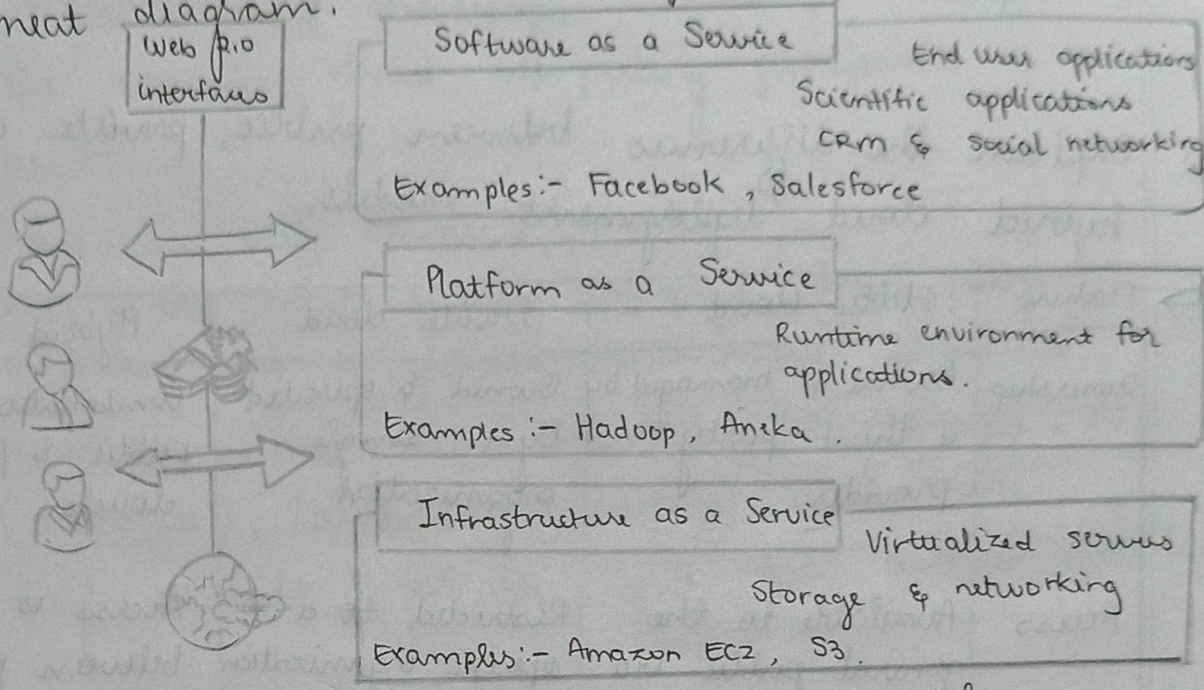
Assignment - I

1. Explain the cloud computing reference model with a neat diagram.



Cloud Computing Reference Model

→ The 3 main cloud service models - SaaS, PaaS & IaaS.

1) SaaS - Software as a Service :-
SaaS delivers software applications over the internet. Users access applications through a web browser. Used by end-users (eg:- employees using Gmail etc).
Examples :- Gmail, Google Docs, Salesforce etc.

2) PaaS - Platform as a Service :-
PaaS provides a platform for developers to build, test and deploy applications. The provider manages infrastructure and platform.
Examples :- Microsoft Azure, Google App Engine etc.

3) IaaS - Infrastructure as a Service :-
IaaS provides virtualized computing resources over the internet. You rent servers, storage & networking

On-demand, Full control over virtual machines.
Examples:- Amazon EC2, Microsoft Azure VM etc,

2. Explain the differences between public, private and hybrid cloud deployment models.

→

Feature	Public Cloud	Private cloud	Hybrid cloud
Ownership	Owned & managed by a third-party provider.	Owned & operated by a single organization.	Combination of public & private clouds.
Access	Available to the general public via internet.	Restricted to a specific organization	Access is shared between public & private clouds.
Cost	Pay-as-you model, low initial cost.	High setup & operational cost	Balanced cost with optimized resource use,
Security	Less control over security & compliance.	High security & compliance control.	Better control with flexibility.
Customization	limited	highly customizable	Some level of customization.
Scalability	Highly scalable	limited to internal resources	Scalable based on architecture.
Example	AWS, Microsoft Azure	Bank's internal cloud, government cloud.	Enterprise using AWS + private cloud for HR.

