Introduction to Cloud Computing

Lê Ngọc Sơn – lnson@fit.hcmus.edu.vn
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The Cloud Computing Phenomenon

- **Significant Adoption Across Organizations**
  - Cloud computing adoption is rising rapidly across industries.
  - Organizations of all sizes leverage cloud technologies for efficiency, scalability, and cost savings.
- **A Leading "Disruptive" Technology**
  - Recognized as a game-changer in the IT landscape.
  - Transforms traditional IT infrastructure, making it more flexible and accessible.
- **Driving Business Model Optimization and Innovation**
  - Enables businesses to optimize operations, reduce costs, and improve agility.
  - Fosters innovation by providing tools for AI, machine learning, big data, and IoT.
  - Supports the creation of new revenue streams and digital-first business models.
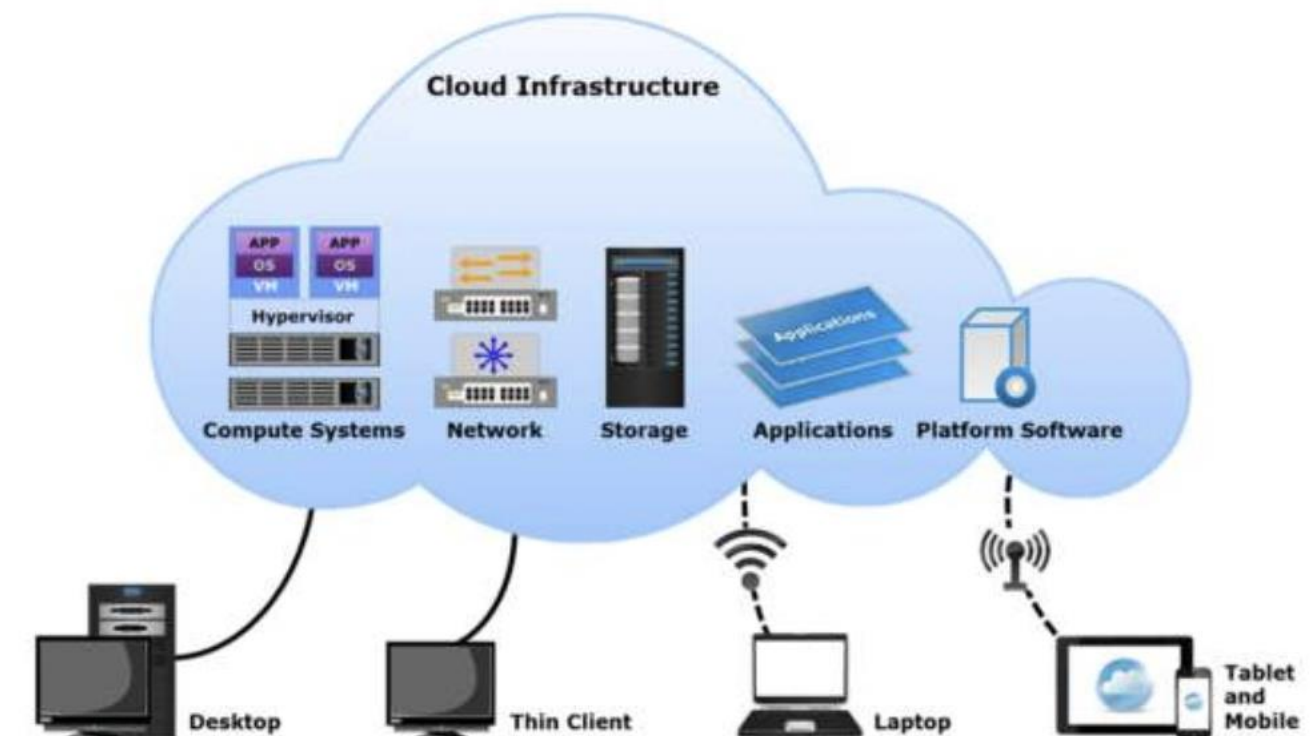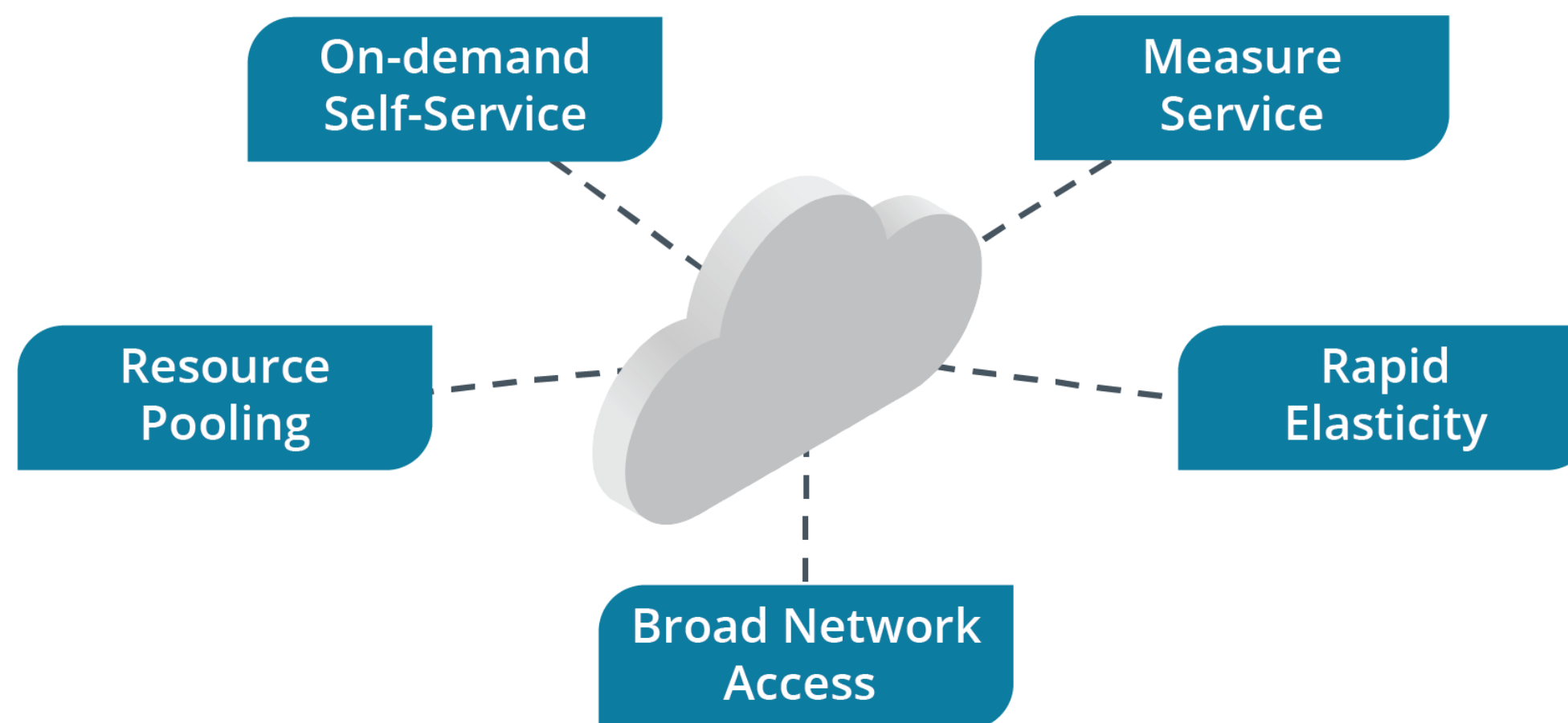
What is cloud computing ?

