of managing physical servers and helps developers build and test code with continuous scaling. It compiles your code, executes unit tests, and gives output artifacts that are ready to deploy.
3. **Security, Identity & Compliance:**It helps in monitoring a safe environment for your AWS resources by providing limited access to specific users.
4. **IAM:**Identity Access Management is a framework that helps in securely maintaining access to AWS services. The service gives you Shared access to your AWS account and Secure access to AWS services that run on the AWS EC2 application.
5. **KMS:**It enables users to create and manage the encryption keys that are used for encrypting data. The service includes a key generation method where digital sign within your applications becomes easier.

With **Management Tools** an individual can optimize costs, minimize risks, and automate all the resources running efficiently on the AWS infrastructure.

1. **Cloud Watch:** It is a monitoring tool for AWS resources and customer applications running on the AWS platform. The service helps you gather and access all your operational data in the form of logs from a single interface.
2. **Cloud Formation:**This service helps you in monitoring all your AWS resources in one place so that you can spend minimum time managing those resources and maximum time developing applications. It allows developers to manage their cloud infrastructure either in a text file or a template.
3. **AWS Autoscaling:** AWS Auto Scaling automatically adjusts resource usage to ensure steady performance at the lowest cost.

Many firms across the world use AWS to create, deploy, and host applications, whether they are IT, giants, startups, governments, or retail businesses. Amazon claims that the number of active AWS users tops one million.

1. **Adobe** uses AWS to provide multi-terabyte operating environments for its customers by integrating its system with AWS Cloud. Adobe can focus on deploying and operating its software instead of trying to deploy and manage the infrastructure.

2. **Netflix** uses Amazon Web Services (AWS) for nearly all its computing and storage needs, including databases, analytics, recommendation engines, video transcoding, and hundreds of functions that in total use more than 100,000 server instances on AWS.
3. **Airbnb**, the online vacation rental marketplace for property owners and travelers to connect, maintains a huge infrastructure in AWS, using nearly all the available services.
4. **Autodesk** develops software for the engineering, design, and entertainment industries. Using services like Amazon RDS and Amazon S3, Autodesk can focus on developing its machine learning tools instead of spending that time on managing the infrastructure
5. **America Online (AOL)** has used AWS to economize, closing data centers, and decommissioning about 14,000 in-house and co-located servers. They have moved mission-critical workloads to the cloud, extended its global reach, and saved millions of dollars on energy resources.
6. **BitDefender** is an internet security software firm, and its portfolio of software includes antivirus and anti-spyware products. Using Amazon EC2, they are running several hundred instances that handle about five terabytes of data. BitDefender also uses the Elastic Load Balancer feature to load balance the connection coming into those instances across availability zones, providing seamless global delivery of service.
7. **BMW** uses AWS for its new connected-car application, collecting sensor data from BMW 7-series cars to give drivers dynamically updated map information.
8. **Canon's** imaging products division benefits from faster deployment times, lower cost, and global reach by using AWS to deliver cloud-based services such as mobile print and office imaging products.
9. **Docker** is a company helping to redefine the way developers build, ship, and run applications making use of containers. The Amazon EC2 container service helps them do it.
10. Although much of the **European Space Agency's** work is done by satellites, some of the program's data storage and computing infrastructure is built on Amazon Web Services.
11. The **Guardian** newspaper uses a wide range of AWS services to power an analytic dashboard used by editors to see how stories are trending in real-time.
12. The **Financial Times** is one of the world's leading business news organizations and they use Amazon Redshift to perform their analyses. Redshift performed their analyses so quickly, some thought it was malfunctioning. They were used to running queries overnight. The Times found that the results were correct, just much faster.
13. **General Electric (GE)** is, at this moment, migrating more than 9,000 workloads - including 300 disparate ERP systems - to AWS while reducing its data center footprint from 34 to four by 2021.

[Source: https://aws.amazon.com]

Google Cloud Platform (GCP)

Google Cloud Platform (GCP) is a set of cloud computing services supplied by Google that operates on the same infrastructure that Google uses internally for its end-user products such as Google Search, Gmail, file storage, and YouTube. Google's cloud platform offers its consumers dependable and highly scalable cloud computing services. These services assist customers in computing and storing data, as well as developers in developing, testing, and deploying applications. The Google cloud platform includes application, storage, and cloud computing capabilities for backend, mobile, and online applications that use the internet. Over four million apps rely on and use the platform. Google makes effort to keep the backend as basic as possible, employing a minimal file system. The Google cloud platform is built on this architecture. It responds to information requests using simple commands such as write, read, and open. It is a computing system that is distributed.

It offers a variety of modular cloud services, including computing, data storage, data analytics, and machine learning, in addition to a set of management tools. Formal paraphrase Registration necessitates the use of credit card or bank account information. Google Cloud Platform offers infrastructure as a service (IaaS), platform as a service (Platform as a Service), and serverless computing environments.

Cornerstone Technology was recently bought by Google Cloud to assist companies in moving their mainframe workloads to Google Cloud Platform. Many small and large businesses are increasingly using the Google Cloud Platform, which is a good thing since it untangles things and makes them more secure at a fair cost. Because of its safe, adaptive, and intelligent solutions, more businesses are shifting to the Google Cloud Platform. It saves money on IT manpower and allows for the near-instant growth of any web platform or application.

The Google cloud application programming interface (API) for MS Office may be used to allow many users to edit a document at the same time. After installing a plugin for the Microsoft Office software suite, you may begin saving files to the cloud. The cloud copy of the data, which becomes the master document, may then be used and edited by everyone. Each file is given a unique URL by Google Cloud Platform. However, before downloading and altering the file in MS Office, the owner or creator of the document must designate someone as an editor.

Google Cloud Implementation

The Google cloud application programming interface (API) for MS Office may be used to allow many users to edit a document at the same time. After installing a plugin for the Microsoft Office software suite, you may begin saving files to the cloud. The cloud copy of the data, which becomes the master document, may then be used and edited by everyone. Each file is given a unique URL by Google Cloud Platform. However, before downloading and altering the file in MS Office, the owner or creator of the document must designate someone as an editor. If anyone makes changes to the document, the changes will be reflected in all of the documents that have been shared. When multiple people make changes to the same piece of content, Google Cloud Platform allows the document owner or creator to choose which changes to keep.

When a file is uploaded to Google Cloud, metadata is added to it. It aids in the identification of the file and the tracking of changes across all copies. As the documents are synced to the master file, Google Cloud Platform updates all downloaded documents with metadata to ensure that the correct records are maintained.

Advantages of Google Cloud Platform

1. **Google Cloud Allows Quick Collaboration**: Many users can contribute to and access projects at the same time as data is stored in the cloud instead of their computers.
2. **Google's Investments in Security Protect Customers**: Customers benefit from process-based and physical security investments made by Google. Google hires leading security experts.
3. **Fewer Data stored on Vulnerable Devices**: Minimal data is stored on computers that may get compromised after a user stops using web-based apps on the cloud.
4. **Google Cloud Enables Rapid Collaboration**: Because data is kept in the cloud rather than on users' PCs, several users may contribute to and access projects at the same time.
5. **Google's Security Investments** Protect Customers: Customers benefit from Google's efforts in process-based and physical security. Google recruits top security professionals.
6. **Less Data Saved on Vulnerable Devices**: Less data is stored on machines that may become hacked once a user discontinues utilizing cloud-based web-based programs.
7. **Increased Uptime and Reliability for Customers**: If a data center is unavailable for whatever reason, the system automatically switches to the secondary center, with no service disruption apparent to users.
8. **Flexibility and control Users** have control over technology as well as ownership of personal data in Google apps. If customers decide not to use the service any longer, they can download their data from the Google cloud.
9. **Google's economies of scale allow customers to spend less money**: Google App Engine reduces costs by combining a limited number of server configurations. It manages this with an effective human-to-computer ratio.

AI and Machine Learning, API Management, Compute, Containers, Data Analytics, Databases, Developer Tools, Healthcare and Life Sciences, Hybrid and Multicloud, Internet of Things (IoT), Management Tools, Media and Gaming, Migration, Networking, Operations, Security and Identity, and Serverless Computing

and Storage are the categories of Google Cloud Platform. Under these categories, GCP encompasses 100s of products. Those products are listed here and some of the most important products are briefly described.

AI and Machine Learning

VERTEX AI

Vertex AI

Unified platform for training, hosting, and managing ML models.

Deep Learning VM Image

Preconfigured VMs for deep learning applications.

Notebooks

An enterprise notebook service to get projects up and running in minutes.

Deep Learning Containers

Preconfigured and optimized containers for deep learning environments.

Vertex Data Labeling

Managed annotation for high-quality model training data.

TensorFlow Enterprise

Reliability and performance for AI apps with enterprise-grade support and managed services.

AI BUILDING BLOCKS

AI building blocks

Easily infuse AI into applications with custom or pre-trained models.

AutoML

Custom machine learning model training and development.

Vision AI

Custom and pre-trained models to detect emotion, text, more.

Video AI

Video classification and recognition using machine learning.

Cloud Natural Language

Sentiment analysis and classification of unstructured text.

Cloud Translation

Language detection, translation, and glossary support.

Media Translation (*beta*)

Add dynamic audio translation directly to your content and applications.

Text-to-Speech

Speech synthesis in 220+ voices and 40+ languages.

Speech-to-Text

Speech recognition and transcription supporting 125 languages.

Dialogflow

Conversation applications and systems development suite for virtual agents.

AutoML Tables (*beta*)

Service for training ML models with structured data.

Cloud Inference API (*alpha*)

Quickly run large-scale correlations over typed time-series datasets.

Recommendations AI

Deliver highly personalized product recommendations at scale.

AI INFRASTRUCTURE

AI Infrastructure

Options for every business to train deep learning and ML models cost-effectively.

Cloud GPUs

GPUs for machine learning, scientific computing, and 3D visualization.

Cloud TPU

Tensor processing units for machine learning applications.

API MANAGEMENT

Apigee API Platform

API management, development, and security platform.

HealthAPIx

FHIR API-based digital service formation.

Apigee Hybrid

Deployment option for managing APIs on-premises or in the cloud.

AppSheet Automation

Reclaim time and talent with no-code automation.

AppSheet

Enable everyone in your organization to build and extend applications without coding.

Apigee Open Banking APIx

Open banking and PSD2-compliant API delivery.

Apigee Sense

Intelligent behavior detection to protect APIs.

Cloud Endpoints

With Cloud Endpoints, Javascript, Android, and iOS clients may access your code via RESTful services from your system. The front-end wiring may be smoothed out, and client libraries can be generated automatically. Client key management, OAuth 2.0 compatibility, and denial of service protection are all part of the extensive in-built architecture.

Features

- Integration of client-side becomes flexible
- Client-server maintenance is low
- App engine infrastructure can be extended
- Multiple clients handling with a single tool

Cloud Healthcare API

The solution to bridging existing care systems and apps on Google Cloud.

API Gateway

Develop, deploy, secure, and manage APIs with a fully managed gateway.

Compute

App Engine

It is a platform-as-a-service (PaaS) (PaaS). You may increase efficiency by developing your apps utilizing built-in services. You must first obtain the software development kit (SDK), after which you can begin developing work instantly and for free.

Features

- Google Scale Deployment
- Known Development Tools
- Strong In-Built Services
- Many Options for Storage
- Code Focus
- Popular Frameworks and Languages

Bare Metal

Infrastructure to run specialized workloads on Google Cloud.

Cloud GPUs

GPUs for ML, scientific computing, and 3D visualization.

Cloud Run

Fully managed environment for running containerized apps.

Compute Engine

It is Google's infrastructure-as-a-service offering (IaaS). Google's infrastructure can be utilized to execute large-scale workloads on virtual machines. You may choose a virtual computer that meets your requirements and benefit from the global stability and performance of Google's network. Because invoicing is done by the minute, you must only pay for what you use.

Features

- Security and Compliance
- Easy and Fast Provisioning
- Balancing of Loads
- High-Performance Virtual Computers

Migrate for Compute Engine

Server and virtual machine migration to Compute Engine.

Preemptible VMs

Compute instances for batch jobs and fault-tolerant workloads.

Recommender

Proactive, easily actionable recommendations to keep your cloud-optimized.