3. List and explain the various cloud computing platforms and technologies.

→ The various cloud computing platforms & technologies are :-

1) Amazon Web Services (AWS):
- One of the most widely adopted cloud platforms offering a broad set of global cloud-based products.
- Services include EC2 (compute), S3 (storage), RDS (database), Lambda (serverless) and more.
- High scalable, reliable with data centers worldwide.

2) Microsoft Azure:
- Cloud computing platform from Microsoft for building, testing, deploying and managing applications.
- Services include virtual machines, Azure SQL database, Azure functions etc.
- Strong integration with Windows & enterprise software

3) Google Cloud Platform:
- Cloud platform by Google offering computing, storage and application development services.
- Compute Engine, Cloud Storage, BigQuery, App Engine are the services offered by Google cloud platform.
- Advanced data analytics, ML capabilities & strong global infrastructure.

4) IBM cloud:
- A set of cloud computing services from IBM including SaaS, IaaS & PaaS.

- Services include Watson AI, blockchain, kubernetes.
- Focus on AI, security & hybrid cloud integration.

5) Salesforce:
- Leading SaaS platform focused on CRM (Customer Relationship Management).
- Specilized in sales, customer service & marketing automation.

6) Oracle Cloud:
- Cloud services from Oracle for databases, applications and infrastructure.
- Services include Oracle Autonomous DB, ERP systems
- Deep enterprise resource planning.

7) VMware Cloud:
- Platform for managing hybrid clouds & virtualized data centers.
- Technologies used here are vSphere, vCloud Director.
- Supports virtualization & smooth transition to cloud for legacy systems.

4. Explain hypervisors and its types.

→ A hypervisor, also called a Virtual Machine Manager (VMM), is software, firmware or hardware that allows you to run multiple operating systems (Guest OSs) on a single physical machine (host). The hypervisor ensures that VMs are isolated, & it handles resource allocation, scheduling &

hardware emulation.
Each VM has its own OS, applications & virtual hardware (CPU, memory, network interface).

2 Types of Hypervisors :-

1) Type 1 Hypervisor (Bare - metal hypervisor):
- Runs directly on the host's hardware. It direct access to CPU, memory, storage & network interfaces and doesn't require a host OS.
- Boots up first when the system starts.
- Then it handle multiple VMs on top of the hardware.

Features:
- High performance and provides better security.
- Typically used in data centers & enterprise environments.

Example: Microsoft Hyper-V.

2) Type 2 Hypervisor (Hosted hypervisor):
- Runs on top of a traditional host OS (like Windows, linux or macOS). It behaves like a normal application on host OS,
- Easier to setup and use.
- Typically used for development, testing & personal use.
- Less efficient than type 1 due to additional OS layer.
- The host OS boots first, the hypervisor runs as an application within the OS, VMs run on top of this hypervisor.

Example: Oracle VirtualBox.

5. Explain machine reference model of execution virtualization.

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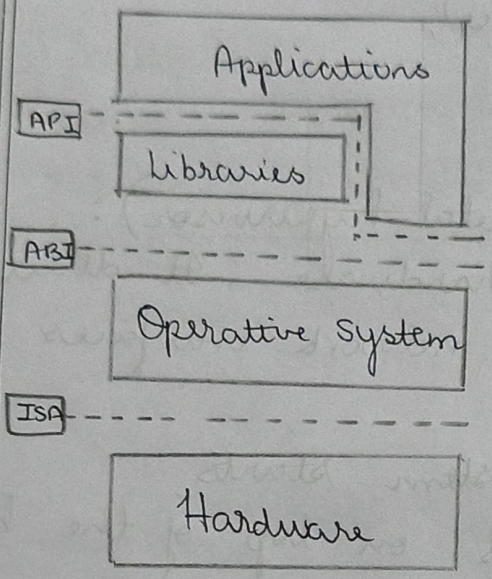
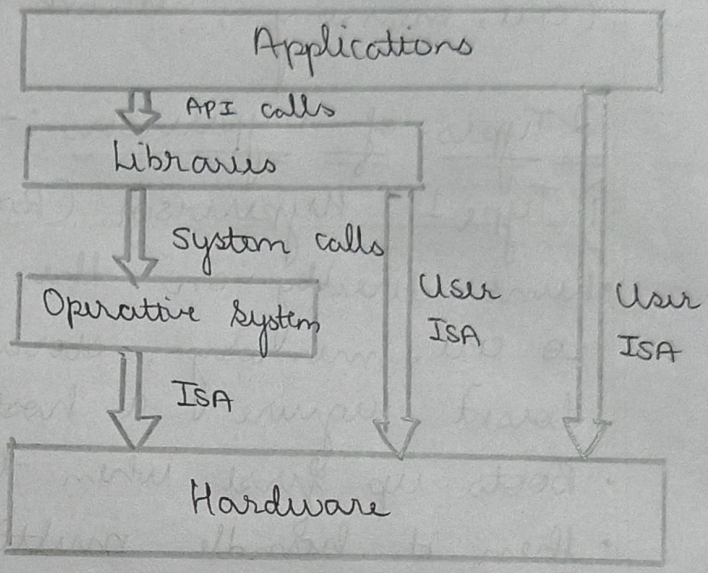