Cloud Computing

A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, (e.g., servers, storage, networks, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

– U.S. National Institute of Standards and Technology, Special Publication 800-145

Cloud Infrastructure

APP OS VM — APP OS VM — Hypervisor — Compute Systems — Network — Storage — Applications — Platform Software

Desktop — Thin Client — Laptop — Tablet and Mobile

Cloud Characteristics

On-demand Self-Service

Measure Service

Resource Pooling

Rapid Elasticity

Broad Network Access

On-demand Self-sevice

- Services are consumed on an as-needed basis without the need for human assistance from the Cloud Service Provider.

- Organizations provision resources such as servers, storage, or web applications when needed.

- Organizations can provision resources by using their own internal IT staff without relying on the Cloud Service Provider's staff.

Broad Network Access

Computing capabilities are available over the network

Computing capabilities are accessed from a broad range of client platforms such as:

- Desktop computer
- Laptop
- Tablet
- Mobile device

Resource Pooling

- Cloud service providers:
  - Pool network, storage, and compute capabilities.
  - Allocate these pooled resources to customers on demand.
  - Take advantage of the economy of scale.
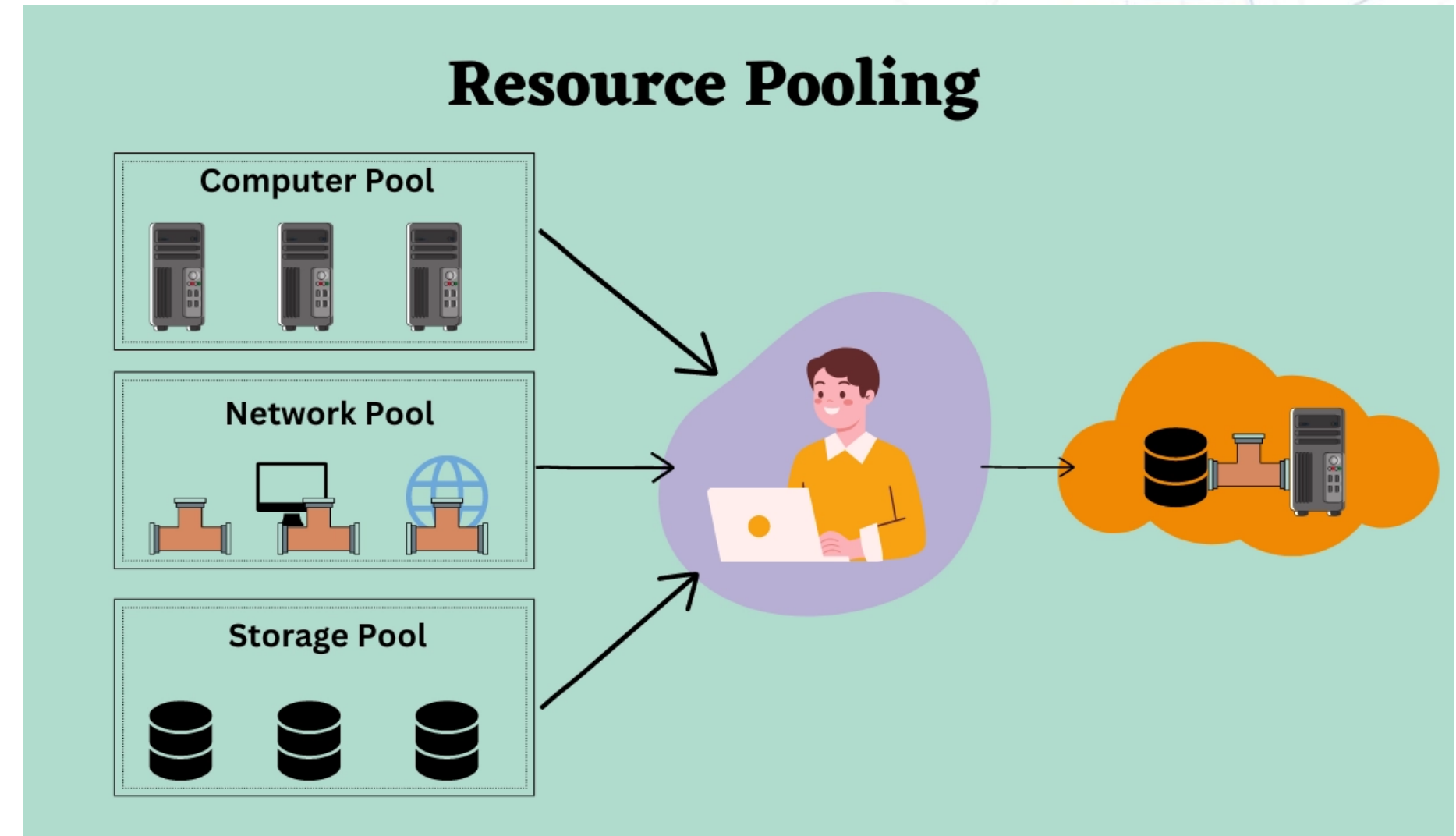
Rapid Elasticity