Shielded VMs
Reinforced virtual machines on Google Cloud.

Sole-tenant Nodes
Dedicated hardware for compliance, licensing, and management.

SQL Server on Google Cloud
Options for running SQL Server virtual machines on Google Cloud.

VMware Engine
Migrate and run your VMware workloads natively on Google Cloud.

CONTAINERS

Artifact Registry
Store, manage, and secure container images and language packages.

Cloud Build
Solution for running build steps in a Docker container.

Cloud Run
Fully managed environment for running containerized apps.

Container Registry
Registry for storing, managing, and securing Docker images.

Container Security
Container environment security for each stage of the life cycle.

Deep Learning Containers
Containers with data science frameworks, libraries, and tools.

Google Kubernetes Engine (GKE)
Managed environment for running containerized apps.

Knative
Components to create Kubernetes-native cloud-based software.

Kubernetes applications on Google Cloud Marketplace
Containerized apps with prebuilt deployment and unified billing.

DATA ANALYTICS

BigQuery

BigQuery analyzes large amounts of data in the cloud. It can analyze datasets totaling many terabytes in a matter of seconds and conduct SQL-like queries quickly. It even delivers real-time information and is scalable and simple to use.

Features

- Suitable Interface
- Economical Big Data
- Easy Import of Data
- Queries Executed in Background

Looker
The platform for BI, data applications, and embedded analytics.

Dataproc
Service for running Apache Spark and Apache Hadoop clusters.

Dataflow

Streaming analytics for stream and batch processing.

Pub/Sub

Messaging service for event ingestion and delivery.

Cloud Data Fusion

Data integration for building and managing data pipelines.

Data Catalog

Metadata solution for exploring and managing data.

Cloud Composer

Workflow orchestration service built on Apache Airflow.

Google Data Studio*

Interactive data suite for dashboarding, reporting, and analytics. This is not an official Google Cloud product.

Google Marketing Platform*

Marketing platform unifying advertising and analytics. This is not an official Google Cloud product.

Cloud Life Sciences (beta)

Tools for managing, processing, and transforming biomedical data.

Dataprep

Service to prepare data for analysis and machine learning.

Dataplex

Intelligent data fabric for unified data management across distributed data silos.

Databases

Bare Metal

Infrastructure to run specialized workloads on Google Cloud.

Cloud Bigtable

Cloud-native wide-column database for large-scale, low-latency workloads.

Cloud Spanner

Cloud-native relational database with unlimited scale and 99.999% availability.

Cloud SQL

Cloud SQL is a relational MySQL database that aids in data management and storage. Google handles database maintenance, patch management, and replication to ensure performance and availability. This is a fully managed database for MySQL, PostgreSQL, and SQL Server.

Features

- Completely Managed
- Easy to Control
- Simpler Migration Without Lock-In
- Robustness, Accessibility, Security
- Pay Per Use and Package Charging
- Standard Infrastructure

Database Migration Service

Serverless, minimal downtime migrations to Cloud SQL.

Firestore
Cloud-native document database for building rich mobile, web, and IoT apps.

Firebase Realtime Database
NoSQL database for storing and syncing data in real-time.

Memorystore
In-memory database for managed Redis and Memcached.

Developer Tools

Artifact Registry
Store, manage, and secure container images and language packages.

Cloud Build
Continuous integration and continuous delivery platform.

Cloud Code
IDE support to write, run, and debug Kubernetes applications.

Cloud Scheduler
Cron job scheduler for task automation and management.

Cloud SDK
Command-line tools and libraries for Google Cloud.

Cloud Source Repositories
Private Git repository to store, manage, and track code.

Cloud Tasks
Task management service for asynchronous task execution.

Container Registry
Private Docker storage for container images on Google Cloud.

Firebase Crashlytics
Prioritize and fix stability issues faster.

Firebase Test Lab
On-demand testing infrastructure for Android apps.

Gradle App Engine Plugin
Use Gradle for your App Engine projects.

Maven App Engine Plugin
Use Maven for your App Engine projects.

Tekton
Kubernetes-native resources for declaring CI/CD pipelines.

Tools for Eclipse
Plugin for Google Cloud development inside the Eclipse IDE.

Tools for PowerShell
Full cloud control from Windows PowerShell.

Healthcare and Life Sciences

Apigee healthcare APIx

FHIR API-based digital service production.

Cloud Healthcare API

Solution for bridging existing care systems and apps on Google Cloud.

Cloud Life Sciences (beta)

Tools for managing, processing, and transforming biomedical data.

Healthcare Natural Language AI

Real-time insights from unstructured medical text.

Hybrid and Multi-cloud

Anthos

The platform for modernizing existing apps and building new ones.

Apigee API Management

API management, development, and security platform.

Cloud Build

Service for executing builds on Google Cloud infrastructure.

Looker

The platform for BI, data applications, and embedded analytics.

Migrate for Anthos

Tool to move workloads and existing applications to GKE.

Internet Of Things (IoT)

Edge TPU

ASIC is designed to run ML inference and AI at the edge.

IoT Core

IoT device management, integration, and connection service.

Management Tools

Anthos Service Mesh

Managed service mesh for complex microservices architectures.

Cloud APIs

Programmatic interfaces for Google Cloud services.

Cloud Console

Web-based interface for managing and monitoring cloud apps.

Cloud Deployment Manager

Service for creating and managing Google Cloud resources.

Cloud Mobile App

App to manage Google Cloud services from your mobile device.

Cloud Shell

Interactive shell environment with a built-in command line.

Cost Management

Tools for monitoring, controlling, and optimizing your costs.

Private Catalog

A service catalog for admins managing internal enterprise solutions.

Media and Gaming

Game Servers

Game server management service running on Google Kubernetes Engine.

OpenCue

Open-source render manager for visual effects and animation.

Transcoder API (beta)

Transform video content for use across a variety of user devices.

Migration

Application migration

App migration to the cloud for low-cost refresh cycles.

BigQuery Data Transfer Service

Data import service for scheduling and moving data into BigQuery.

Cloud Foundation Toolkit

Reference templates for Deployment Manager and Terraform.

Migrate for Anthos

Components for migrating VMs into system containers on GKE.

Migrate for Compute Engine

Components for migrating VMs and physical servers to Compute Engine.

Transfer Appliance

Storage server for moving large volumes of data to Google Cloud.

Networking

Cloud Armor

Security policies and defense against web and DDoS attacks.

Cloud CDN

Content delivery network for serving web and video content.

Cloud Domains

Easy domain name registration and management.

Cloud DNS

Domain name system for reliable and low-latency name lookups.

Cloud Load Balancing

Service for distributing traffic across applications and regions.

Cloud NAT

NAT service for giving private instances internet access.

Hybrid Connectivity

Connectivity options for VPN, peering, and enterprise needs.

Network Connectivity Center

Use Google's network as your own. Reimagine how you deploy, manage, and scale your networks.

Network Intelligence Center

Network monitoring, verification, and optimization platform.

Network Service Tiers

Cloud network options are based on performance, availability, and cost.

Network Telemetry

VPC flow logs for network monitoring, forensics, and security.

Service Directory

The platform for discovering, publishing, and connecting services.

Traffic Director

Traffic control pane and management for open service mesh.

Virtual Private Cloud (VPC)

Virtual network for Google Cloud resources and cloud-based services.

Operations

Cloud Debugger

Real-time application state inspection and in-production debugging.

Cloud Logging

Google Cloud audit, platform, and application logs management.

Cloud Monitoring

Infrastructure and application health with rich metrics.

Cloud Profiler

CPU and heap profiler for analyzing application performance.

Cloud Trace

Tracing system collecting latency data from applications.

Kubernetes Engine Monitoring

GKE app development and troubleshooting.

Security and Identity

Security

Access Transparency

Cloud provider visibility through near real-time logs.

Assured Workloads

Compliance and security controls for sensitive workloads.

Binary Authorization

Deploy only trusted containers on Kubernetes Engine.

Chronicle

Extract signals from your security telemetry to find threats instantly.

Cloud Asset Inventory

View, monitor, and analyze Google Cloud and Anthos assets across projects and services.

Cloud Data Loss Prevention

Sensitive data inspection, classification, and redaction platform.

Cloud Key Management

Manage encryption keys on Google Cloud.

Confidential Computing

Encrypt data in use with Confidential VMs.

Firewalls
Global and flexible firewalls to protect your cloud resources.

Risk Protection Program (preview)
Reduce security risk and gain access to an exclusive cyber insurance policy.

Secret Manager
Store API keys, passwords, certificates, and other sensitive data.

Security Command Center
The platform for defending against threats to your Google Cloud assets.

Shielded VMs
Virtual machines are hardened with security controls and defenses.

VPC Service Controls
Protect sensitive data in Google Cloud services using security perimeters.

Identity and Access

BeyondCorp Enterprise
Zero trust solution for secure application and resource access.

Certificate Authority Service (beta)
Simplify the deployment and management of private CAs.

Cloud Identity
Unified platform for IT admins to manage user devices and apps.

Identity and Access Management
Permissions management system for Google Cloud resources.

Identity-Aware Proxy
Use identity and context to guard access to your applications and VMs.

Identity Platform
Add Google-grade identity and access management to your apps.

Managed Service for Microsoft Active Directory
Hardened service running Microsoft® Active Directory (AD).

Policy Intelligence
Smart access control for your Google Cloud resources.

Resource Manager
Hierarchical management for organizing resources on Google Cloud.

Titan Security Key
Two-factor authentication device for user account protection.

User Protection Services

CAPTCHA Enterprise
Help protect your website from fraudulent activity, spam, and abuse.

Web Risk
Detect malicious URLs on your website and in client applications.

Serverless Computing

App Engine

Serverless application platform for apps and back ends.

Cloud Functions

The platform for creating functions that respond to cloud events.

Cloud Run

Fully managed environment for running containerized apps.

Workflows

Workflow orchestration for serverless products and API services.

Storage

Archive Storage

Data archive that offers online access speed at an ultra-low-cost.

Storage Transfer Service

Tools and services for transferring your data to Google Cloud.

Cloud Storage

It is an object storage service that is highly available and durable. Users can quickly access data from their app from anywhere, on account of edge-caching on a global scale. Google presents a simple application programming interface (API), provides a robust service-level agreement, and runs versioning to let you handle data programmatically.

Features

- Variable Access
- Storage of Objects with Feature-Rich API
- Adjustable and Viable Pricing
- Safe and Secure

Cloud Datastore

It provides a schema-less, NoSQL, and managed database for storing non-relational data. SQL-like queries, as well as transactions, are well supported, and the data storage expands as needed.

Features

- Access to Data Anywhere
- Local Tools for Development
- In-built Redundancy
- ACID Transactions
- Scaling Automatically with Users
- Database Management
- SQL-Like Querying and Schema-less Access

Cloud Storage for Firebase

Object storage for storing and serving user-generated content.

Filestore

File storage that is highly scalable and secure.

Google Workspace Essentials

Cloud-based file sharing, content collaboration, and storage.

Local SSD

Block storage that is locally attached for high-performance needs.

Persistent Disk

Block storage for virtual machine instances running on Google Cloud.

More Google Cloud Products

Google Workspace

An integrated suite of secure, cloud-native collaboration and productivity apps powered by Google AI.

Google Meet

Easy-to-join video meetings.

Chrome Enterprise

Google Chrome Enterprise unlocks the business capabilities of Chrome OS, Chrome Browser, and Chrome devices, freeing IT to power your cloud workforce.

Google Maps Platform

Create immersive location experiences and improve your business operations with real-time, comprehensive data.

Along with the cloud platform, Google offers developer tools such as Google Plugin for Eclipse, Google Cloud Platform SDK, Android Studio, Cloud Playground, and Push-to-Deploy.

Google cloud has had a huge influence, particularly in the realm of online and mobile app development, where small and large businesses (SMBs) may utilize Google technology. It has simplified and made things more accessible to app developers. However, its reliance on internet access may stymie its future advancement.Adopting the Google cloud platform allows your company to make use of several special features, such as live migration on the Google cloud, that are not accessible in Azure or AWS. It even offers you access to a vast staff of security professionals who are tasked with safeguarding your data. Small and medium-sized companies stand to benefit greatly from migration, including increased flexibility and scalability in matching IT resources to demand.