Machine Reference Model

The Machine Reference Model is used to understand how virtualization works by abstracting hardware and software layers. It helps to visualize how VMs interact with the underlying hardware through virtualization software.

Layers of Machine Reference Model :-

1. Instruction Set Architecture (ISA):
   - The lowest layer representing the hardware-level instructions (like ARM).
   - It's what the CPU understands & executes.

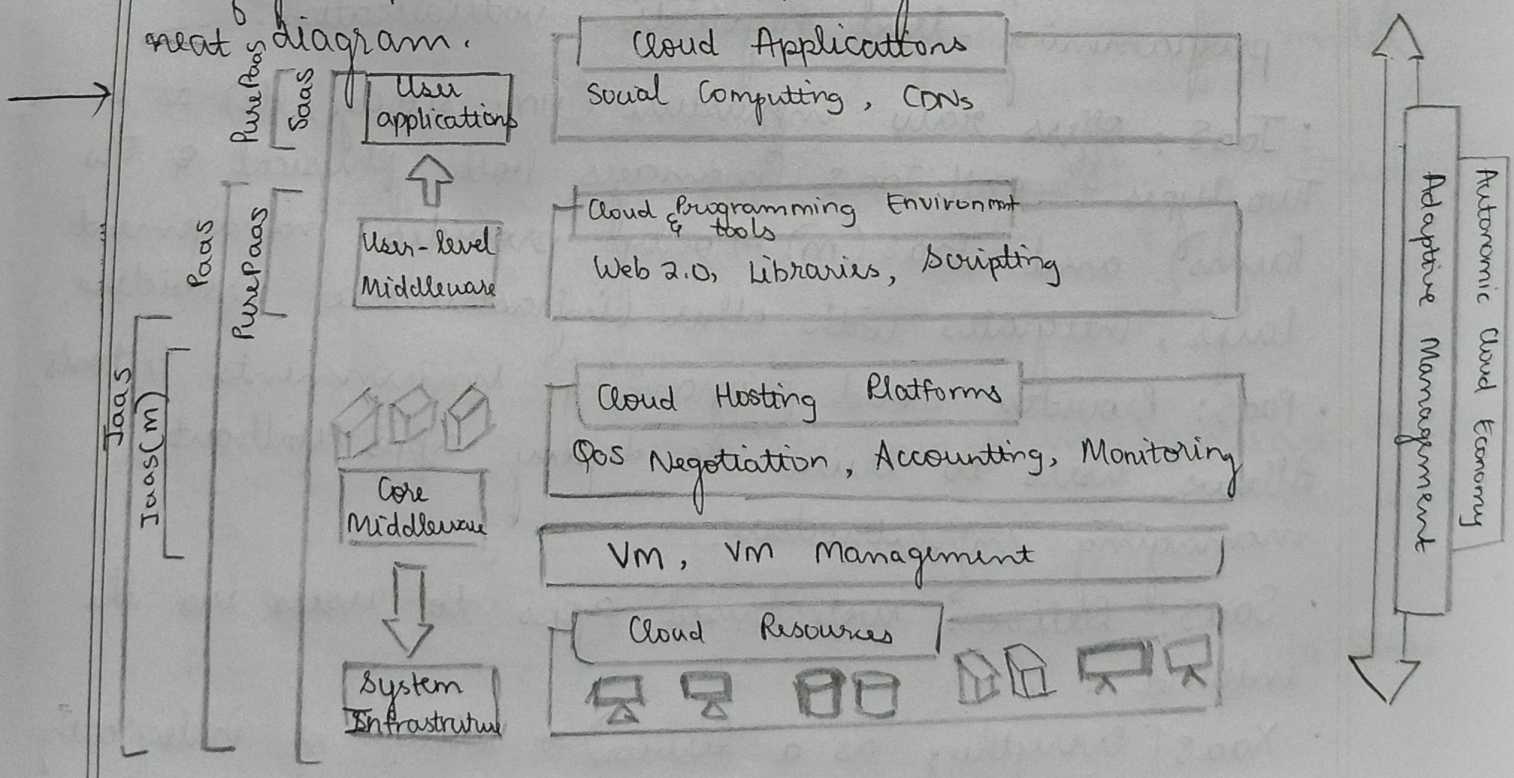
2. Application Binary Interface (ABI):
   - sits above ISA and provides an interface for applications to interact with the OS.
   - Includes system calls, data types & binary formats.