- Scale computing resources—such as storage, processing power, or memory—up or down quickly and efficiently, based on the current demand.
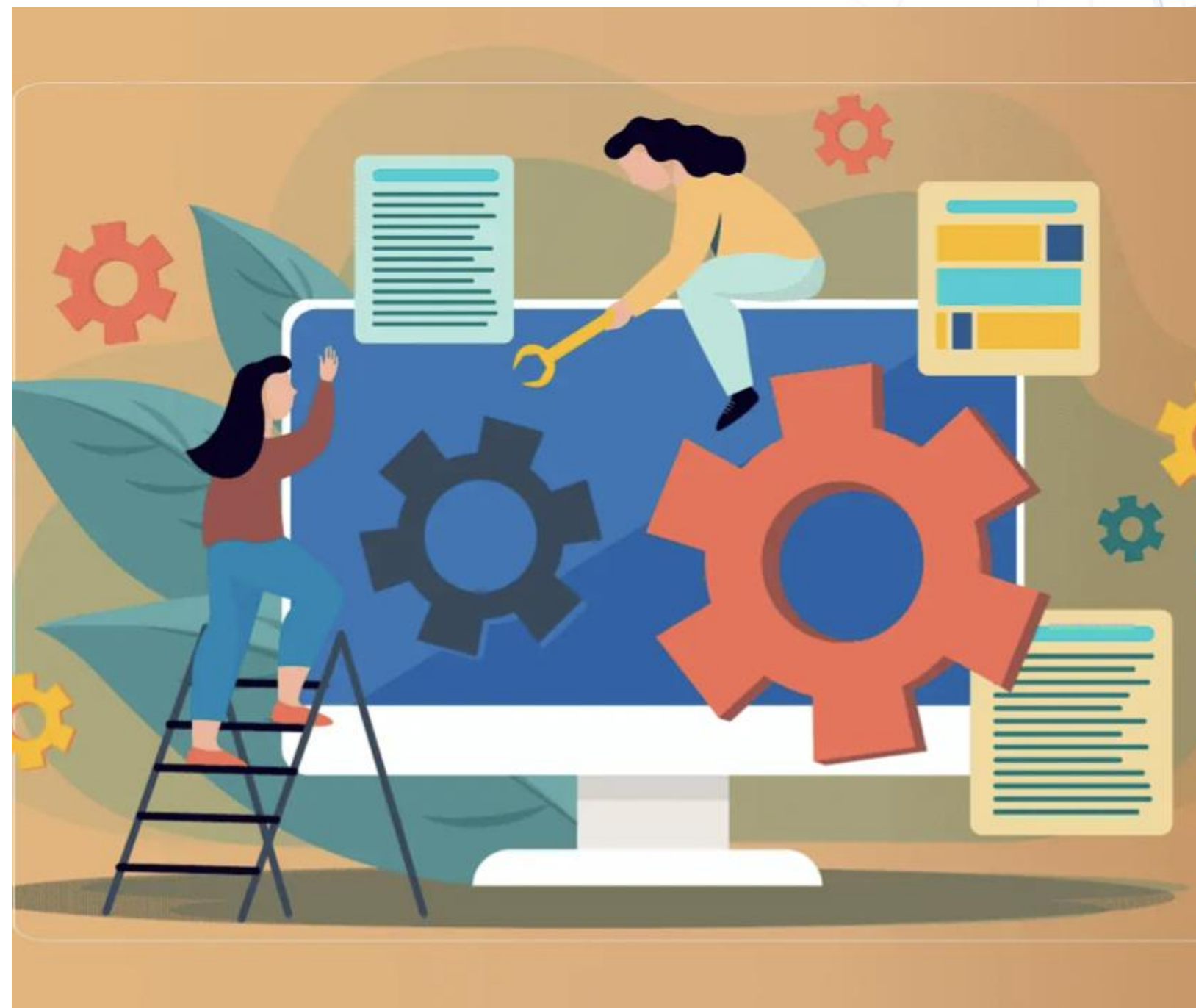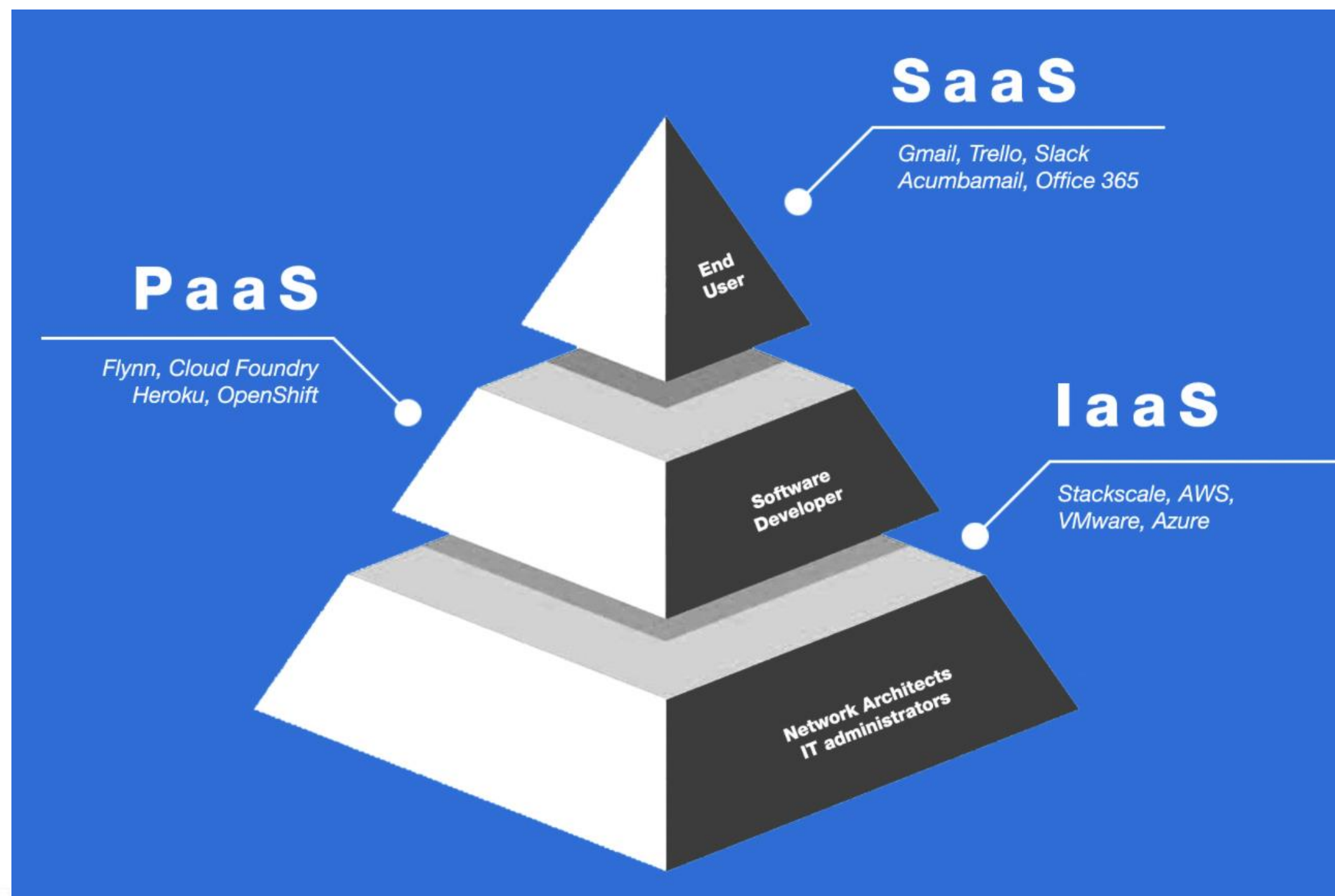
Measured Services

