Fundamentals of Cloud Computing

Lecture Series: Introduction to the Technologies of tomorrow

What is Cloud Computing?

Simply put, cloud computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet ("the cloud") to offer faster innovation, flexible resources, and economies of scale. You typically pay only for cloud services you use, helping lower your operating costs, run your infrastructure more efficiently and scale as your business needs change.

History of Cloud Computing

- Old Mainframes & Mini Computers introduced idea of time-sharing & Client-Server Model. This terminology was mostly associated with large vendors such as IBM and DEC.
- In the 1990s, telecommunications companies, who previously offered primarily dedicated point-to-point data circuits, began offering virtual private network (VPN) services with comparable quality of service, but at a lower cost.
- In March 2006 Amazon introduced its Simple Storage Service (S3), followed by Elastic Compute Cloud (EC2) in August of the same year.
- In February 2010, Microsoft released Microsoft Azure
- On March 1, 2011, IBM announced the IBM SmartCloud framework
- In May 2012, Google Compute Engine was released

Top benefits of cloud computing

Cloud computing is a big shift from the traditional way businesses think about IT resources.

Here are seven common reasons organisations are turning to cloud computing services:

- **Cost-** Cloud computing eliminates the capital expense of buying hardware and software and setting up and running on-site datacenters—the racks of servers, the round-the-clock electricity for power and cooling, the IT experts for managing the infrastructure. It adds up fast.
- **Speed-** Most cloud computing services are provided self service and on demand, so even vast amounts of computing resources can be provisioned in minutes, typically with just a few mouse clicks, giving businesses a lot of flexibility and taking the pressure off capacity planning.

Top benefits of cloud computing-contd.

Global scale-The benefits of cloud computing services include the ability to scale elastically. In cloud speak, that means delivering the right amount of IT resources—for example, more or less computing power, storage, bandwidth—right when it is needed and from the right geographic location.

Productivity-On-site datacenters typically require a lot of “racking and stacking”—hardware setup, software patching, and other time-consuming IT management chores. Cloud computing removes the need for many of these tasks, so IT teams can spend time on achieving more important business goals.

Top benefits of cloud computing-contd.

Performance-The biggest cloud computing services run on a worldwide network of secure datacenters, which are regularly upgraded to the latest generation of fast and efficient computing hardware. This offers several benefits over a single corporate datacenter, including reduced network latency for applications and greater economies of scale.

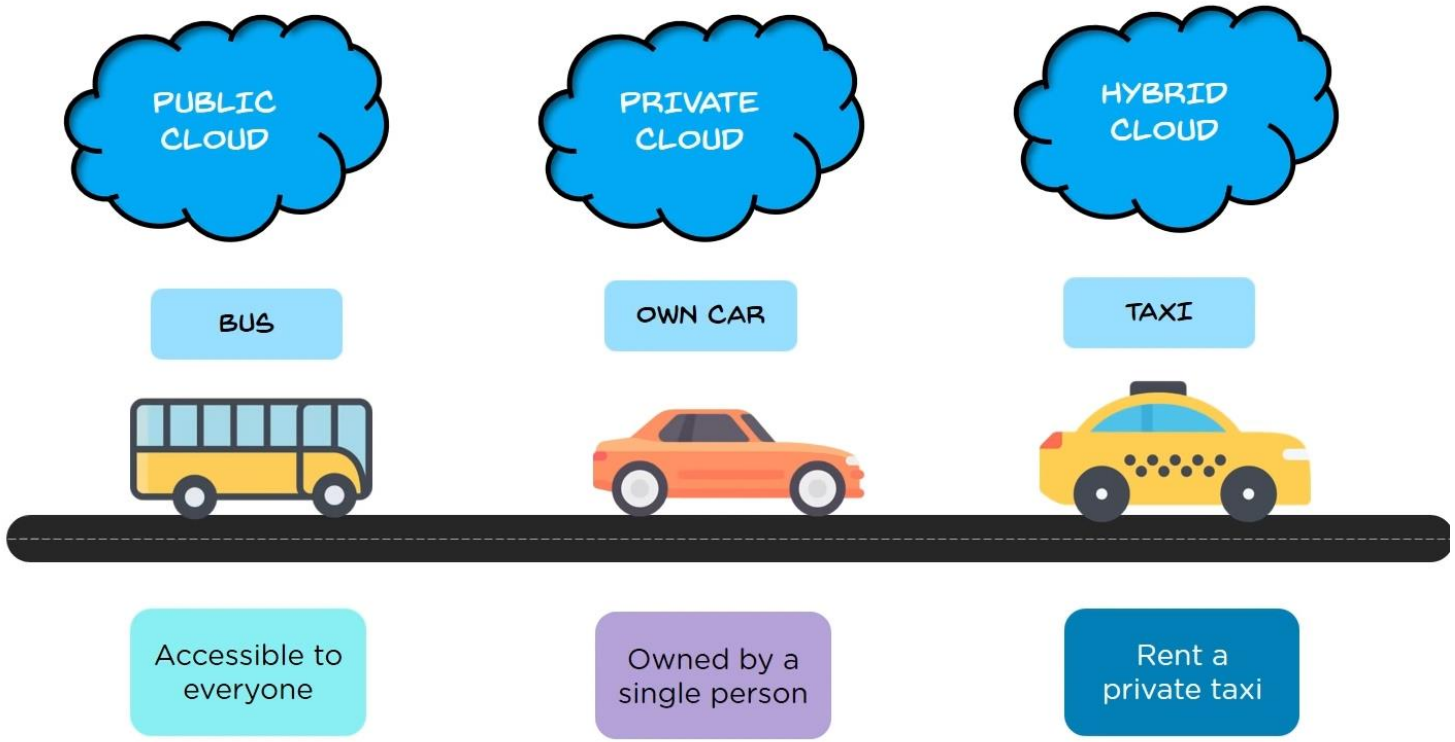
Reliability-Cloud computing makes data backup, disaster recovery and business continuity easier and less expensive because data can be mirrored at multiple redundant sites on the cloud provider's network.