3. Application Programming Interface (API):
- High-level functions that developers use to write software.
- These APIs communicate with the OS & runtime environment.

4. User Applications:
- Programs and apps run by the end-user.
- They sit on top of API layer.

Purpose of this Model:- Helps in virtualization, where the goal is to run application independently of the underlying hardware. This model shows how virtual environments emulate these layers so that multiple VMs can run different OSes & apps on shared physical hardware.

6. Briefly Explain cloud computing architecture with a neat diagram.



Cloud Computing Architecture

→ • Cloud architecture is organized in layers - from physical hardware up to user-level services.
• Each layer builds on top of the other to provide computing services.
• Physical Infrastructure (Bottom layer): Made up of data centers containing hundreds or thousands of nodes. This layer includes compute nodes, storage systems, clusters and networked PCs. May also include databases and distributed file storage systems.
• Virtualization layer: Provides run time environment customization, isolation and sandboxing. Uses hypervisors to manage and partition hardware into virtual machines (VMs). Often paired with storage and network virtualization.
• Core Middleware: Manages infrastructure resources & provides services like Quality of Service (QoS) negotiation, admission control etc, can use programming-level negotiation virtualization.
• IaaS: Offers raw infrastructure (VMs, storage, etc) as service. Two types: Full IaaS (manages both physical & S/w layers) and IaaS (M) ⇒ only provides management layer, integrates with other infrastructure providers.
• PaaS: Provides cloud programming environments & tools. Allows users to build & deploy apps without managing infrastructure.
• SaaS: Delivers web-based apps to users via the internet.
• XaaS (Everything as a Service) ⇒ vision of integrating various cloud services across layers.

7. What is SaaS? Explain its characteristics & its initial benefits.

→ Software as a Service (SaaS) is a cloud computing model where application-level services are delivered over the internet. Instead of purchasing s/w, users access it via the web through the browser.

* Characteristics of SaaS :-

- Web-based access :- Applications are hosted on cloud & accessed via browsers (no local installation).
- Centralized management :- All users access the same core application, which is maintained & updated centrally by provider.
- Multi-tenancy :- Multiple users (tenants) share the same application instance securely.
- Elastic scalability :- SaaS apps can automatically scale to accomodate changing user demand.
- Application-level services :- Typically includes complete software solutions such as CRM, email, accounting etc.
- SaaS is often offered on a pay-as-you-go model or monthly subscription basis.
- Users don't manage or control underlying cloud infrastructure or platform.

* Initial Benefits of SaaS :-

- Reduced cost :- No need to invest in hardware or software licenses upfront. Pay-as-you-use pricing reduces capital expenditure.
- Faster deployment :- applications are ready to use without installation steps.
- Maintenance free :- cloud providers handle software

updates, patches, backups & server management.

- Accessibility: Accessible from any device with an internet connection, enhancing mobility.
- Easy collaboration: supports collaborative workflows since data and interfaces are centralized.
- Scalability & Flexibility: Resources are allocated dynamically to meet changing demand without reconfiguration.