- Cloud resource utilization is carefully metered by cloud service providers.

- Billing for cloud resources is based on actual use of the resources.

Cloud Service models

SaaS

PaaS

IaaS

XaaS

Catch-all phrase for any technology solutions that are moved to the cloud or that exhibit the same pay-as-you-go subscription model as the three primary cloud service models.

Everything as a service (XaaS)

Cloud deployment models

Public Cloud

Public Cloud

The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

– U.S. National Institute of Standards and Technology, Special Publication 800-145
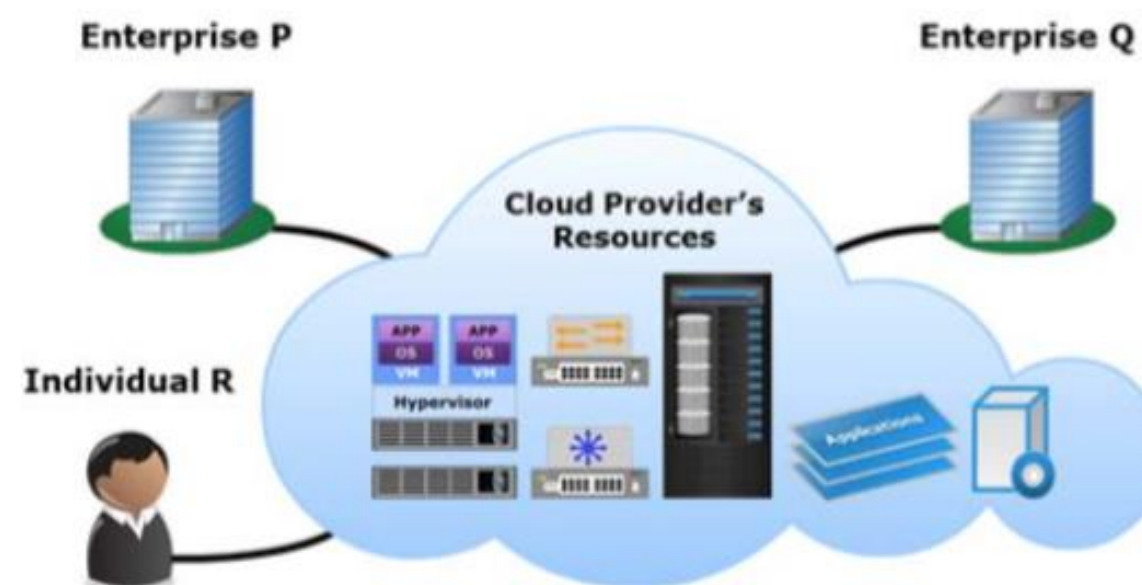
Private Cloud

Private Cloud

Private Cloud

The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (for example, business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

– U.S. National Institute of Standards and Technology, Special Publication 800-145

- There are two variants of private cloud:
  - On-premise
  - Externally-hosted

Community Cloud

Community Cloud

> The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
>
> – U.S. National Institute of Standards and Technology, Special Publication 800-145

- There are two variants of community cloud:
  - On-premise
  - Externally-hosted

Hybrid Cloud

Hybrid Cloud

The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

— *U.S. National Institute of Standards and Technology, Special Publication 800-145*