Security-Many cloud providers offer a broad set of policies, technologies and controls that strengthen your security posture overall, helping protect your data, apps and infrastructure from potential threats.

Types of cloud computing

- Not all clouds are the same and not one type of cloud computing is right for everyone. Several different models, types and services have evolved to help offer the right solution for your needs.
- There are three different ways to deploy cloud services: on
  - **Public cloud,**
  - **Private cloud,**
  - **Hybrid cloud**

Types of Deployment Models



Types of cloud computing

Public Cloud Computing

Public clouds are owned and operated by a third-party cloud service providers, which deliver their computing resources like servers and storage over the Internet. Microsoft Azure is an example of a public cloud. With a public cloud, all hardware, software and other supporting infrastructure is owned and managed by the cloud provider. You access these services and manage your account using a web browser.

In a public cloud, you share the same hardware, storage and network devices with other organisations or cloud "tenants," and you access services and manage your account using a web browser. Public cloud deployments are frequently used to provide web-based email, online office applications, storage and testing and development environments.

Advantages of public clouds:

- **Lower costs**—no need to purchase hardware or software and you pay only for the service you use.
- **No maintenance**—your service provider provides the maintenance.
- **Near-unlimited scalability**—on-demand resources are available to meet your business needs.
- **High reliability**—a vast network of servers ensures against failure.

Private Cloud Computing

A private cloud consists of cloud computing resources used exclusively by one business or organisation. The private cloud can be physically located at your organisation's on-site datacenter or it can be hosted by a third-party service provider. But in a private cloud, the services and infrastructure are always maintained on a private network and the hardware and software are dedicated solely to your organisation.

In this way, a private cloud can make it easier for an organisation to customise its resources to meet specific IT requirements. Private clouds are often used by government agencies, financial institutions, any other mid- to large-size organisations with business-critical operations seeking enhanced control over their environment.

Advantages of a private cloud:

- **More flexibility**—your organisation can customise its cloud environment to meet specific business needs.
- **More control**—resources are not shared with others, so higher levels of control and privacy are possible.

More scalability—private clouds often offer more scalability compared to on-premises infrastructure.

Hybrid Cloud

A hybrid cloud is a type of cloud computing that combines on-premises infrastructure—or a private cloud—with a public cloud. Hybrid clouds allow data and apps to move between the two environments.

Many organisations choose a hybrid cloud approach due to business imperatives such as meeting regulatory and data sovereignty requirements, taking full advantage of on-premises technology investment or addressing low latency issues.

The hybrid cloud is evolving to include edge workloads as well. Edge computing brings the computing power of the cloud to IoT devices—closer to where the data resides. By moving workloads to the edge, devices spend less time communicating with the cloud, reducing latency and they are even able to operate reliably in extended offline periods.

Benefits of Hybrid Cloud

A hybrid cloud platform gives organisations many advantages—such as greater flexibility, more deployment options, security, compliance and getting more value from their existing infrastructure. Organisations gain the flexibility and innovation the public cloud provides by running certain workloads in the cloud while keeping highly sensitive data in their own datacenter to meet client needs or regulatory requirements.