[Source: https://cloud.google.com/gcp]

Google App Engine (Gae)

Google App Engine (GAE) or just 'App Engine', is a cloud computing platform as a service that allows you to create and run web applications in Google-managed data centers. Applications are sandboxed and run across multiple servers. App Engine provides automatic scaling for web applications, which means that when the number of requests for an application rises, App Engine automatically assigns more resources to the web application to accommodate the increased demand.

Google App Engine is a Google Cloud Platform service that helps build highly scalable applications on a fully managed serverless platform. It generally supports apps written in Go, PHP, Java, Python, Node.js, .NET, and Ruby, but it can also support additional languages via "custom runtimes." The service is free up to a particular number of consumed resources, and it is only available in a regular environment, not a flexible environment. Fees are levied for additional storage, bandwidth, or instance hours required by the application.

Google Workspace Essentials

Cloud-based file sharing, content collaboration, and storage.

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Block storage that is locally attached for high-performance needs.

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Google App Engine is a Platform as a Service (PaaS) cloud computing paradigm that provides a platform for developers to construct scalable apps on the Google cloud platform. The most impressive feature of GAE is its capacity to handle built-in apps in Google's data centers. As a result, enterprises simply have one task to master: creating cloud-based apps. The remainder of the time, the App Engine provides the platform and administers the apps.

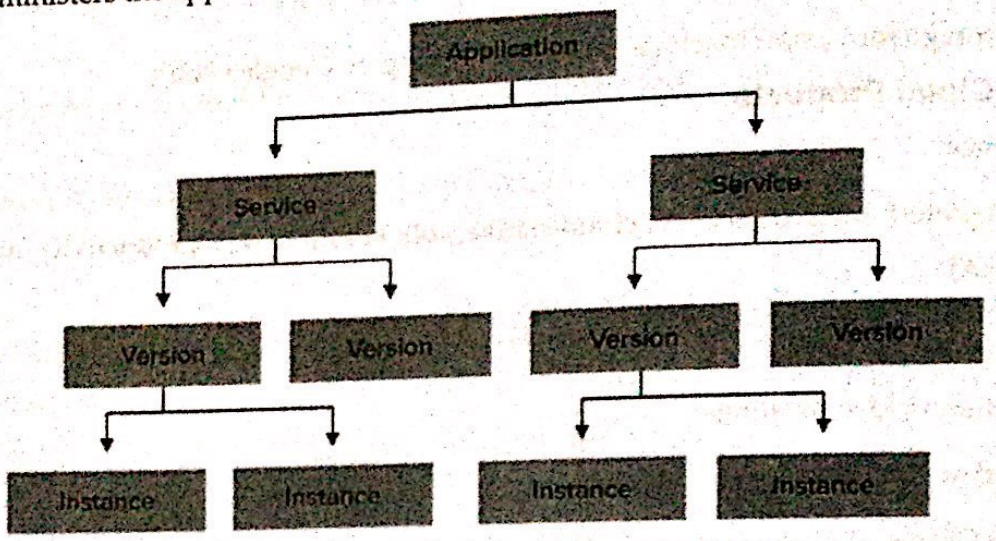

Figure 8.11: The App Engine architecture in cloud computing

Services Provided by App Engine Includes

- Platform as a Service (PaaS) to build and deploy scalable applications
- Hosting facility is fully managed data centers
- A fully managed, flexible environment platform for managing application server and infrastructure
- Support in the form of popular development languages and developer tools

Features of Google App Engine

1. **Development Languages and Tools Collection:** For developers, the App Engine supports a wide range of programming languages and allows them to import libraries and frameworks via Docker containers. You can develop and test an app locally by using the SDK, which includes app deployment tools. Every language has its SDK and runtime environment. Python, PHP, .NET, Java, Ruby, C#, Go, and Node.js are among the languages available.
2. **Completely Managed:** Google lets you add your web application code to the platform while they manage the infrastructure. By enabling the firewall, the engine ensures that your web apps are secure and operational, as well as protecting them from malware and threats.
3. **Pay-Per-Use:** The app engine operates on a pay-as-you-go basis, which means you only pay for what you use. When application traffic increases, the app engine automatically scales up resources, and vice versa.
4. **Reliable Diagnostic Services:** Cloud Monitoring and Cloud Logging that aids in the execution of app scans to identify bugs. The app reporting document assists developers in resolving bugs as soon as possible.
5. **Traffic Segmentation:**As part of A/B testing, the app engine automatically routes incoming traffic to different versions of the apps. The consecutive increments can be planned based on which version of the app works best.

Benefits of Google App Engine for Websites

Adopting the App Engine is a wise decision for your company because it will enable you to innovate and remain valuable. Here's why Google App Engine is a better choice for developing applications:

1. **High Availability:** When you develop and deploy web applications to the cloud, you enable remote access to your applications. Considering the huge impact of COVID-19 on businesses, Google App Engine is the best option because it allows developers to develop applications remotely while the cloud service manages the infrastructure requirements.
2. **Ensure a quicker time to market:** For your web applications to succeed, a shorter time to market is critical, as requirements are likely to change if the launch time is extended. For developers, using Google App Engine is as simple as it gets. The diverse tool repository and other functionalities ensure that development and testing time are reduced, resulting in a faster MVP and consecutive launch time.
3. **User-Friendly Platform:** The only thing the developers need to do is write code. You eliminate all of the burdens of managing and deploying the code with zero configuration and server management. Google App Engine makes it simple to use the platform, allowing you to focus on other concurrent web applications and processes. The best part is that GAE handles the increased traffic automatically via patching, provisioning, and monitoring.
4. **A wide range of APIs:** Google App Engine includes many APIs and services that enable developers to create robust and feature-rich apps. These characteristics are as follows:
   - Access to the application log
   - **Blobstore,** serve large data objects
   - Google App Engine Cloud Storage
   - SSL Support
   - Page Speed Services
   - Google Cloud Endpoint, for mobile application
   - URL Fetch API, User API, Memcache API, Channel API, XXMP API, File API
5. **Enhanced Scalability:** Scalability is synonymous with growth, and it is a critical factor in ensuring success and competitive advantage. The Google App Engine cloud development platform, on the other hand, is automatically scalable. GAE automatically scales up the resources when the traffic to the web application increases, and vice versa.
6. **Increased Savings:** You do not have to spend extra money on server management when you use Google App Engine. The Google Cloud service is adept at handling backend operations. Furthermore, Google App Engine pricing is adaptable because resources can be scaled up or down based on app usage. The resources automatically scale up and down based on how well the app performs in the market, ensuring that the pricing is fair in the end.
7. **Pricing Intelligence:** The main concern of enterprises is how much does Google App Engine cost. Google App Engine has a daily and monthly billing cycle for your convenience.
   - Daily: You will be charged for the resources you utilize daily.
   - Every month: All daily charges are calculated, added to any applicable taxes, and deducted from your payment method.

The App Engine offers a separate billing dashboard, "App Engine Dashboard," where you can check and control your account and subsequent billings.

[Source: https://cloud.google.com/appengine]

Microsoft Azure Platform (MAP)

Microsoft Azure, originally known as Windows Azure, is a public cloud computing platform developed by Microsoft offering solutions such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) that can be used for analytics, virtual computing, storage, networking, and much more. It offers a variety of cloud services such as computation, analytics, storage, and networking. Users can select among these services to create and grow new applications, as well as run existing apps on the public cloud. It may be used to augment or replace your on-premises servers.

1. **High Availability:** When you develop and deploy web applications to the cloud, you enable remote access to your applications. Considering the huge impact of COVID-19 on businesses, Google App Engine is the best option because it allows developers to develop applications remotely while the cloud service manages the infrastructure requirements.
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   - Google Cloud Endpoint, for mobile application
   - URL Fetch API, User API, Memcache API, Channel API, XXMP API, File API
5. **Enhanced Scalability:** Scalability is synonymous with growth, and it is a critical factor in ensuring success and competitive advantage. The Google App Engine cloud development platform, on the other hand, is automatically scalable. GAE automatically scales up the resources when the traffic to the web application increases, and vice versa.
6. **Increased Savings:** You do not have to spend extra money on server management when you use Google App Engine. The Google Cloud service is adept at handling backend operations. Furthermore, Google App Engine pricing is adaptable because resources can be scaled up or down based on app usage. The resources automatically scale up and down based on how well the app performs in the market, ensuring that the pricing is fair in the end.
7. **Pricing Intelligence:** The main concern of enterprises is how much does Google App Engine cost. Google App Engine has a daily and monthly billing cycle for your convenience.
   - Daily: You will be charged for the resources you utilize daily.
   - Every month: All daily charges are calculated, added to any applicable taxes, and deducted from your payment method.

The App Engine offers a separate billing dashboard, "App Engine Dashboard," where you can check and control your account and subsequent billings.

[Source: https://cloud.google.com/appengine]

Microsoft Azure Platform (MAP)

Microsoft Azure, originally known as Windows Azure, is a public cloud computing platform developed by Microsoft offering solutions such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) that can be used for analytics, virtual computing, storage, networking, and much more. It offers a variety of cloud services such as computation, analytics, storage, and networking. Users can select among these services to create and grow new applications, as well as run existing apps on the public cloud. It may be used to augment or replace your on-premises servers.

The Azure platform is designed to assist organizations in managing difficulties and meeting organizational goals. It provides tools for all industries, including e-commerce, banking, and several *Fortune 500* organizations, and is compatible with open-source technology. This gives users the freedom to utilize their favorite tools and technology. Furthermore, Azure provides four types of cloud computing services: infrastructure as a service (IaaS), platform as a service (PaaS), software as a service (SaaS), and serverless. Microsoft charges for Azure on a pay-as-you-go basis, which means that users receive a monthly payment that only costs them for the resources they have utilized.

Customers that subscribe to Azure get access to all of the services available through the Azure interface. These services enable subscribers to establish cloud-based resources such as virtual machines (VM) and databases. In addition to the services provided by Microsoft through the Azure portal, several third-party companies provide software directly through Azure. The cost of third-party apps varies greatly; however, it may include a subscription charge for the program as well as a use charge for the infrastructure needed to host the program.

Microsoft provides five different customer support options for Azure:

- Basic
- Developer
- Standard
- Professional Direct
- Premier

The scope and cost of these customer assistance programs vary. Basic assistance is free for all Azure accounts; however, Microsoft charges a premium for additional support services. Developer support is $29 per month, $100 per month for Standard assistance, and $1000 per month for Professional Direct assistance. Microsoft does not provide price information for Premier support.

What is Microsoft Azure Used for?

Microsoft Azure's use cases are quite diversified because it comprises multiple service offerings. Running virtual machines or containers in the cloud is one of Microsoft Azure's most common uses. These computational resources can run infrastructure components including domain name system (DNS), Windows Server services like Internet Information Services (IIS), or third-party apps. Third-party operating systems, such as Linux, are also supported by Microsoft.

Azure is also extensively utilized as a platform for cloud-based database hosting. Microsoft provides serverless relational databases like Azure SQL as well as non-relational databases like NoSQL.

Furthermore, the platform is commonly used for disaster recovery and backup. Many businesses utilize Azure storage as an archive to satisfy their long-term data preservation obligations.

Azure Products and Services

Microsoft categorizes Azure cloud services into more than two dozen groups, which include:

1. **Compute:** These services allow users to deploy and manage virtual machines, containers, and batch tasks, as well as enabling remote application access. Depending on whether the resource needs to be available to the outside world, compute resources established in the Azure cloud can be configured with either public or private IP addresses.
2. **Mobile:** These solutions aid developers in the creation of cloud apps for mobile devices by offering notification services, back-end task support, tools for creating application program interfaces (APIs), and the ability to combine geographic context with data.
3. **Web:** These services aid in the creation and deployment of web applications. They also provide search, content delivery, API administration, alerting, and reporting tools.
4. **Storage:** This service category offers scalable cloud storage for organized and unstructured data. It also provides support for big data projects, persistent storage, and archive storage.