Enterprise P

Enterprise Q

Cloud Provider's Resources

Resources of Enterprise Q

Individual R

EMC²
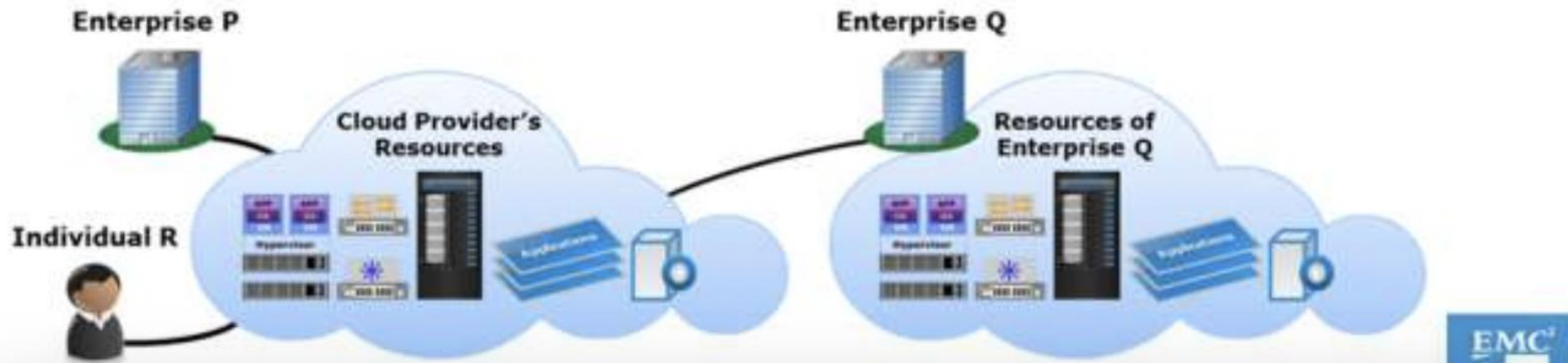
The evolution of cloud compting

1. Pre-Cloud Era (1950s-1990s)

1950s-1970s: Foundation Era

- **Mainframe Computing (1950s-1960s)**
  - Large, centralized computers in dedicated data centers
  - IBM dominated the mainframe market
- **Time-Sharing Systems (1960s-1970s)**
  - Multiple users could access mainframe resources simultaneously
  - UNIX development began at Bell Labs (1969)

1980s-1990s: Distributed Computing

- **Client-Server Architecture (1980s)**
  - Personal computers became widespread
  - Local Area Networks (LANs) enabled resource sharing
  - Distributed computing concepts emerged
- **Early Virtualization (1990s)**
  - VMware founded (1998)
  - First x86 virtualization products released (1999)
- **Internet Service Providers (1990s)**
  - Web hosting services emerged
  - Early Application Service Providers (ASPs) appeared
  - Telecommunications companies began offering Virtual Private Networks (VPNs)

The evolution of cloud compting

2. Birth of Modern Cloud Computing (1999-2006)

- **Early Innovations**

- **1999:**
  - Salesforce launches as one of the first successful SaaS companies
  - VMware introduces virtual machine technology for x86 systems

- **2000-2001:**
  - Early grid computing projects gain traction
  - Concept of utility computing resurfaces

- **2002:**
  - Amazon Web Services launches with initial web services
  - First basic storage and computation services offered

- **2006:**
  - Amazon EC2 (Elastic Compute Cloud) launches
  - Modern cloud computing era officially begins
  - Pay-as-you-go compute resources become available

The evolution of cloud compting
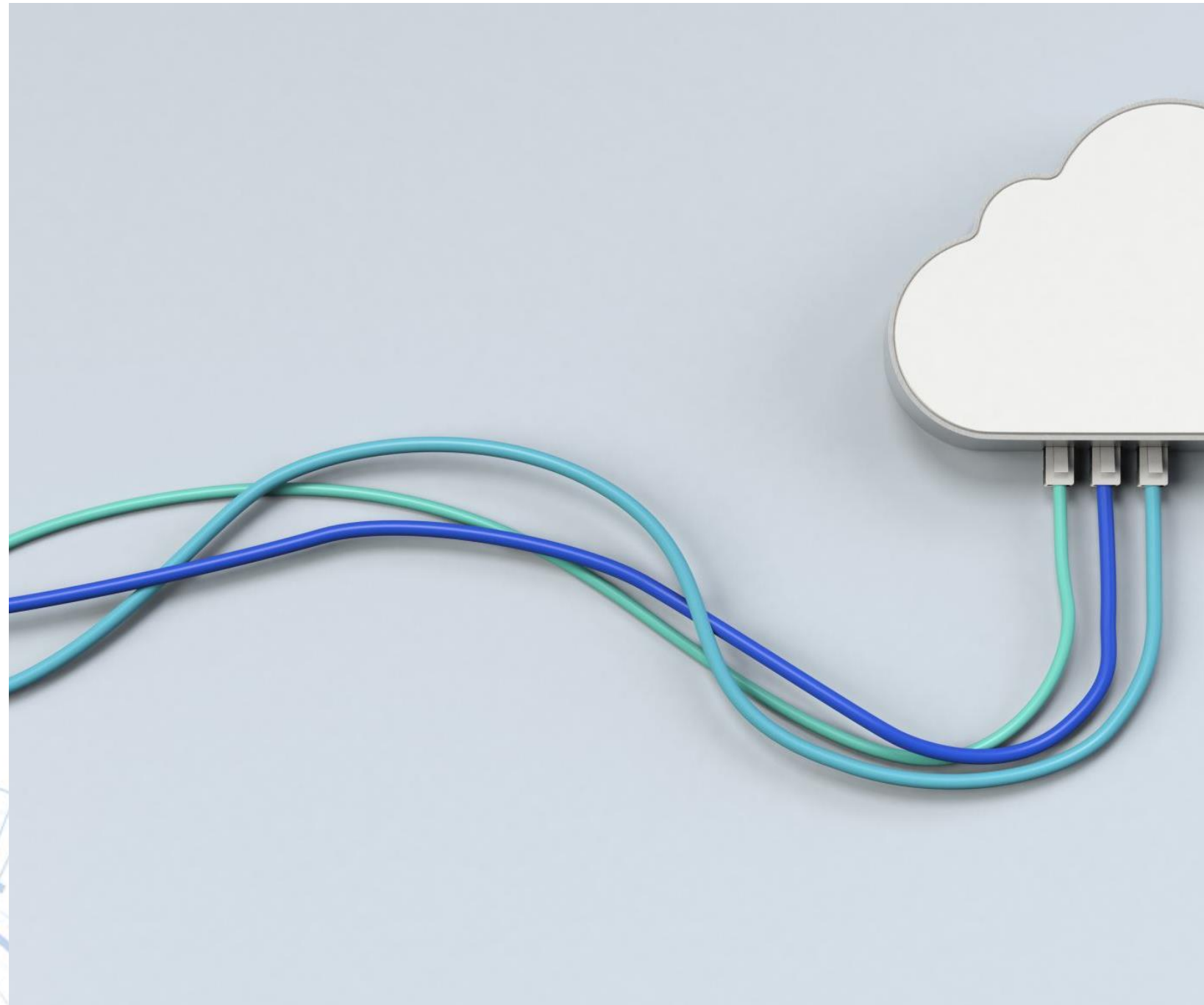
3. Cloud Computing Growth (2007-2014)