- Advantages of the hybrid cloud:
- **Control**—your organisation can maintain a private infrastructure for sensitive assets or workloads that require low latency.
- **Flexibility**—you can take advantage of additional resources in the public cloud when you need them.
- **Cost-effectiveness**—with the ability to scale to the public cloud, you pay for extra computing power only when needed.
- **Ease**—transitioning to the cloud does not have to be overwhelming because you can migrate gradually—phasing in workloads over time.

Types of cloud services: IaaS, PaaS, serverless and SaaS

Most cloud computing services fall into four broad categories:

- **Infrastructure as a service (IaaS),**
- **Platform as a service (PaaS),**
- **Serverless and**
- **Software as a service (SaaS).**

These are sometimes called the cloud computing stack because they build on top of one another. Knowing what they are and how they are different makes it easier to accomplish your business goals.

Differences between IaaS, PaaS and SaaS

On-Premises	IaaS	PaaS	SaaS
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware
O/S	O/S	O/S	O/S
Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking

Managed by you

Managed by Vendor

Differences between IaaS, PaaS and SaaS

On-Premises	IaaS	PaaS	SaaS
Made at Home	Buy & bake	Cake delivery	Dine out
Dinning table	Dinning table	Dinning table	Dinning table
Water	Water	Water	Water
Electricity	Electricity	Electricity	Electricity
Oven	Oven	Oven	Oven
Cake Pan	Cake Pan	Cake Pan	Cake Pan
Flour	Flour	Flour	Flour
Sugar	Sugar	Sugar	Sugar
Butter	Butter	Butter	Butter
Eggs	Eggs	Eggs	Eggs

Managed by you

Managed by Vendor

Infrastructure as a service (IaaS)

Infrastructure as a service (IaaS) is an instant computing infrastructure, provisioned and managed over the internet.

IaaS quickly scales up and down with demand, letting you pay only for what you use. It helps you avoid the expense and complexity of buying and managing your own physical servers and other datacentre infrastructure. Each resource is offered as a separate service component and you only need to rent a particular one for as long as you need it. A cloud computing service provider, such as Azure, manages the infrastructure, while you purchase, install, configure and manage your own software—operating systems, middleware and applications.

Common IaaS business scenarios

Typical things businesses do with IaaS include:

- **Test and development.** Teams can quickly set up and dismantle test and development environments, bringing new applications to market faster. IaaS makes it quick and economical to scale up dev-test environments up and down.
- **Website hosting.** Running websites using IaaS can be less expensive than traditional web hosting.
- **Storage, backup and recovery.** Organisations avoid the capital outlay for storage and complexity of storage management, which typically requires a skilled staff to manage data and meet legal and compliance requirements. IaaS is useful for handling unpredictable demand and steadily growing storage needs. It can also simplify planning and management of backup and recovery systems.
- **Web apps.** IaaS provides all the infrastructure to support web apps, including storage, web and application servers and networking resources. Organisations can quickly deploy web apps on IaaS and easily scale infrastructure up and down when demand for the apps is unpredictable.
- **High-performance computing.** High-performance computing (HPC) on supercomputers, computer grids or computer clusters helps solve complex problems involving millions of variables or calculations. Examples include earthquake and protein folding simulations, climate and weather predictions, financial modeling and evaluating product designs.
- **Big data analysis.** Big data is a popular term for massive data sets that contain potentially valuable patterns, trends and associations. Mining data sets to locate or tease out these hidden patterns requires a huge amount of processing power, which IaaS economically provides.

Advantages of IaaS

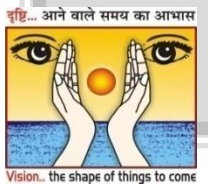
- **Eliminates capital expense and reduces ongoing cost.** IaaS sidesteps the upfront expense of setting up and managing an onsite datacentre, making it an economical option for start-ups and businesses testing new ideas.
- **Improves business continuity and disaster recovery.** Achieving high availability, business continuity and disaster recovery is expensive, since it requires a significant amount of technology and staff. But with the right service level agreement (SLA) in place, IaaS can reduce this cost and access applications and data as usual during a disaster or outage.
- **Innovate rapidly.** As soon as you have decided to launch a new product or initiative, the necessary computing infrastructure can be ready in minutes or hours, rather than the days or weeks—and sometimes months—it could take to set up internally.
- **Respond quicker to shifting business conditions.** IaaS enables you to quickly scale up resources to accommodate spikes in demand for your application— during the holidays, for example—then scale resources back down again when activity decreases to save money.
- **Focus on your core business.** IaaS frees up your team to focus on your organisation's core business rather than on IT infrastructure.
- **Increase stability, reliability and supportability.** With IaaS there is no need to maintain and upgrade software and hardware or troubleshoot equipment problems. With the appropriate agreement in place, the service provider assures that your infrastructure is reliable and meets SLAs.
- **Better security.** With the appropriate service agreement, a cloud service provider can provide security for your applications and data that may be better than what you can attain in-house.
- **Gets new apps to users faster.** Because you don't need to first set up the infrastructure before you can develop and deliver apps, you can get them to users faster with IaaS.