5. **Analytics**: These services include distributed analytics and storage, as well as real-time analytics, big data analytics, data lakes, machine learning (ML), business intelligence (BI), internet of things (IoT) data streams, and data warehousing.
6. **Networking:** This category comprises virtual networks, dedicated connections, and gateways, as well as traffic management and diagnostics, load balancing, DNS hosting, and network defense against distributed denial-of-service (DDoS) assaults.
7. **Media and content delivery network (CDN)**: On-demand streaming, digital rights management, encoding, media playing, and indexing are among the CDN services available.
8. **Integration:** These are services for backing up servers, recovering websites, and connecting private and public clouds.
9. **Identity**: These services guarantee that only authorized users may access Azure services and aid in the protection of encryption keys and other sensitive data in the cloud. Support for Azure Active Directory and multifactor authentication are among the services provided (MFA).
10. **Internet of Things (IoT)**: These services assist customers in collecting, monitoring, and analyzing IoT data from sensors and other devices. Notifications, analytics, monitoring, and code and execution help are all available as services.
11. **DevOps**: This group offers project and collaboration solutions, including Azure DevOps (previously Visual Studio Team Services), to help with DevOps software development processes. It also includes application diagnostics, DevOps tool connectors, and test laboratories for build testing and experimentation.
12. **Development:** These services aid application developers in the sharing of code, testing of apps, and tracking of possible bugs. JavaScript, Python, .NET, and Node.js are among the application programming languages supported by Azure. This category also includes tools that assist Azure DevOps, software development kits (SDKs), and blockchain.
13. **Security:** These technologies enable the detection and response to cloud security risks, as well as the management of encryption keys and other sensitive assets.
14. **Artificial intelligence (AI) and machine learning**: A developer may utilize this service to incorporate artificial intelligence, machine learning, and cognitive computing capabilities into apps and data sets.
15. **Containers:** Containers are used to store items. These services assist enterprises in creating, registering, orchestrating, and managing massive quantities of containers on the Azure cloud, utilizing standard platforms such as Docker and Kubernetes.
16. **Database:** Database as a Service (DBaaS) services for SQL and NoSQL, as well as additional database instances, such as Azure Cosmos DB and Azure Database for PostgreSQL, are included in this category. It also supports Azure SQL Data Warehouse, caching, and hybrid database integration and migration. The platform's main database service is Azure SQL. It is a relational database that enables SQL capabilities without the requirement for a SQL server to be installed.
17. **Migration:** This package of tools assists an organization in estimating workload migration expenses and performing real workload migrations from local data centers to the Azure cloud.
18. **Management and governance:** These services offer a variety of backup, recovery, compliance, automation, scheduling, and monitoring capabilities to assist a cloud administrator in managing an Azure project.
19. **Mixed reality.** These services are intended to assist developers in developing content for the Windows Mixed Reality environment.
20. **Blockchain:** You may use the Azure Blockchain Service to join a blockchain consortium or to form your own.
21. **Intune:** Microsoft Intune may be used to enroll user devices, allowing security policies and mobile apps to be sent to those devices. Mobile apps can be distributed to groups of users or a set of devices. In addition, Intune has features for tracking which applications are being utilized. A remote wipe capability enables the organization's data to be safely erased from devices without uninstalling the user's mobile apps.

Azure for DR and Backup

Azure is used by certain businesses for data backup and disaster recovery. Azure may also be used as a substitute for a company's own data center. Instead of investing in local servers and storage, many businesses choose to operate some or all of their business apps in Azure. Microsoft has Azure data centers placed all around the world to ensure availability. Microsoft Azure services are offered in 55 regions and 140 countries as of January 2020. Regrettably, not all services are accessible in every location. As a result, Azure customers must verify that their workloads and data storage locations adhere to any applicable compliance standards or other regulations.

Privacy

Privacy is a big worry for cloud customers due to data security issues and regulatory compliance obligations. To alleviate these concerns, Microsoft established the online Trust Center, which gives thorough information on the company's security, privacy, and compliance operations. According to the Trust Center, Microsoft will only use customer data to provide the agreed-upon services and will never share customer data with government agencies unless compelled by law.

Azure Pricing and Costs

Azure, like other public cloud companies, generally employs a pay-as-you-go pricing model that assesses costs depending on consumption. If a single application makes use of many Azure services, each service may have different price levels. Furthermore, if a customer commits to a long-term commitment to particular services, such as compute instances, Microsoft also provides a discount. Given the numerous elements that influence cloud service price, a business should evaluate and manage its cloud utilization to save expenses. Azure-native technologies, such as Azure Cost Management, can aid in the monitoring, visualization, and optimization of cloud expenditure. Third-party solutions, such as Cloudability or RightScale, can also be used to control Azure resource utilization and expenditures.

Azure Competitors

Microsoft Azure is one of the prominent public cloud service providers with a global presence. Google Cloud Platform (GCP) and Amazon Web Services (AWS) are major competitors of Microsoft Azure. There is currently a lack of standardization across cloud services and capabilities, which means that no two cloud providers deliver the same service, in the same way, utilizing the same APIs or connectors. When pursuing a multi-cloud strategy, this makes it impossible for a company to use more than one public cloud provider. Some of these issues can be mitigated by using third-party cloud management technologies.

[Source: https://www.microsoft.com]

Apache Hadoop

Apache Hadoop is a Java-based open-source software framework for scalable and distributed computing that manages data processing and storage in large data applications. Hadoop distributes big data sets and analytical jobs among nodes in a computing cluster, breaking them down into smaller tasks that may be handled concurrently. Hadoop can process both organized and unstructured data and scale up from a single server to thousands of computers in a reliable manner.

The Apache Hadoop software library provides a platform for distributed processing of massive data volumes across computer clusters using simple programming techniques. It is intended to grow from a single server to thousands of computers, each of which provides local computing and storage. Rather than relying on hardware to provide high availability, the library is designed to identify and manage problems at the application layer, giving a highly available service on top of a cluster of machines, each of which may fail.

Hadoop was a significant advancement in the big data arena. Indeed, it is recognized as laying the groundwork for the present cloud data lake. Hadoop democratized processing power by allowing businesses to examine and query large data sets in a scalable manner utilizing free, open-source software and low-cost off-the-shelf hardware. This was an important breakthrough because it provided a viable alternative to the proprietary data warehouse (DW) systems and closed data formats that had previously dominated the market. With the launch of Hadoop, enterprises soon gained access to the capacity to store and analyze massive volumes of data, higher computation capacity, fault tolerance, data management flexibility, cheaper costs compared to DWs, and more scalability - simply add more nodes. Finally, Hadoop laid the stage for future big data analytics breakthroughs, such as the release of Apache Spark.

The term Hadoop is a general term that may refer to any of the following:

- The overall Hadoop ecosystem, which encompasses both the core modules and related sub-modules.
- The core Hadoop modules, including Hadoop Distributed File System (HDFS), Yet Another Resource Negotiator (YARN), MapReduce, and Hadoop Common. These are the basic building blocks of a typical Hadoop deployment.
- Hadoop-related sub-modules such as Apache Hive™, Apache Impala™, Apache Pig™, and Apache Zookeeper™. These related pieces of software can be used to customize, improve upon, or extend the functionality of core Hadoop.

The core modules of Hadoop include:

- Hadoop Common: The common utilities that support the other Hadoop modules.
- Hadoop Distributed File System (HDFS): A distributed file system that provides high-throughput access to application data.
- Hadoop Yet Another Resource Negotiator (YARN): A framework for job scheduling and cluster resource management.
- Hadoop MapReduce: A YARN-based system for parallel processing of large data sets.
- Hadoop Ozone: An object store for Hadoop

Examples of Popular Hadoop-related Software

Popular Hadoop packages that are not strictly a part of the core Hadoop modules, but that are frequently used in conjunction with them, include:

- **Apache Hive** is data warehouse software that runs on Hadoop and enables users to work with data in HDFS using a SQL-like query language called HiveQL.
- **Apache Impala** is the open-source, native analytic database for Apache Hadoop.
- **Apache Pig** is a tool that is generally used with Hadoop as an abstraction over MapReduce to analyze large sets of data represented as data flows. Pig enables operations like join, filter, sort, load, etc.
- **Apache Zookeeper** is a centralized service for enabling highly reliable distributed processing.
- **Apache Sqoop™** is a tool designed for efficiently transferring bulk data between Apache Hadoop and structured datastores such as relational databases.
- **Apache Oozie** is a workflow scheduler system to manage Apache Hadoop jobs. Oozie Workflow jobs are Directed Acyclical Graphs (DAGs) of actions.

Benefits oF Hadoop

- **Scalability**: Unlike traditional systems, which have storage limitations, Hadoop is scalable since it functions in a distributed environment. This enabled data architects to create early Hadoop data lakes.
- **Resilience:** The Hadoop Distributed File System (HDFS) is intrinsically robust. To prepare for the risk of hardware or software failures, data stored on each node of a Hadoop cluster is also duplicated on other nodes of the cluster. This design is purposely redundant to ensure failure tolerance. If one node fails, there is always a backup of the data in the cluster.
- **Flexibility**: Unlike typical relational database management systems, Hadoop allows you to store data in any format, including semi-structured or unstructured data. Hadoop allows organizations to readily access new data sources and access various sorts of data.

Challenges with Hadoop Architectures

- **Complexity**: Hadoop is a low-level, Java-based platform that might be too complicated to deal with for end users. Hadoop infrastructures can also need a substantial amount of skill and resources to set up, maintain, and update.
- **Performance**: Hadoop performs calculations by doing frequent reads and writes to disk, which is time-consuming and inefficient when compared to frameworks that attempt to store and process data in memory as much as possible, such as Apache Spark.
- **Viability in the long run**: The world witnessed a tremendous unraveling inside the Hadoop realm in 2019. Google, whose groundbreaking 2004 article on MapReduce served as the foundation for the construction of Apache Hadoop, has discontinued using MapReduce entirely. In the Hadoop industry, there were also some high-profile mergers and acquisitions. Furthermore, in 2020, a prominent Hadoop supplier switched its product set away from being Hadoop-centric, since Hadoop is now considered to be "more of a mindset than a technology."

[Source: http://hadoop.apache.org]

Aneka

Manjrasoft is dedicated to developing revolutionary software solutions that facilitate the development and deployment of applications on private or public Clouds. Their product, Aneka, serves as an Application Platform as a Service for Cloud Computing. Aneka provides a variety of programming paradigms such as Task Programming, Thread Programming, and MapReduce Programming, as well as tools for quick application development and smooth deployment on private or public Clouds to distribute applications.

Figure 8.12: Variety of programming paradigms provided by Aneka

Aneka is a cloud-based platform and framework for constructing distributed applications. It makes use of the idle CPU cycles of a heterogeneous network of desktop PCs, servers, and data centers. Aneka provides a comprehensive set of APIs for developers to transparently use such resources and express the business

logic of apps using the chosen programming abstractions. To monitor and govern the deployed infrastructure, system administrators might use a set of tools. This can be a public cloud accessible over the Internet, or a private cloud comprised of a group of nodes with restricted access.

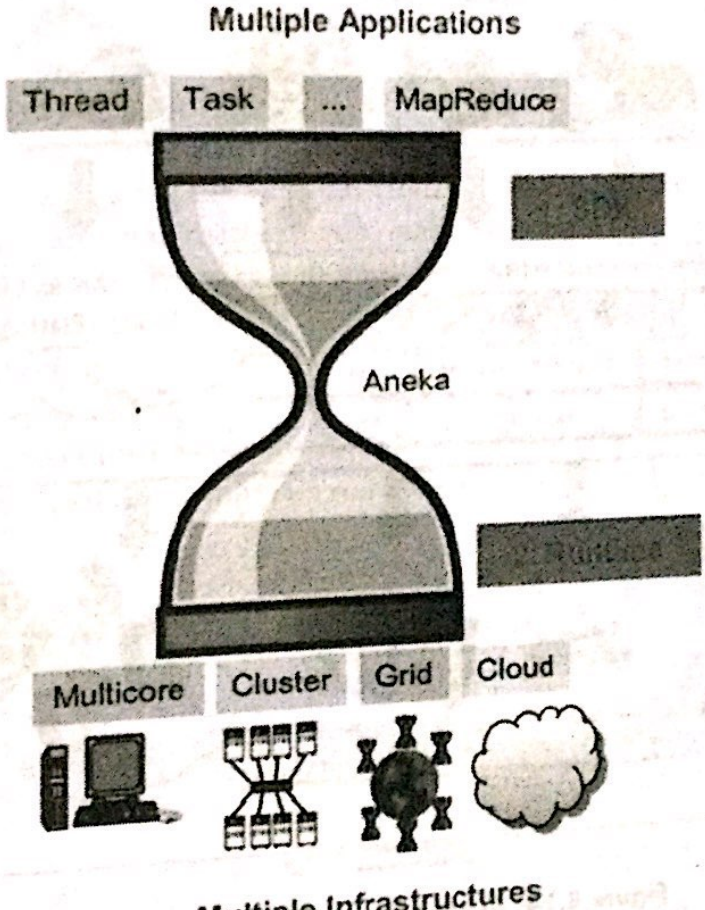

Figure 8.13: Aneka's capabilities at a glance.