8. Explain PAAS with a neat diagram.

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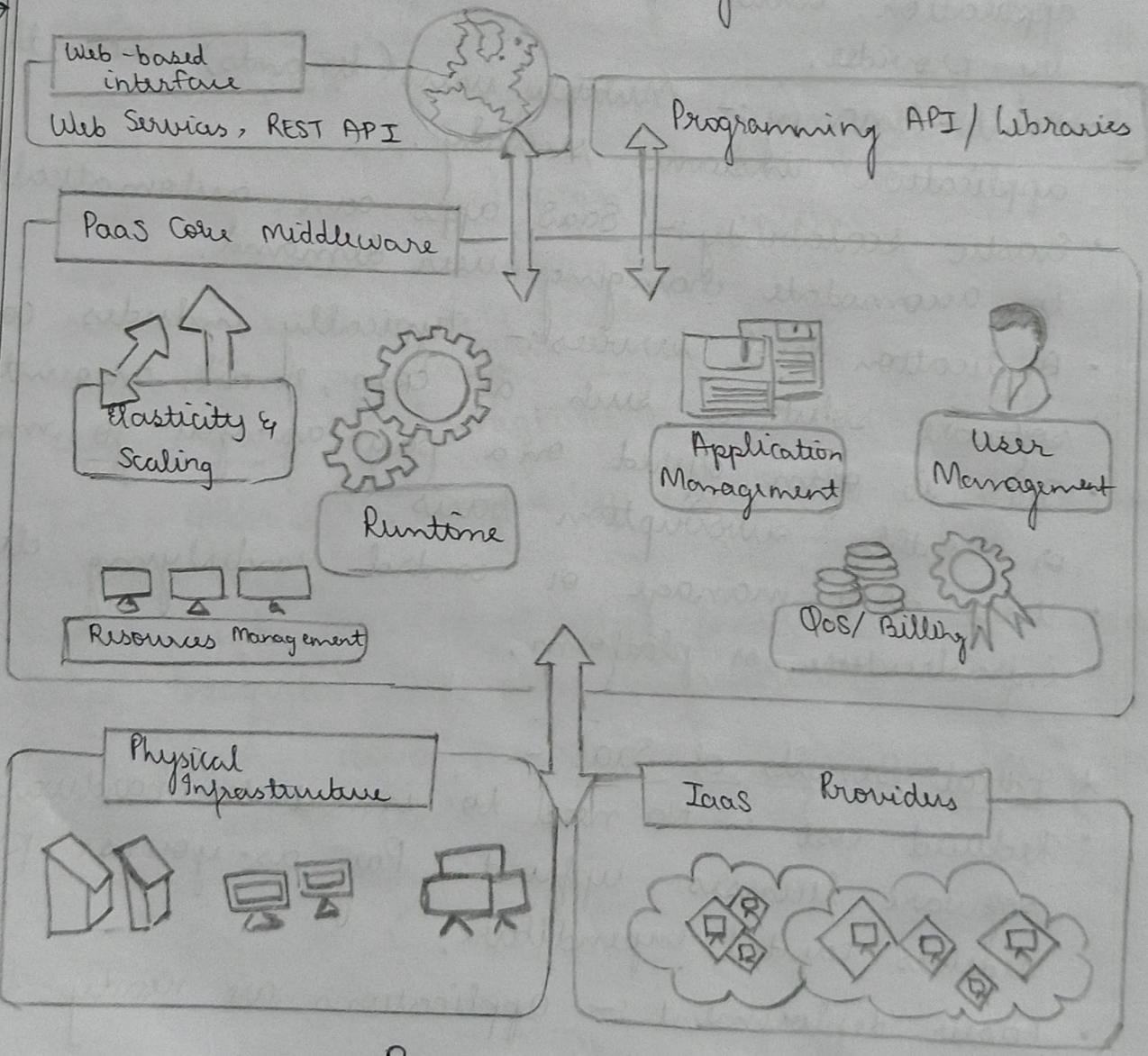

Paas reference Model.

→ Platform as a Service (PaaS) is a cloud computing model that offers a complete development & deployment environment in the cloud. It provides developers with a platform - including tools, programming languages & infrastructure - to build, test and deploy applications without managing underlying hardware & OS.

- Key characteristics of PAAS :-
- Development platform :- Offers programming environments, APIs, libraries and tools. Enables users to create & deploy applications easily.
- Infrastructure is abstracted :- Users don't deal with VMs, servers or OS configuration. Infrastructure is bundled with a service.
- Cloud Based Middleware :- provides user-level middleware for app development & deployment.
- Supports scalability :- PaaS environments supports elastic scaling of applications based on usage.
- Web based applications :- Provides GUIs and command line tools for application management.
- Vendor - specific Technologies :- Typically supports specific languages / platforms (eg :- Java, NET, Python).
- Integrated lifecycle Management :- Tools for code management, versioning, building, testing and deployment.

Common examples are Google App Engine, Heroku, Microsoft Azure App Service etc.

Assignment - II

1. Explain operating system security and virtual machine security.

→ * Operating system (OS) Security :-

OS security ensures that the OS protects the system's resources and data from malicious access or misuse, particularly in a cloud environment.

- Access Control Policies: Controls how users & programs can access system resources.
- Authentication Mechanism: Ensures only authorized users or processes access secure system components.
- Cryptographic Usage: Protects data in storage & during transition.
- Trusted applications: Programs performing security functions should run with the least privilage necessary.
- Lack of Layered Security: Commercial Oses often lack fine-grained security layers, system compromise can affect the whole system.
- Trusted policies: Mechanisms that securely connect users to trusted system components, preventing impersonation.
- Traditional OSes provide weak isolation and limited assurance.