- **Major Platform Launches**

- **2007-2008:**
  - Google Docs becomes free to all users
  - Google App Engine launches (2008)
  - Eucalyptus, first open-source AWS-compatible platform, releases

- **2009-2010:**
  - Microsoft Azure launches (initially as Windows Azure)
  - OpenStack project begins
  - Rackspace launches Cloud Servers product

- **2011-2012:**
  - Google Cloud Platform launches
  - IBM SmartCloud Enterprise debuts
  - Oracle Cloud launches

- **Technology Advances**

- **2013-2014:**
  - Docker containerization technology released (2013)
  - AWS Lambda introduces serverless computing (2014)
  - Major providers begin rapid service expansion
  - Cloud storage prices begin dramatic decline

The evolution of cloud compting

4. Maturation Era (2015-2019)

- **Cloud-Native Technologies**
- **Container Orchestration**
  - Kubernetes released by Google (2015)
  - Container adoption accelerates
  - Microservices architecture becomes mainstream
- **DevOps Integration**
  - CI/CD pipelines become standard
  - Infrastructure as Code (IaC) gains prominence
  - Automation tools proliferate
- **Industry Consolidation**
- Market leaders emerge clearly:
  - AWS dominates market share
  - Microsoft Azure establishes strong enterprise presence
  - Google Cloud Platform gains traction
- Enterprise adoption accelerates
- Hybrid cloud models mature

The evolution of cloud compting

Modern Era (2020-Present)

- **Current Trends**
- **Multi-Cloud Strategy**
  - Organizations leverage multiple cloud providers
  - Cloud-agnostic tools become essential
  - Focus on avoiding vendor lock-in
- **Edge Computing**
  - Processing moves closer to data sources
  - 5G enables new edge use cases
  - IoT drives edge computing adoption
- **AI/ML Integration**
  - Cloud providers offer comprehensive AI services
  - Machine learning becomes more accessible
  - AI-optimized infrastructure emerges

Key benefits of Cloud Computing

C **Cost Benefits**

- No upfront infrastructure costs
- Pay-as-you-go pricing model
- Reduced maintenance costs

B **Business Agility**

- Rapid resource provisioning
- Faster time to market
- Global market reach

T **Technical Advantages**

- Automatic scaling based on demand
- High-performance computing capabilities
- Built-in redundancy and reliability

E **Enhanced Security**

- Enterprise-grade security features
- Regular security updates
- Advanced threat protection

Key Benefits of Cloud Computing

D Data Analytics

- Advanced analytics capabilities
- Real-time data processing
- Machine learning integration

S Sustainability

- Reduced carbon footprint
- Optimized energy consumption
- Green data center initiatives

O Operational Benefits

- Simplified management
- Improved collaboration
- Focus on core business

B Business Continuity

- Automated backup systems
- Geographic redundancy
- 24/7 system availability

Key Challenges in Cloud Computing

S Security and Privacy

• Data breaches and unauthorized access risks

• Compliance with regulations (GDPR, HIPAA)

• Multi-tenancy security concerns

C Cost Management

• Unexpected costs and billing surprises

• Resource over-provisioning waste

• Hidden costs in data transfer and API calls

T Technical Issues

• Network latency and performance inconsistency

• Service outages and reliability concerns

• Legacy system integration complexity

V Vendor Dependencies

• Vendor lock-in problems

• Limited customization options

• Service provider reliability concerns

Key Challenges in Cloud Computing

D Data Management

- Complex data migration processes
- Data governance and consistency issues
- Backup and recovery challenges

O Operational Issues

- Skilled personnel shortage
- Continuous training requirements
- Change management difficulties

O Operational Issues

- Skilled personnel shortage
- Continuous training requirements
- Change management difficulties

N Network Concerns

- Internet dependency risks
- Bandwidth limitations
- Geographic distribution challenges

AWS

1. Amazon Web Services (AWS)

Launched in 2006, AWS is the best cloud service provider **leading in the market**. It becomes a major player in AI, database, machine learning, 5G cloud, multi-cloud and serverless deployments. AWS operates in **20 geographical regions** across the world. The company reported a revenue of **9 billion dollars** in Q3 2019.

- AWS offers **175 fully-featured services** to meet any kind of business requirements. These services are database storage, computing power, networking and many more
- You can virtually host any applications, including networks like firewall, DNS, Load balancing, or even you can have your virtual private cloud.
- AWS applications are scalable, flexible, reliable, secure and trustworthy.
- Easy sign-up and fast deployment. The best thing is there is no upfront cost and you pay for what you use. It also offers a FREE tier for some of their popular services.

Top Companies using Amazon Web Services (AWS)

- *Netflix*
- *Spotify*
- *Airbnb*
- *Uber*
- *Peloton*
- *Expedia*
- *Pinterest*
- *Samsung*
- *Sony*
- *Novartis*

Azure

2. Microsoft Azure

Microsoft Azure was launched in 2010 as Windows Azure, and later in 2014, it was renamed, Microsoft Azure. It was launched years after the release of AWS and Google cloud but still, it is the fastest-growing cloud and giving tough competition to AWS and other cloud service providers. There is a five-year partnership between Microsoft and **Disney**. In this partnership, the new method will be developed to move production content to the cloud. Azure has **54 data centers** regions across the world available in **140 countries**.