Aneka technology primarily consists of two key components:

- SDK (Software Development Kit) containing application programming interfaces (APIs) and tools essential for the rapid development of applications. Aneka APIs supports three popular Cloud programming models: Task, Thread, and MapReduce; and
- A Runtime Engine and Platform for managing deployment and execution of applications on private or public Clouds.

Aneka PaaS is famous for its ability to supply private cloud resources such as desktops, clusters, and virtual datacenters utilizing VMWare, Citrix Zen server, and public cloud resources such as Windows Azure, Amazon EC2, and GoGrid Cloud Service. Aneka's promise as a Platform as a Service has been effectively realized by its users and clients across three industries: engineering, life science, education, and business intelligence.

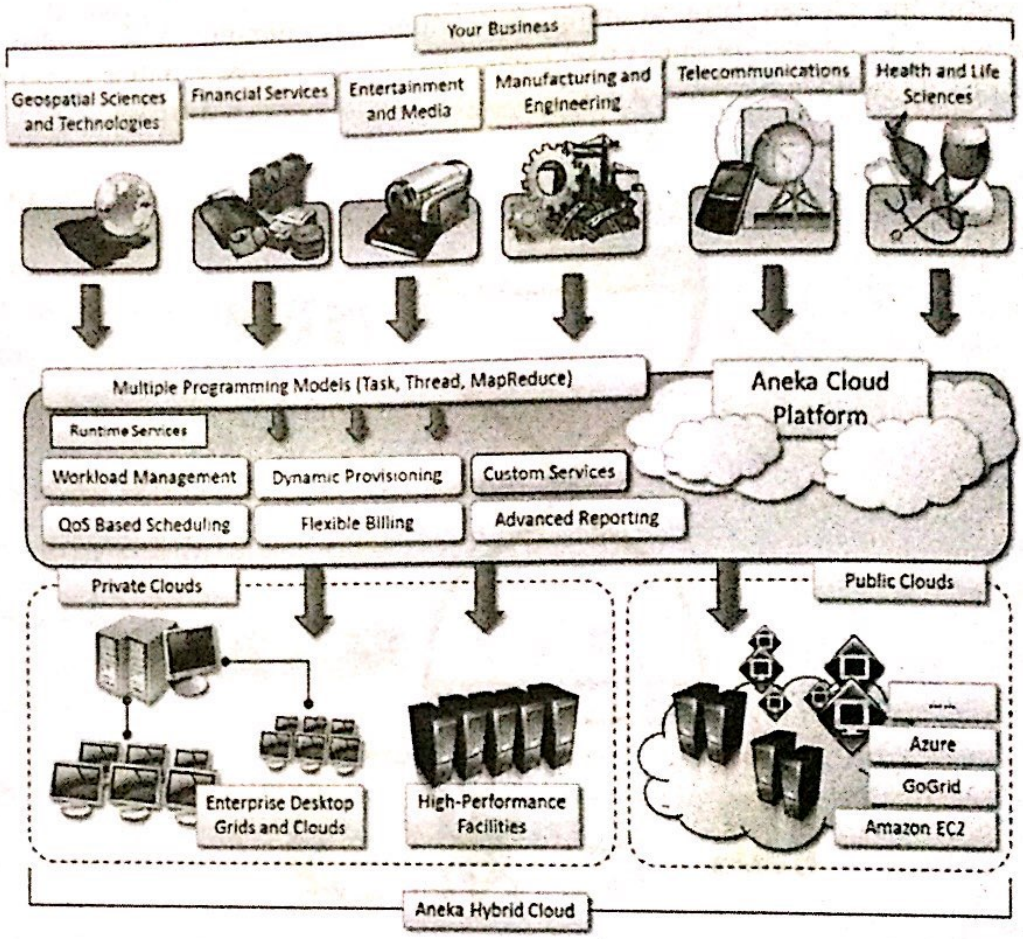

Figure 8.14: Aneka cloud computing schema

Highlights of Aneka

Technical Value

- Support of multiple programming and application environments
- Simultaneous support of multiple run-time environments
- Rapid deployment tools and framework
- Simplicity is developing applications on Cloud
- Dynamic Scalability
- Ability to harness multiple virtual and/or physical machines for accelerating application result
- Provisioning based on QoS/SLA

Business Value

- Improved reliability and Simplicity
- Faster time to value
- Operational Agility
- Definite application performance enhancement
- Optimizing the capital expenditure and operational expenditure

All these features make Aneka a winning solution for enterprise customers in the Platform-as-a-Service scenario.

1. **Build:** Aneka includes a Software Development Kit (SDK) which contains a combination of APIs and Tools to enable you to express your application. Aneka also allows you to build different run-time environments and build new applications.
2. **Accelerate:** Aneka supports Rapid Development and Deployment of Applications in Multiple Run-Time environments. Aneka uses physical machines as much as possible to achieve maximum utilization in the local environment. As demand increases, Aneka provisions VMs via private clouds (Xen or VMWare) or Public Clouds (Amazon EC2).

3. **Manage:** Aneka Management includes a Graphical User Interface (GUI) and APIs to set up, monitor, manage and maintain remote and global Aneka compute clouds. Aneka also has an accounting mechanism and manages priorities and scalability based on SLA/QoS which enables dynamic provisioning.

Architecture

The Aneka-based computing cloud is a collection of physical and virtualized resources that are linked via a network, which can be the Internet or a private intranet. Each of these resources contains an instance of the Aneka Container, which represents the runtime environment in which the distributed apps operate. The container offers the fundamental management features of a single node and leverages all other activities on the services that it hosts. The services are divided into three categories: fabric, foundation, and execution. Fabric services provide hardware profiling and dynamic resource provisioning by interacting directly with the node via the Platform Abstraction Layer (PAL). The fundamental system of the Aneka middleware is identified by foundation services, which provide a collection of fundamental capabilities that allow Aneka containers to conduct specialized sets of jobs. Execution services deal directly with the scheduling and execution of Cloud applications.

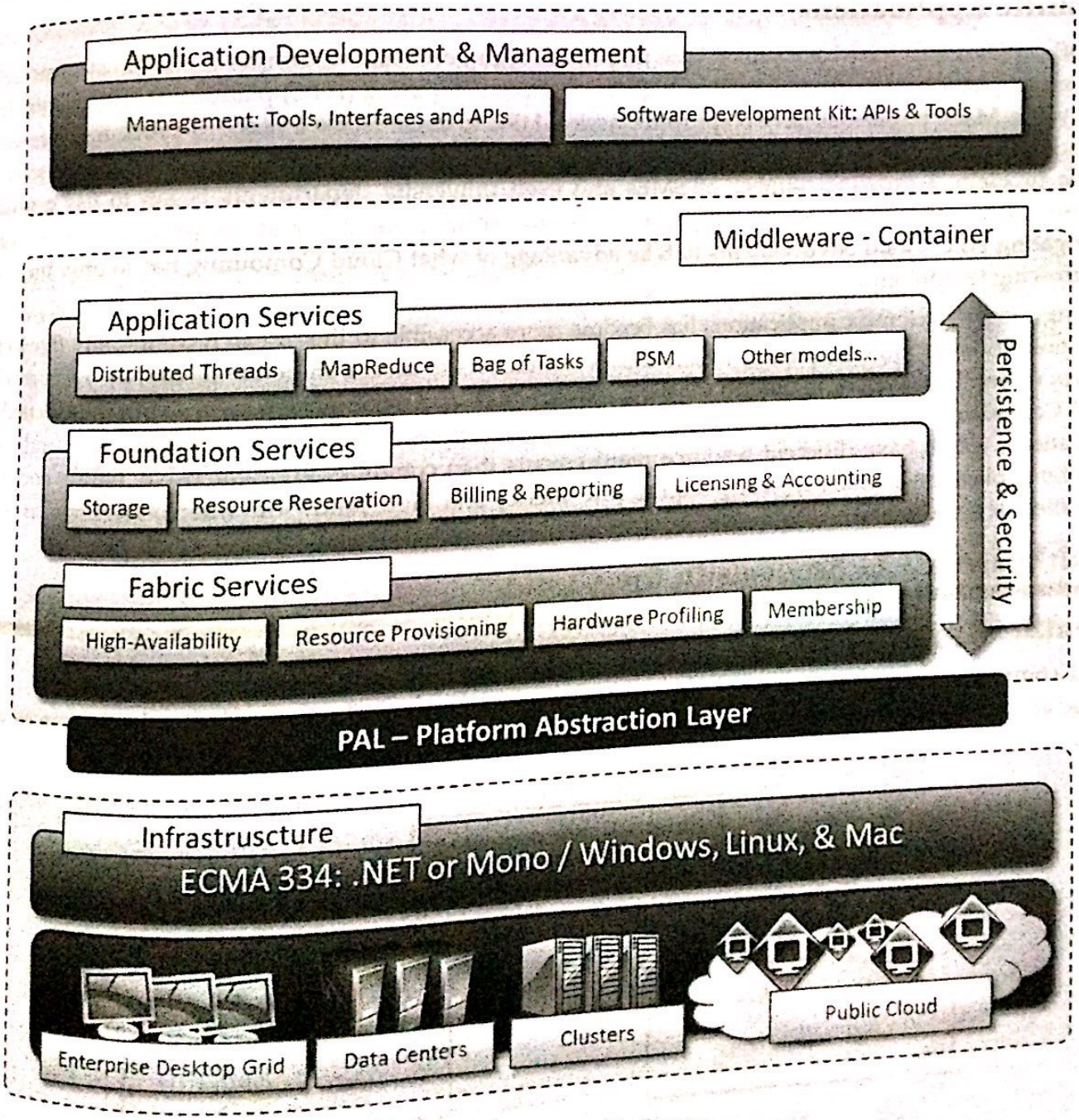

Figure 8.15: Aneka Platform

Aneka's ability to provide alternative methods of expressing distributed applications by delivering alternative programming models is one of its primary advantages; execution services are largely concerned with supplying the middleware with an implementation for these models. Additional services, such as persistence and security, are cross-cutting throughout the full stack of services hosted by the Container. At the application level, a variety of components and tools are given to 1) ease application development (SDK); 2) move existing apps to the Cloud; and 3) monitor and manage the Aneka Cloud.

Aneka's most typical deployment is shown in the figure. An Aneka-based Cloud is made up of a collection of networked resources that may be dynamically adjusted to meet the demands of the user through resource virtualization or by utilizing the spare CPU cycles of desktop PCs. If the deployment designates a private Cloud, all resources, for example, are in-house, such as within the organization. This deployment is expanded by adding on-demand publicly accessible resources or by interfacing with other Aneka public clouds that provide computing resources connected over the Internet.

[Source: http://www.manjrasoft.com]

Applications of Cloud Computing

Scientific Applications

Scientific applications have been run on both traditional high-performance computing (HPC) systems such as supercomputers and clusters, as well as high throughput computing (HTC) platforms such as Grids, for many years. Many businesses have employed classical HPC to assist tackle a range of problems since they have access to enormous quantities of computer power. Although these systems were often built to solve a specific problem, a growing number of SMEs and even university departments began to use general-purpose HPC systems.Scientists, engineers, system administrators, and developers have been investigating HPC Cloud environments to take advantage of what Cloud Computing has to offer them as new growing technology.