* Virtual Machine (VM) Security :-

Securing VMs and hypervisors (Virtual machine Monitors VMMs) in cloud environments to protect against attacks targeting virtualized systems.

- VMs provide better isolation than traditional OS processes.
- VMMs acts as a security boundary between the guest OS and hardware.

- Can monitor, inspect, & control OS behavior from outside the OS.
- Hypervisor (VMM) security models:- Self-Securing VMM: The hypervisor itself provides all the necessary security
- Securing Services VM: A separate security-focused VM monitors and manages the others.
- Best practices for VM security are:- encrypt memory, storage volumes and VM states,
- Validate image (VM) integrity using hashes and secure signing, isolate management and data networks.
- Using secure cloning & sandboxing for untrusted VM deployments, limit hypervisors calls to authorized actions.

Explain the concept of privacy impact assessment & its importance in cloud computing.

A Privacy Impact Assessment (PIA) is a systematic process that helps organisations evaluate how personal data is handled & protected within an information system, especially in cloud computing. It helps to identify & mitigate privacy risks before system is implemented or changed.

- It ensures the data handling complies with the laws such as GDPR (EU) or UK's Data Protection Act.

⇒ Helps to demonstrate accountability & responsible data practices.

- PIA is conducted before deploying a system to prevent privacy violations rather than reacting after they occur.

* Importance of PIA in cloud computing :-

- Loss of data control :- When data is stored in the cloud, the user often loses control over where it is stored, how long and by whom,
- Lack of transparency :- Cloud service providers may not disclose full details of subcontracting, data replication or retention policies.
- Unauthorized secondary use :- Cloud data could be used for analytics, advertising or by third parties without user's knowledge,
- Data Proliferation :- Copies of data may exist across various regions and backup systems, making deletion and control difficult,
- Dynamic Provisioning :- Cloud resources are shared and rapidly provisioned, making it difficult to ensure consistent privacy protection,

Explain the following associated with cloud computing.

i) cloud security risks

ii) Security : top concern for cloud users.

i) Cloud security risks :-

⇒ Cloud computing introduces several unique security risks due to its distributed, multi-tenant, and on-demand nature. These risks arise from a loss of control over physical infrastructure and the complexity of cloud environments,

- Data breaches : Unauthorized access to sensitive user data (eg:- credit cards) due to poor access control or vulnerabilities.

- Insecure APIs and interfaces: Weak authentication, improper input validation or insecure endpoints may allow attackers to exploit cloud services.
- Insider threats: Malicious or careless actions by employees of the cloud service provider or user organisation can lead to data loss or corruption.
- Shared technology Vulnerabilities: Multi-tenancy & shared infrastructure (like CPU or memory) may allow one tenant to infere with another.
- Malicious use of cloud services: Attackers may use cloud infrastructure for botnets, phishing or malware hosting,
- Data loss or leakage: Improper deletion, storage misconfiguration or weak encryption can cause accidental or intentional data exposure.

ii) Security: The top Concern for Cloud Users:-

⇒ Security is consistently cited as the number one concern when adopting or mitigating cloud services. Security is the top concern because:-

- Loss of Control:- Users don't own or physically manage the servers hosting their data, creating trust and transparency issues,
- Data Confidentiality and Integrity:- Ensuring data is not accessed, altered or deleted by unauthorized entities is a critical concern.
- Multi-tenancy risks:- Shared resources increase the risk of cross-tenant data leakage or privilage escalation.
- Incident response limitations:- In cloud enviro-

nments, investigating breaches or responding to threats may depend heavily on provider cooperation.

- Trust in third-party vendors:- Users must rely on the provider's security posture, patch management and policies which may not always visible or verifiable.
- Geographic data location:- Legal & privacy concerns arise when data is stored across borders without user knowledge.
- As cloud adoption increases, attackers are increasingly targeting cloud specific vulnerabilities.