- Azure offers hundreds of services including **AI + Machine Learning**, **Analytics,** Blockchain, Compute, Containers, Databases, Developer Tools, DevOps, Identity, Integration, Internet of Things, Management, Media, Microsoft Azure Stack, Migration, Mixed Reality, Mobile, Networking, Security, Storage, Web, and Windows Virtual Desktop.
- Microsoft Azure is available with public or private cloud service or hybrid cloud service consists of both private and public.
- Scalability, consistency, security, flexibility, and cost-effectiveness.
- Azure supports various operating systems, databases, tools, programming languages and frameworks.
- It's easier for users to move their application or framework without any hassle and recoding them again.
- 24/7 cooperative team paying attention to their customers. A free trial version of Microsoft Azure is available for 30 days.

Top Companies using Microsoft Azure

- *Walmart*
- *Macy's*
- *The Home Depot*
- *Starbucks*
- *Coca-Cola*
- *Bank of America*
- *JPMorgan Chase*
- *Citigroup*
- *Fidelity Investments*
- *Standard Chartered*

Google Cloud Platform (GCP)
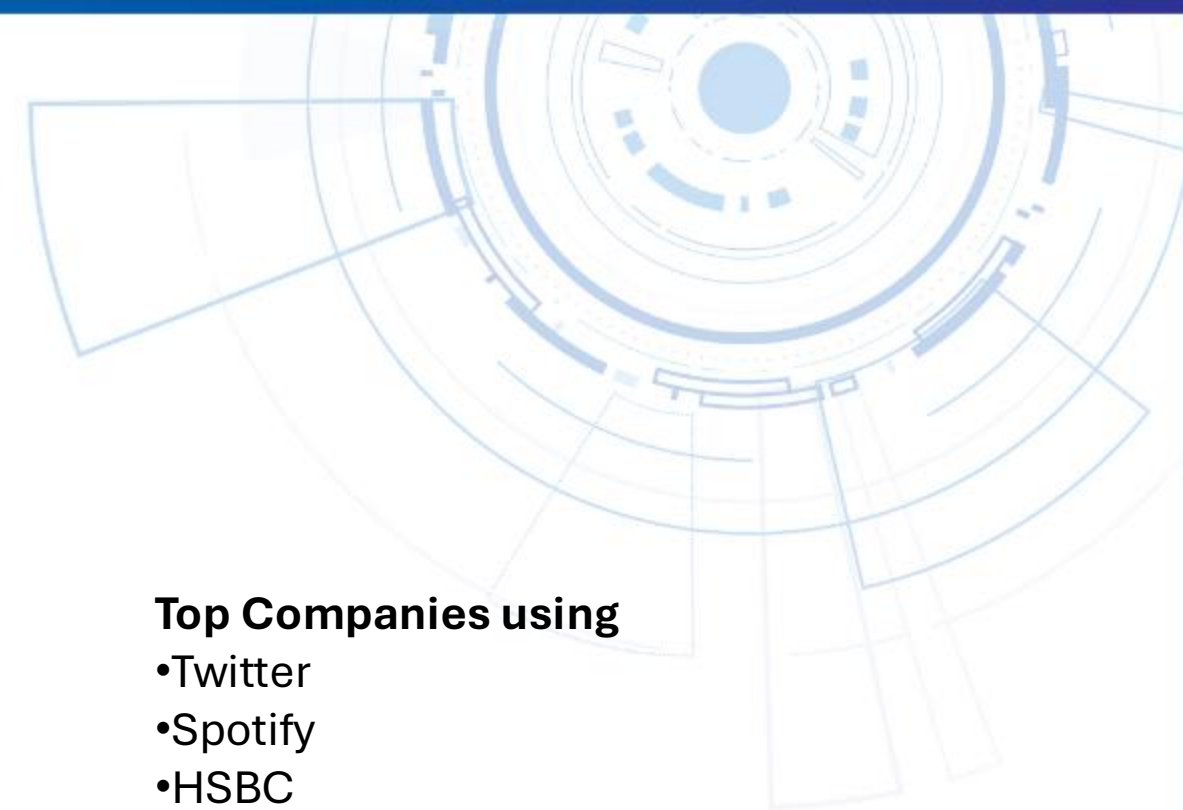
3. Google Cloud Platform

Google Cloud Platform was launched in 2008 with the introduction of App Engine, marking its entry into the Platform-as-a-Service (PaaS) market. Over the years, GCP has expanded into a comprehensive cloud service provider, delivering a wide range of services to compete with AWS and Microsoft Azure. Known for its expertise in data analytics and machine learning, GCP has established itself as a leader in these areas. Google's ongoing innovations, such as the introduction of BigQuery and Vertex AI, have further strengthened its position in the cloud industry.

- GCP operates in **38 regions globally**, serving **200+ countries**, ensuring **reliable and low-latency performance**.

- Committed to **sustainability** with **carbon-neutral energy** and **renewable energy initiatives** in its data centers.

- Offers a wide range of services, including **Compute, Storage, Databases, AI & Machine Learning, Networking, Big Data, Developer Tools, IoT, and Kubernetes Engine**.

- Seamlessly integrates with other Google services like **Workspace** and Android development tools.

- Provides a **90-day free trial** and a **generous free tier** for new customers.