Running complex scientific applications has become more accessible to the research community thanks to the popularity of Cloud Computing, which allows researchers to access on-demand compute resources in minutes rather than waiting in queues for their compute jobs and experiencing peak demand bottlenecks. Cloud Computing has a lot of promise for scientific applications, but it was built for business and web applications, which have different resource requirements than communication-intensive, tightly coupled scientific applications, which typically require low latency and high bandwidth interconnections, as well as parallel file systems.

Healthcare: ECG Analysis in the Cloud

Scientific Applications

Cloud computing is getting involved in scientific applications and because of this the resources and storage are not available infinitely at reasonable prices.

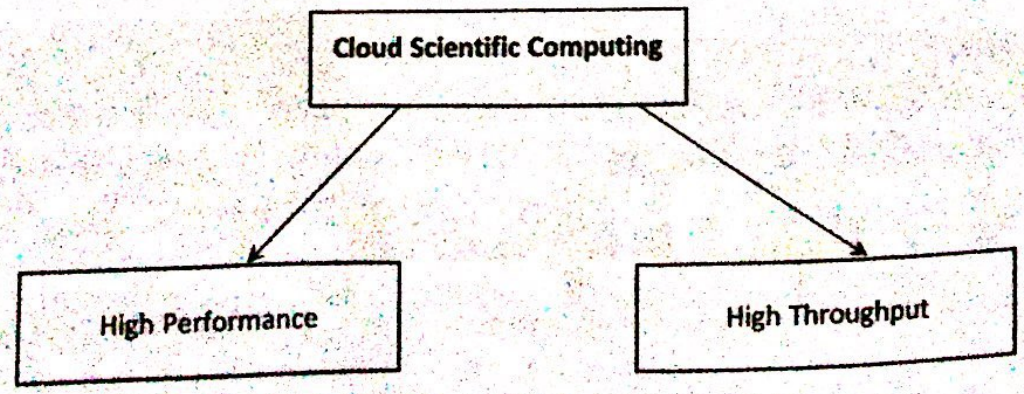

Figure 8.16: Areas of Cloud Scientific Computing

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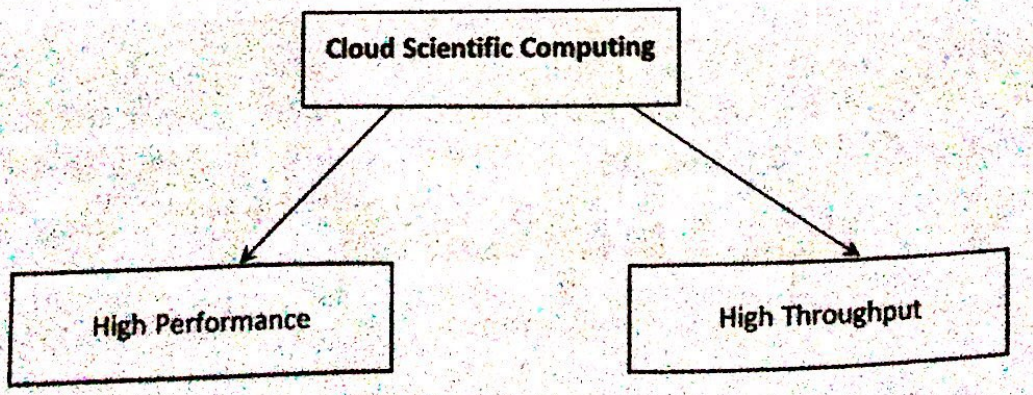

Figure 8.16: Areas of Cloud Scientific Computing

Details of Computing Categories such as High-Performance Computing (HPC) and High Throughput Computing (HTC) were already discussed in the task programming section of Unit V.

1. **High-Performance Computing:** This term signifies computing with high performance. High performance in terms of resource availability, quality of service, monitoring of service, etc.

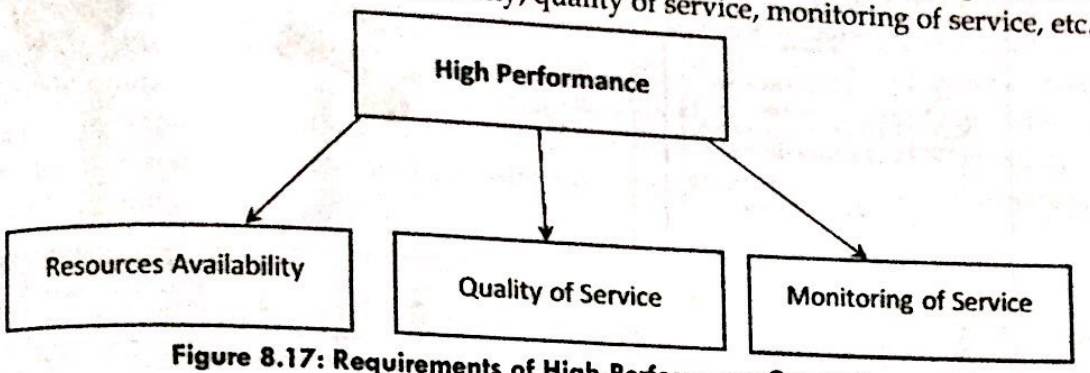

Figure 8.17: Requirements of High-Performance Computing

2. **High Throughput Computing:** High-throughput computing (HTC) refers to the usage of a large number of computing resources over a lengthy period to complete a complex computational job.

Healthcare: ECG *(Electrocardiogram)* Analysis in cloud computing

Healthcare is a field, subject, sector, or territory in which information technology has several uses. These apps are being used to aid businesses in supporting scientists in developing disease prevention solutions. Cloud computing has emerged as an appealing alternative for constructing health monitoring systems as a result of the development of the Internet or to put it another way, as a result of the availability of the internet. The ECG machine, for example, is a health monitoring device that measures the human body's heartbeat and prints the results on graph paper.

The electrocardiogram (ECG) measures the electrical activity of the heart's Cardium. A waveform is created as a result of this action, which is repeated throughout time and symbolizes the heartbeat.

- The analysis of the shape is used to identify arrhythmias, and it is the most common way of detecting heart diseases.
- Here the meaning of arrhythmias means "not having a steady rhythm", "an arrhythmic heartbeat" means a heartbeat that is not in its rhythm.

Now we will let this concept enter into cloud computing.

- Cloud computing technologies allow the remote monitoring of a patient's heartbeat data.
- Through this way, the patient at risk can be constantly monitored without going to the hospital for ECG analysis.

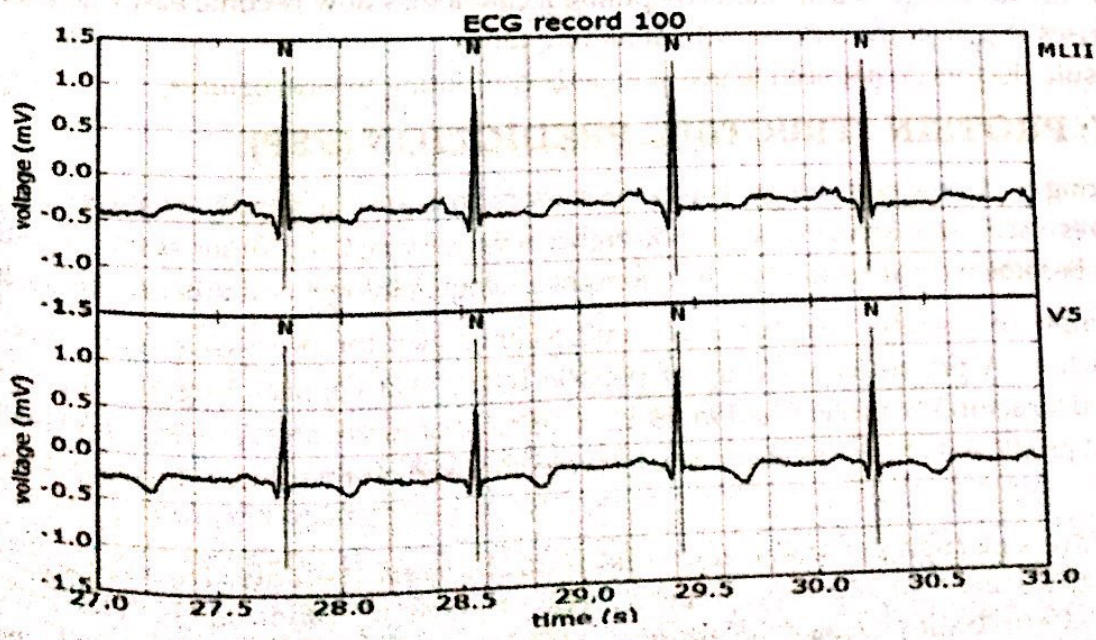

Figure 8.18: A Sample ECG Report

- At the same time, the Doctors can instantly be notified of cases that need their attention.

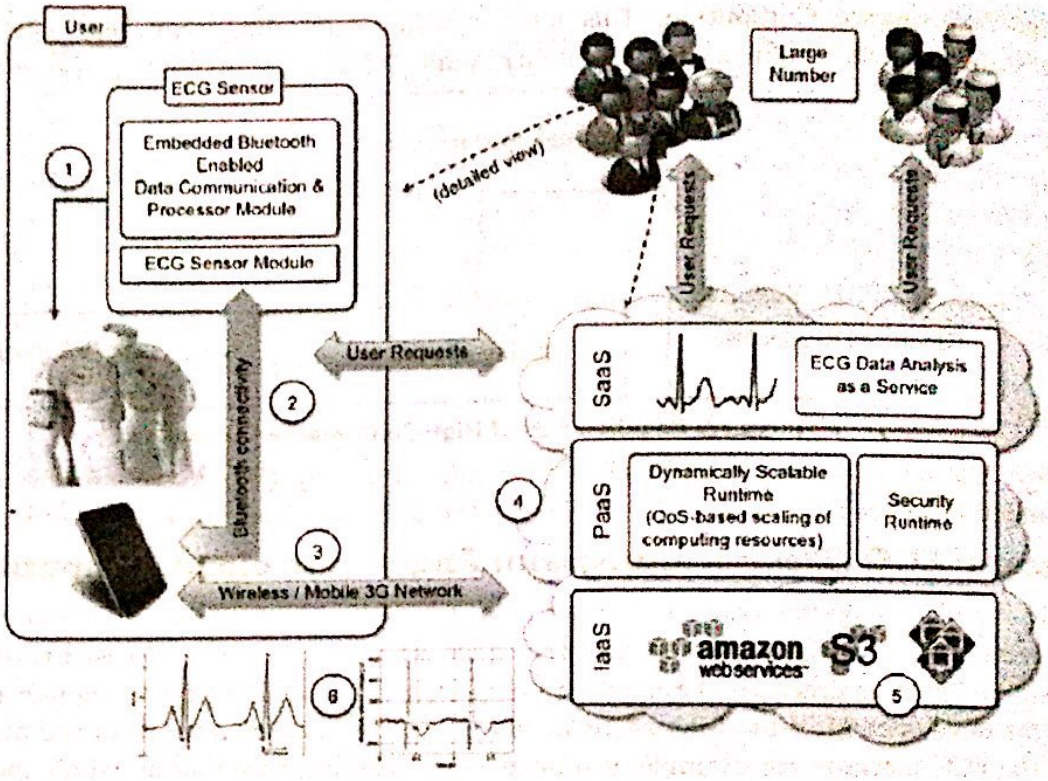

Figure 8.19: ECG Analysis through Cloud Services

- In this figure, there are different types of computing devices equipped with ECG sensors to constantly monitor the patient's heartbeat.
- The respective information is transmitted to the patient's mobile device that will immediately forward to the cloud-hosted web services for analysis.
- The entire web service from the front end of a platform that is completely hosted in the cloud consists of three layers: SaaS, PaaS, IaaS.

Advantages

- The first advantage is the elasticity of the cloud infrastructure that can minimize and maximize according to the requests served.
- The second advantage is that cloud computing technologies now become easily accessible and also it promises to deliver the services with minimum time.
- As a result, doctors do not need to invest in large computing infrastructures.

BIOLOGY: PROTEIN STRUCTURE PREDICTION (PSP)

Cloud computing is a new technology that allows users to access a variety of computer services on demand. It gives users easy access to a pool of higher-level services and other system resources. Cloud computing has become more important in the realms of geology, biology, and other scientific studies.