4. Explain the core components of Google app engine.

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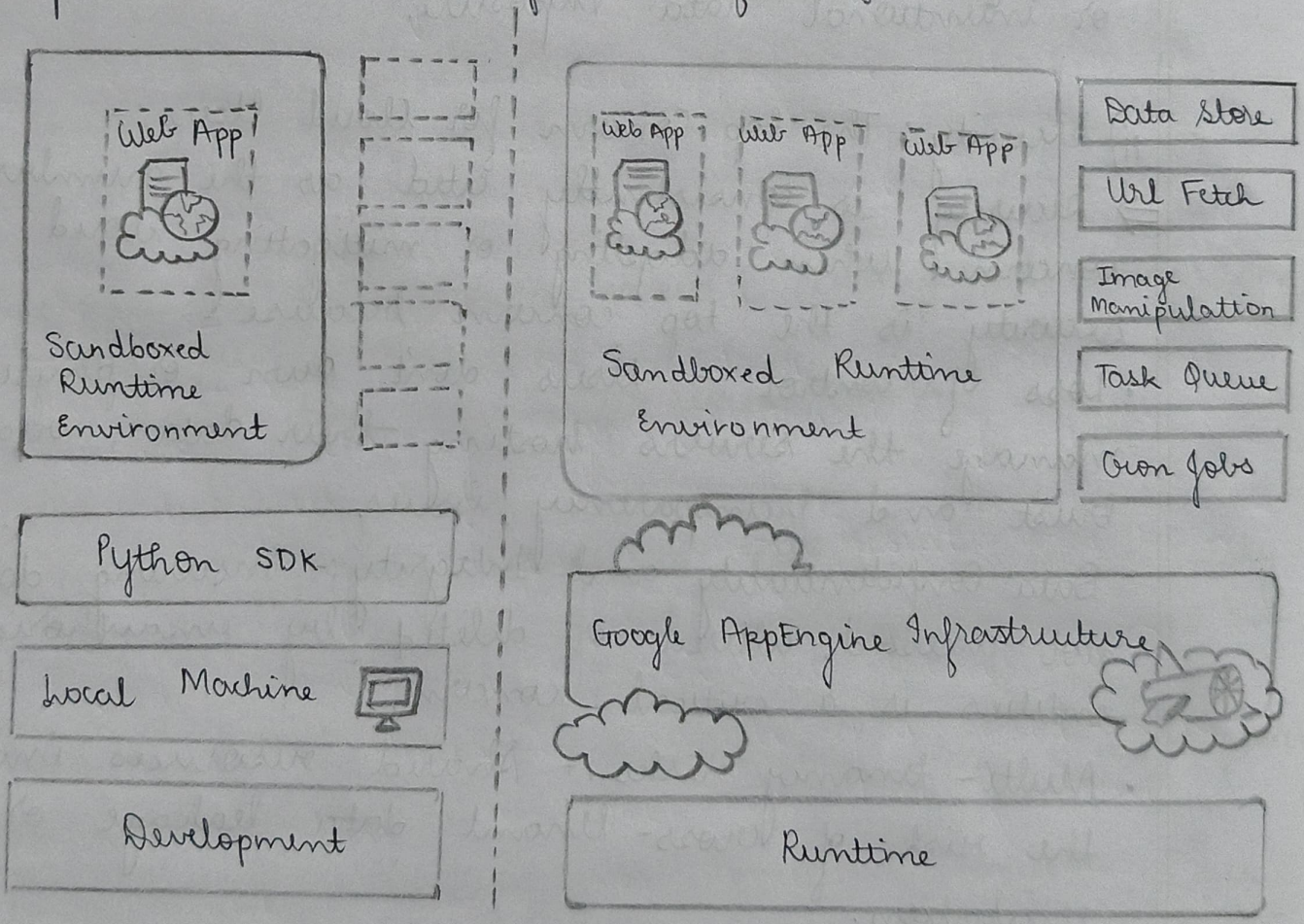

Google AppEngine Platform Architecture.

⇒ Core Components of Google App Engine :-

1. Infrastructure :
- GAE utilizes Google's globally distributed architecture. It automatically provisions servers and balances load based on incoming traffic. Each HTTP request is routed to an appropriate server hosting the app.

2. Runtime Environment :
- Provides an isolated, sandboxed environment to run web applications. Supports only managed/ interpreted languages : Java, Python and Go.

3. Storage Services :
- Google App Engine offers multiple types of storage based on data volatility.

a) Static file Servers :- Hosts static content like HTML, CSS, Javascript, images etc. Optimized for fast delivery of rarely changing files.

b) DataStore :- A scalable, semistructured database built on Bigtable. Stores data in the form of entities and properties. Queries resemblem SQL but are optimized using pre-declared indexes.

4. Application Services :- A set of managed APIs and features to build feature-rich cloud applications.

a) URLFetch :- Fetches web resources using HTTP / HTTPS. Supports synchronous/ asynchronous calls with timeouts.

b) MemCache :- In-memory cache for frequently accessed objects. Reduces read latency by avoiding repeated database lookups.

c) Mail or XMPP :- Enables sending/ receiving email & chat messages (eg :- Google Talk).

d) Account Management – Integrates with Google Accounts for user authentication and profile management.

e) Image Manipulation – Performs basic image operations like resize, crop, rotate etc.

f) Compute Services (Task Queue & Cron Jobs)
- Task Queues: Run background tasks outside user request timeline.
- Cron Jobs: Schedule time-based execution (eg:- daily reports).