Top Companies using
- Twitter
- Spotify
- HSBC
- PayPal
- Snap Inc.
- Etsy
- Target
- ShareChat
- L'Oréal
- AccuWeather

Other Cloud Providers
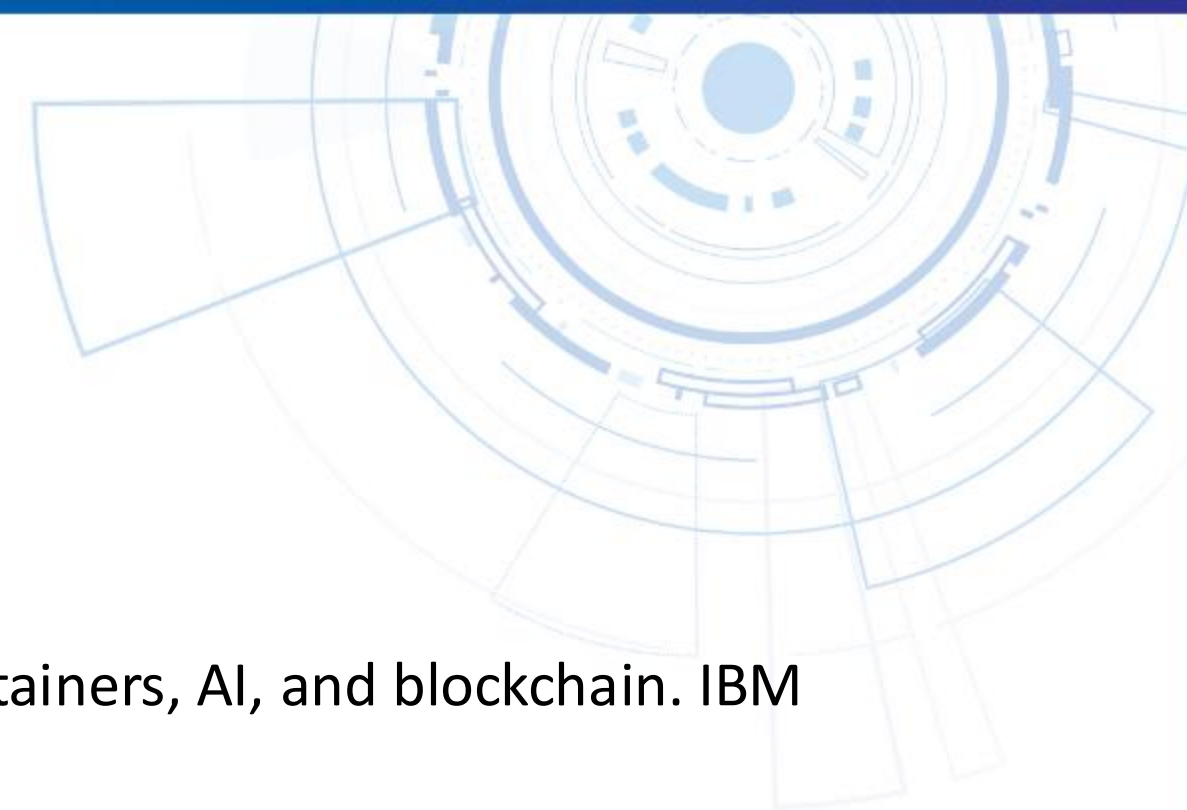
- **IBM Cloud**

Provides a full stack cloud platform with over 170 products and services covering data, containers, AI, and blockchain. IBM Cloud is noted for its enterprise-grade solutions and strong emphasis on security.

- **Oracle Cloud**

Offers integrated cloud applications and platform services, including database services, enterprise applications, and infrastructure solutions. Oracle Cloud is known for its robust database services and enterprise solutions

- **Alibaba Cloud**

Provides a comprehensive suite of global cloud computing services, including elastic computing, data storage, and big data processing. Alibaba Cloud is a leading cloud provider in the Asia-Pacific region

- **Salesforce**

Specializes in customer relationship management (CRM) software and applications focused on sales and customer service. Salesforce is renowned for its CRM solutions and cloud-based applications.

- **RackSpace Technology**

Offers multi-cloud solutions, including cloud migration, management, and optimization services. Rackspace is known for its managed cloud services and support across various cloud platforms.

- **VMware Cloud**

Provides cloud infrastructure and management services, enabling businesses to run, manage, and secure applications across clouds and devices. VMware Cloud is recognized for its virtualization technologies and hybrid cloud solutions.

Case studies of Cloud Computing

Netflix – Global Video Streaming Service

- **Challenge**: Scaling to support millions of users while maintaining high availability and performance.
- **Solution**:
  - Migrated to **Amazon Web Services (AWS)** to leverage scalability and redundancy.
  - Used **EC2 instances** for compute and **S3** for storage.
- **Outcome**:
  - Achieved seamless scaling during peak demand (e.g., new series releases).
  - Enhanced global content delivery using AWS's Content Delivery Network (CDN).

Case studies of Cloud Computing

Coca-Cola – Marketing and Analytics

- **Challenge**: Analyzing massive amounts of data for targeted marketing campaigns.
- **Solution**:
  - Deployed on **Google Cloud Platform (GCP)**.
  - Used **BigQuery** for data analytics and **Google Kubernetes Engine (GKE)** for scalable applications.
- **Outcome**:
  - Gained insights into customer behavior for personalized campaigns.
  - Reduced data processing time significantly.

Case studies of Cloud Computing

Zoom – Video Conferencing Platform

- **Challenge**: Scaling rapidly to meet unprecedented demand during the COVID-19 pandemic.
- **Solution**:
  - Partnered with **AWS** for elastic scaling of compute and network resources.
  - Used **Azure** for additional cloud capacity.
- **Outcome**:
  - Handled exponential growth in daily users (from 10M to 300M in 2020).
  - Maintained reliability and performance under pressure.

Case studies of Cloud Computing

General Electric (GE) – Industrial IoT

- **Challenge**: Managing and analyzing massive industrial data from IoT devices.
- **Solution**:
  - Built its **Predix** platform on **Microsoft Azure**.
  - Integrated Azure IoT services for real-time analytics.
- **Outcome**:
  - Improved operational efficiency by analyzing machine performance.
  - Enabled predictive maintenance, reducing downtime and costs.

Case studies of Cloud Computing

The Weather Company – Forecasting and Analytics

- **Challenge**: Processing vast amounts of weather data in real-time for accurate forecasting.
- **Solution**:
  - Migrated to **IBM Cloud**.
  - Used cloud-based analytics tools and IoT platforms.
- **Outcome**:
  - Delivered precise, real-time weather forecasts.
  - Enhanced decision-making for industries like aviation and logistics.