The finest example of a study area that uses cloud technologies for processing and storage is protein structure prediction. A protein is made up of peptide bonds that connect lengthy sequences of amino acids. The varied structures of proteins aid in the development of novel therapeutics, and Protein structure prediction is the prediction of various sequences of proteins based on their three-dimensional structure.

Protein

- Proteins are long chains of amino acids that form the basis of all life. They are large molecules that our cells need to function properly. They consist of amino acids. The structure and function of our bodies depend on proteins. The regulation of the body's cells, tissues, and organs cannot happen without them.

- Muscles, skin, bones, and other parts of the human body contain significant amounts of protein, including enzymes, hormones, and antibodies.
- The human body consists of around 100 trillion cells. Each cell has thousands of different proteins. Together, these cause each cell to do its job. The proteins are like tiny machines inside the cell.

Protein primary structures are created first, and secondary, tertiary, and quaternary structures are predicted from the fundamental structure. Protein structural predictions are made in this manner. Protein structure prediction employs a variety of different technologies, including artificial neural networks, artificial intelligence, machine learning, and probabilistic approaches, and is crucial in disciplines such as theoretical chemistry and bioinformatics.

Why cloud computing for PSP?

- It requires high computing capabilities and often operates on large data- sets that cause extensive I/O operations.
- Protein structure prediction is a computationally intensive task that is fundamental to different types of research in the life sciences.
- Manually 3D structure determination is difficult, slow, and expensive.
- Structure helps in the design of new drugs for the treatment of diseases.

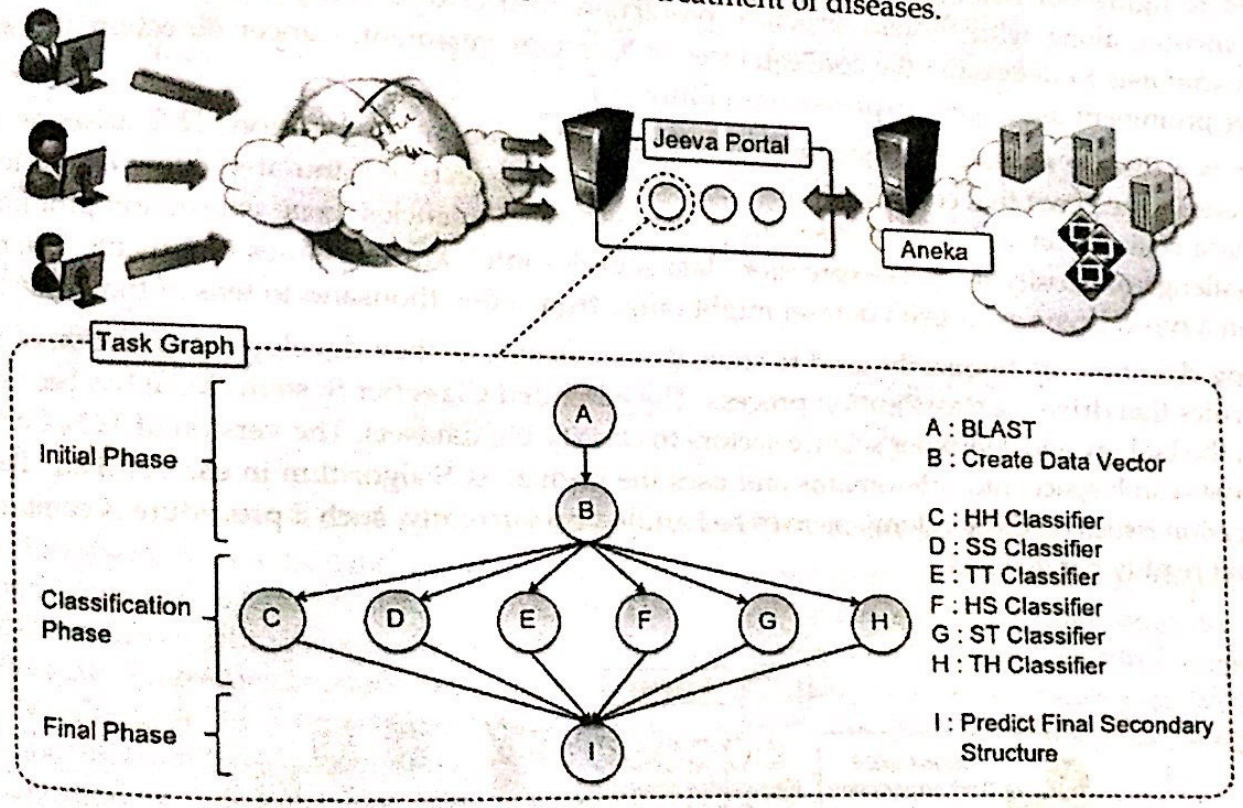

Figure 8.20: Jeeva Portal

- The geometric structure of a protein cannot be directly inferred from the sequence of genes that compose its structure, but it is the result of complex computations aimed at identifying the structure that minimizes the required energy. While doing so, high computational power is required which is extremely expensive to own.
- Cloud computing grants access to such capacity on pay per use basis.

Jeeva, an integrated Web site that allows scientists to outsource the prediction process to a computing cloud based on Aneka, is one project that studies the use of cloud technology for protein structure prediction. Machine learning approaches are used in the prediction job to determine the secondary structure of proteins. These methods turn the problem into a pattern recognition issue, in which a sequence must be sorted into one of three categories (E, H, and C). The pattern recognition issue is divided into three steps by a popular method based on support vector machines: initialization, classification, and a final phase.

Even though all three stages must be completed in order, it is possible to use parallel execution in the classification step, where many classifiers are run simultaneously. This opens up the possibility of reducing the prediction's computing time sensibly. After that, the prediction method is converted into a task graph, which is then sent to Aneka. The middleware makes the findings accessible for display through the portal once the task is done.

Protein structure prediction may be done using a variety of techniques and methods. CASP (Critical Assessment of Protein Structure Prediction) is a well-known technology that gives ways for automated web servers, and research findings are stored in clouds such as the CAMEO (Continuous Automated Model Evaluation) server. These servers may be accessible by anybody at any time and from any location, depending on their needs. Phobius, FoldX, LOMETS, Prime, Predict Protein, SignalP, BBSP, EVfold, Biskit, HHpred, Phone, and ESyired 3D are some of the tools or services used in protein structure prediction. New structures are anticipated using these technologies, and the findings are stored on cloud-based servers.

Biology: Gene Expression Data Analysis

Gene expression profiling is the simultaneous assessment of thousands of genes' expression levels. It is utilized to figure out what biological processes are activated at the cellular level by medicinal therapy. This function, along with protein structure prediction, is a critical component of drug design since it allows scientists to determine the consequences of a certain treatment. Cancer detection and therapy are another prominent use of gene expression profiling.

Cancer is a disease marked by uncontrolled cell multiplication and expansion. This arises as a result of mutations in the genes that control cell development. This suggests that mutated genes can be found in all malignant cells. To offer a more precise categorization of malignancies, gene expression profiling is used. The challenge of classifying gene expression data samples into various classes is difficult. The number of genes in a typical gene expression dataset might range from a few thousand to tens of thousands.

Learning classifiers are frequently used to solve this challenge, as they develop a population of condition-action rules that drive the classification process. The eXtended Classifier System (XCS) has been effectively used in the biology and computer science sectors to classify big datasets. The version of XCS, CoXCS, splits the whole search space into subdomains and uses the normal XCS algorithm in each of them. Because the classification issues on the subdomains may be handled concurrently, such a procedure is computationally costly yet readily parallelized.

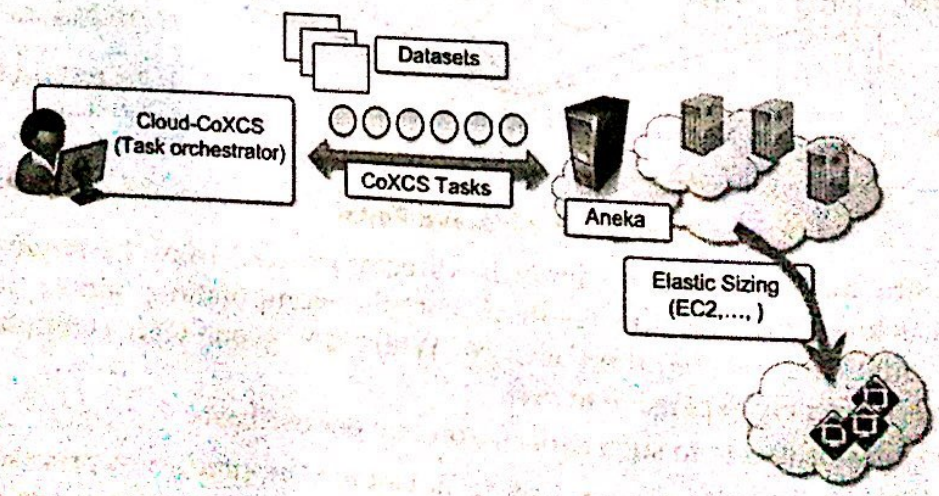

Figure 8.21: Cloud-CoXCS

Cloud-CoXCS is a cloud-based CoXCS solution that uses Aneka to solve classification problems in parallel and assemble the results. The algorithm is guided by strategies, which specify how the outputs are combined and if the process is complete.

GEOSCIENCE: SATELLITE IMAGE PROCESSING

Massive volumes of geographic and non-spatial data are collected, produced, and analyzed by geoscience applications. The volume of data that has to be processed grows considerably as technology advances and our world gets increasingly instrumented (e.g., through the deployment of sensors and satellites for monitoring). A fundamental component of geoscience applications is the geographic information system (GIS). All sorts of spatially linked data may be captured, stored, manipulated, analyzed, managed, and presented using GIS applications. This sort of data is becoming increasingly important in a range of application sectors, ranging from advanced agriculture to civic security and natural resource management. As a result, large amounts of geo-referenced data are fed into computer systems for processing and analysis. Cloud computing is a compelling alternative for completing these time-consuming processes and collecting useful data to aid decision-making.

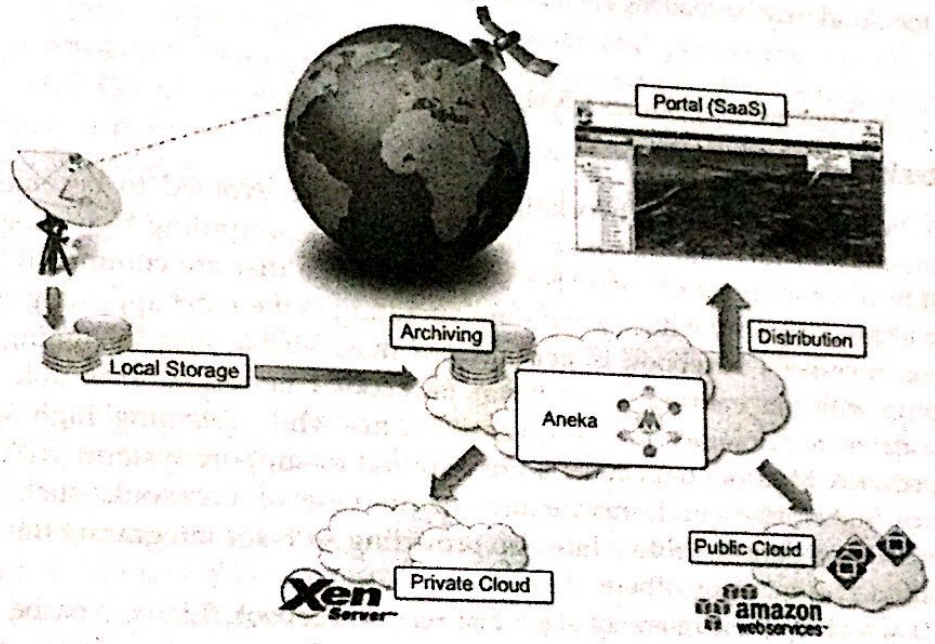

Figure 8.22: A cloud environment for satellite data processing

Hundreds of terabytes of raw pictures are generated by satellite remote sensing, which must be processed before being used to create a variety of GIS products. This procedure needs both I/O and computationally heavy operations. Large pictures must be sent from a ground station's local storage to compute facilities, where they must undergo multiple transformations and adjustments. Cloud computing offers the necessary infrastructure to support these types of applications. Several technologies are integrated throughout the full computer stack in the system depicted in Figure.