5. Discuss in detail the following media applications of cloud computing technologies.
i) Animoto ii) Maya Rendering with Aneka
iii) Video encoding on Cloud.

→ i) Animoto :-

⇒ Animoto is a web-based application that enables users to create custom videos by uploading images, video clips and music. It automatically generates high quality video slideshows with professional transitions & effects.

Features :-
- The user uploads media, selects a style and music.
- Animoto's rendering engine automatically applies cinematic effects.
- Each rendering produces a unique result, even with the same inputs.
- Hosted entirely on Amazon Web Services (AWS).

Animoto is a successful example of a cloud-native media application that takes advantage of cloud elasticity and parallel processing for rendering millions of videos quickly and efficiently.

ii) Maya rendering with Aneka (Private Cloud Rendering):-

⇒ A private cloud solution used for rendering 3D models of high-speed trains using Autodesk Maya, enabled by the Aneka cloud platforms.

- Conducted by GoFront Group (part of China Southern Railway)
- Renders 3D visuals of high-speed train designs for engineering and validation purposes.
- Maya models are rendered using Aneka in a LAN-based private cloud. Rendering jobs are split into tasks & distributed across desktop PCs. Each rendering task is processed independently and later stitched into complete images.

Benefits are :- reduced rendering time (from several days to few hours), provided engineers with a web-based interface to configure render settings & view results.

iii) Video encoding on cloud :-

⇒ Encoding.com is a commercial service that performs cloud-based video encoding and transcoding. It helps content creators to convert videos into different formats suitable for streaming, mobile playback etc.

Features :- • Converts video files into multiple formats (eg:- MP4, WebM).

- Offers additional services: watermarking, thumbnail creation, audio extraction, image conversion.
- Supports scheduled jobs, watched folders & API integration.
- Uses both AWS (EC2, S3, CloudFront) and Rackspace Cloud.
- Accessed through GUI on website, XML API, desktop and cloud-based interfaces.
- Serves 2000+ clients, offers pay-per-use & volume based pricing models.

6. Explain in detail about the application of cloud computing in.
i) Healthcare : ECG analysis in the cloud.
ii) Geoscience : Satellite image processing.

→ i) Healthcare: ECG analysis in the cloud :-

⇒ Electrocardiogram (ECG) analysis is one of the most common diagnostic techniques used to detect heart disease like arrhythmia. Traditionally, patients visit hospitals to get ECG readings, but cloud computing allows continuous remote monitoring & analysis.

* Cloud - based Solution :- A wearable ECG sensor constantly records heartbeat data from the patient.

- This data is transmitted to mobile device & then sent to cloud-based web service for analysis, The web service act as a SaaS application & is supported by a complete cloud stack (SaaS, PaaS & IaaS). ECG data is stored in S3, It is a runtime platform composed of dynamically scalable instances runs the analysis engine using Aneka middleware, The platform can scale according to incoming request loads (elastic scaling)

Benefits :- Real-time monitoring, cost-effectiveness, accessible from any internet-enabled device using SOAP / REST web services, automatic notifications are sent to doctors or emergency personnel when anomalies are detected, the system can scale up/down depending on demand.

ii) Geoscience : Satellite image processing :-

⇒ Geoscience applications deal with massive geospatial

datasets collected through satellite sensors. Processing this data for GIS (Geographic Information System) usage in both storage and compute intensive.

* Cloud - Based Workflows :-

- Satellite data (hundreds of GB) is collected at ground ~~geocode~~ stations and uploaded to cloud infrastructure.
- Saas portal provides services like geocode generation, data visualisation & GIS product creation.
- Aneka as a PaaS middleware, manages importing raw satellite images and coordinating distributed image-processing tasks.
- The infrastructure uses XEN-based private cloud.
- The system automatically scales based on demand to efficiently utilize resources.

Benefits :- . Elastic processing :- easily adjusts power based on data volume.

- Reduced local load :- offloads compute-intensive tasks from local stations to the cloud.
- Integration :- enables building a complete data-to-decision pipeline on cloud platforms.

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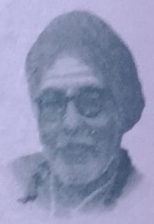

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