A SaaS application is a bundle of services that may be used for activities like geocoding and data visualization. Aneka manages the data importation into the virtualized infrastructure and the image processing processes that create the necessary result from raw satellite photos at the PaaS level. The platform uses a Xen private cloud and Aneka technology to dynamically provision (i.e., increase or shrink) the appropriate resources on demand. The research shows how cloud computing technologies may be used to offload heavy workloads from local computer facilities and use more elastic computing infrastructures.

BUSINESS AND CONSUMER APPLICATIONS

Cloud computing innovations are likely to help the commercial and consumer sectors the most. On the one hand, the ability to convert capital expenses into operating costs makes clouds an appealing alternative for any IT-centric business. On the other hand, the cloud's feeling of ubiquity in terms of accessing data and services makes it appealing to end-users. Furthermore, because cloud technologies are elastic, they do not necessitate large upfront investments, allowing innovative ideas to be easily converted into products and services that can readily scale with demand.

CRM and ERP

CRM (customer relationship management) and ERP (enterprise resource planning) systems are two industry categories that are thriving in the cloud, with CRM being the more mature of the two. Cloud CRM programs provide small businesses and start-ups a terrific way to get fully working CRM software without big upfront expenditures and by paying monthly fees. Furthermore, CRM is not a task that needs a certain set of requirements, and it can be readily migrated to the cloud. Cloud CRM software has grown in popularity as a result of this feature, as well as the ability to view your business and customer data from anywhere and on any device.Cloud-based ERP systems are less mature, and they must compete with well-established in-house solutions. Finance and accounting, human resources, manufacturing, supply chain management, project management, and CRM are all integrated into ERP systems. Their purpose is to give a unified perspective and access to all activities required to keep a complicated company running. The move to cloud-based models is more challenging because of the enterprises they target: the long-term cost advantage may not be evident, and the conversion to the cloud may be challenging if firms already have significant ERP installations.

Examples

- Salesforce.com, Microsoft Dynamics CRM, NetSuite

Social Networking

In the previous several years, social networking programs have evolved to become the most popular websites on the Internet. Twitter and Facebook have used cloud computing technology to maintain their traffic and smoothly serve millions of users. For social networks that are continually growing their user base, the ability to expand capacity while systems are operating in the most appealing aspect.

With over 1 billion members, Facebook is perhaps the most visible and intriguing social networking platform. To keep up with this enormous expansion, Facebook has needed to be able to expand capacity and build new scalable technologies and software systems while retaining high speed to provide a seamless user experience. Multiple data centers are required to support systems with a large number of users. They require highly efficient infrastructure. In the case of Facebook, such a platform largely supports the system's major functionality while also providing APIs for integrating third-party apps - such as social games and quizzes made by others.

LAMP is the foundation of the basic reference stack that serves Facebook (Linux, Apache, MySQL, and PHP). This set of technologies is complemented by a suite of additional in-house services. These services are written in several languages and include features like search, news feeds, alerts, and analytics, among others.

The user's social graph is built while serving page requests. The social graph identifies a set of interconnected data that is relevant to a certain person. The majority of the user data is retrieved via a distributed cluster of MySQL instances, which are largely key-value pairs. After then, the data is cached for speedier retrieval. The rest of the pertinent data is subsequently put together utilizing the previously described services. These services are closer to the data and are written in languages that are more performant than PHP. A collection of domestically built tools aids in the creation of services.

Examples

- Facebook, Twitter, Instagram, Linked In, Pinterest, etc.

Productivity

From document storage to office automation and whole desktop environments hosted in the cloud, productivity tools mimic some of the most typical actions that we are used to executing on our desktop.

Examples

- Dropbox, Google Drive, iCloud, Google Docs, Microsoft Office 365

Media Applications

The use of cloud computing technology can benefit media applications as well. Encoding, transcoding, composition, and rendering are examples of video processing tasks that are well suited to a cloud environment. These are computationally expensive jobs that can readily be transferred to cloud computing infrastructures.

Examples

- Animoto, Maya rendering with Aneka, Video encoding on the cloud: Encoding.com, Multiplayer online gaming, etc.

More Uses of Cloud Computing

1. **Scalable Usage:** Through different subscription arrangements, cloud computing provides scalable resources. This means you will only be charged for the computer resources you utilize. This allows for the management of demand spikes without the need to invest in computer hardware on a long-term basis. Netflix, for example, takes advantage of cloud computing's capabilities. It experiences substantial spikes in server load during peak periods due to its on-demand streaming service. The shift to the cloud from on-premises data centers allowed the firm to dramatically grow its client base without having to engage in costly infrastructure setup and upkeep.
2. Chatbots: We can save information about customer preferences thanks to the cloud's increased computational power and capacity. Users' behavior and preferences may be leveraged to give personalized solutions, messages, and goods. The cloud-based natural-language intelligent bots Siri, Alexa, and Google Assistant are all cloud-based natural-language intelligent bots. These chatbots make use of the cloud's computational power to deliver tailored, context-relevant consumer experiences. Remember that the next time you say, "Hey Google!" there is a cloud-based AI solution behind it.
3. **Communication:** Users might have network-based access to communication tools like emails and calendars thanks to the cloud. The majority of messaging and calling apps, such as Skype and WhatsApp, rely on cloud infrastructure. Rather than on your device, all of your messages and information are saved on the service provider's hardware. This allows you to access your information over the internet from anywhere.
4. **Productivity:** Cloud computing is used by office applications like Microsoft Office 365 and Google Docs, allowing you to use your most productive tools via the internet. You can work on your documents, presentations, and spreadsheets whenever you want, from anywhere. You do not have to worry about data loss if your device is stolen, lost, or destroyed because your data is kept on the cloud. The cloud also facilitates document sharing and allows several people to work on the same document at the same time.
5. **Business Process:** A cloud service provider is also used by many business management programs, such as customer relationship management (CRM) and enterprise resource planning (ERP). SAAS (Applications as a Service) has grown in popularity as a technique of providing corporate software. Popular examples of this approach include Salesforce, Hubspot, and Marketo. Both the service provider and the clients benefit from this strategy since it is cost-effective and efficient. It helps you to manage, maintain, and secure your organization's important business resources with ease, and it allows you to access these apps via a web browser.
6. **Backup and recovery:** When you use the cloud to store your data, your service provider is also responsible for your data. This eliminates the need for capital expenditures for infrastructure and upkeep. Data security and legal and compliance standards are the responsibility of your cloud service provider. Large storage and on-demand backups are also available in the cloud, giving you greater flexibility. Because the data is stored over a network of physical computers rather than in a single on-site data center, cloud recovery is also faster. Popular cloud backup systems include Dropbox, Google Drive, and Amazon S3.
7. **Application development:** Cloud platforms have shown to be a solid alternative for creating web, mobile, and even gaming applications. You can quickly construct scalable cross-platform experiences for your consumers using the cloud. Many pre-programmed tools and libraries, such as directory services, search, and security, are included in these platforms. This can help to streamline and speed up the development process. Amazon Lumberyard is a popular cloud-based mobile game creation platform.

8. Test and development: The cloud can help you save money while also allowing you to get your apps to market faster. Developers may utilize the cloud to build up and teardown test and development environments instead of building up physical environments. This prevents the technical team from getting finances and devoting time and resources to the project. According to the needs, the test environments may easily be scaled up or down. Popular testing tools include LoadStorm and BlazeMeter.
9. **Big data analytics:** Data scientists may use cloud computing to access any corporate data and analyze it for patterns and insights, uncover connections, foresee future crises, and aid in data-driven decision making. Cloud services enable large-scale data mining by supplying more processing capacity and advanced tools. Many open-source cloud-based big data solutions, such as Hadoop, Cassandra, and HPCC, are available.
10. **Social Networking:** The most well-known and sometimes ignored use of cloud computing is social media. Cloud computing is used by Facebook, Linked In, Twitter, Pinterest, and many other social networking sites. Social networking services are intended to connect you with individuals you already know or want to meet. We end up disclosing a lot of personal information when looking for folks. Of course, when you share material on social media, you are sharing it with more than just your friends; you are also sharing it with the platform's creators. As a result, the platform will need a robust hosting solution to manage and store data in real-time, making cloud utilization essential.

Some other fields leveraging Cloud Computing:

- Government
- Healthcare
- Production & Manufacturing
- Entertainment
- Education
- Banking and Insurance
- Automotive
- Retail etc.

OBJECTIVE QUESTIONS

1) Which of the following roles of web service architecture provides a central place where developers can publish new services or find existing ones?

a. Service Provider b. Service Requestor c. Service Registry d. None of the above

2) How is the response sent in XML-RPC?

a. XML responses are appended to the URL of the HTTP response.
b. XML responses are embedded in the body of the HTTP response.
c. Both of the above.
d. None of the above.

3) Which of the following is correct about SOAP?

a. SOAP is language-independent. b. SOAP is simple and extensible.
c. Both of the above d. None of the above.

4) _____ is used to convert your application into Web-Application.

a. Struts Services b. Web Services c. Java Service d. Browser Action

5) Which of the following is correct about the Service Description layer in Web Service Protocol Stack?

a. This layer is responsible for describing the public interface to a specific web service
b. Currently, service description is handled via the Web Service Description Language (WSDL)
c. Both of the above
d. None of the above

6) Web services can be discovered using _____
a. UDDII b. UDDI c. UDDDI d. UDII

7) What are roles in Windows Azure?
a. Web Role b. Worker Role c. VM Role d. All of these

8) Azure Storage plays the same role in Azure that _____ plays in Amazon Web Services.
a. EC2 b. S3 c. EC3 d. All of the mentioned

9) What are the options to manage the session state in Windows Azure?
a SQL Azure b. Windows Azure Caching
c. Azure Table d. All of the above

10) Which of the following web applications can be deployed with Azure?
a. PHP b. ASP.NET c. WCF d. All of the above

11) Which of the following elements in Azure stands for management service?
a. Application b. Config c. Virtual machines d. None of the above

12) Which service in Azure is used to manage resources in Azure?
a, Azure Resource Manager b. Application Insights
c. Log Analytics d. Azure Portal

13) Aneka is based on which service model?
a. IaaS b. PaaS c. SaaS d. BPaaS

14) Which features of Aneka provide scalability of the resources?
a. Manage b. Accelerate c. Provisioning d. Build

15) Which of the following is not a PAL service in Aneka?
a. Application b. Managing c. Fabric d. Foundation

16) — is a complete operating environment with applications, management, and the user interface.
a. IaaS b. PaaS c. SaaS d. All of the above

17) In which category of SaaS services does customer relationship management (CRM) software fall?
a. Consumer services b. Communication services
c. Infrastructure services d. Business services

18. A company interested in cloud computing is looking for a provider who offers a set of basic services such as virtual server provisioning and on-demand storage that can be combined into a platform for deploying and running customized applications. What type of cloud computing model fits these requirements?
a. PaaS b. SaaS c. IaaS d. CaaS

19) Which of the following protocols lets a Web site list in an XML file information?
a. Sitemaps b. Mashups c. Hashups d. All of the mentioned

20) Which of the following can be considered PaaS offering?
a. Google Maps b. Gmail c. Google Earth d. All of the mentioned

QUESTION

1. What is a third-party cloud Service? Explain MetaCDN and SpotCloud in brief.
2. What are the types of applications that can benefit from cloud computing?
3. What fundamental advantages does cloud technology bring to scientific applications?
4. Describe how cloud computing technology can be applied to support remote ECG monitoring.
5. Describe an application of cloud computing technology in the field of biology.
6. What are the advantages cloud computing brings to the field of geoscience? Explain with an example.
7. Describe some examples of CRM and ERP implementations based on cloud computing technologies. Explain the services of Salesforce.com.
8. What are Dropbox and iCloud? Which kinds of problems do they solve by using cloud technologies?
9. What is the most important advantage of cloud technologies for social networking applications?
10. Provide some examples of media applications that use cloud technologies.
11. Explain the applications of Cloud Computing in various fields with proper examples.

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