Platform as a service (PaaS)

Platform as a service (PaaS) is a complete development and deployment environment in the cloud, with resources that enable you to deliver everything from simple cloud-based apps to sophisticated, cloud-enabled enterprise applications. You purchase the resources you need from a cloud service provider on a pay-as-you-go basis and access them over a secure Internet connection.

Like IaaS, PaaS includes infrastructure—servers, storage and networking—but also middleware, development tools, business intelligence (BI) services, database management systems and more. PaaS is designed to support the complete web application lifecycle: building, testing, deploying, managing and updating.

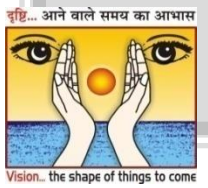
PaaS allows you to avoid the expense and complexity of buying and managing software licenses, the underlying application infrastructure and middleware, container orchestrators such as Kubernetes or the development tools and other resources. You manage the applications and services you develop and the cloud service provider typically manages everything else.



Common PaaS scenarios

Organisations typically use PaaS for these scenarios:

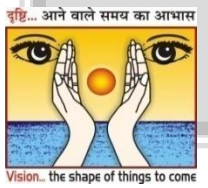
- **Development framework.** PaaS provides a framework that developers can build upon to develop or customise cloud-based applications. Similar to the way you create an Excel macro, PaaS lets developers create applications using built-in software components. Cloud features such as scalability, high-availability and multi-tenant capability are included, reducing the amount of coding that developers must do.
- **Analytics or business intelligence.** Tools provided as a service with PaaS allow organisations to analyse and mine their data, finding insights and patterns and predicting outcomes to improve forecasting, product design decisions, investment returns and other business decisions.
- **Additional services.** PaaS providers may offer other services that enhance applications, such as workflow, directory, security and scheduling.



Advantages of PaaS

By delivering infrastructure as a service, PaaS offers the same advantages as IaaS. But its additional features—middleware, development tools and other business tools—give you more advantages:

- **Cut coding time.** PaaS development tools can cut the time it takes to code new apps with pre-coded application components built into the platform, such as workflow, directory services, security features, search and so on.
- **Add development capabilities without adding staff.** Platform as a Service components can give your development team new capabilities without your needing to add staff having the required skills.
- **Develop for multiple platforms—including mobile—more easily.** Some service providers give you development options for multiple platforms, such as computers, mobile devices and browsers making cross-platform apps quicker and easier to develop.
- **Use sophisticated tools affordably.** A pay-as-you-go model makes it possible for individuals or organisations to use sophisticated development software and business intelligence and analytics tools that they could not afford to purchase outright.
- **Support geographically distributed development teams.** Because the development environment is accessed over the Internet, development teams can work together on projects even when team members are in remote locations.
- **Efficiently manage the application lifecycle.** PaaS provides all of the capabilities that you need to support the complete web application lifecycle: building, testing, deploying, managing and updating within the same integrated environment.



What is serverless computing?

Serverless computing enables developers to build applications faster by eliminating the need for them to manage infrastructure. In understanding the definition of serverless computing, it is important to note that servers are still running the code. The serverless name comes from the fact that the tasks associated with infrastructure provisioning and management are invisible to the developer.

Why an end-to-end serverless platform is important

A serverless approach offers developers, teams and organisations a level of abstraction that enables them to minimise the time and resources invested in infrastructure management. Every component of an application benefits from this approach, from computing and the database engine to messaging, analytics and AI. Using an end-to-end serverless platform that provides a comprehensive set of serverless technologies is the best way to ensure that the organisation gains the maximum benefit from going serverless.

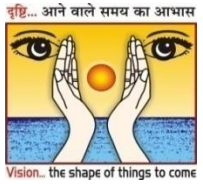
Benefits of serverless computing

- **No infrastructure management-**Using fully managed services enables developers to avoid administrative tasks and focus on core business logic. With a serverless platform, you simply deploy your code and it runs with high availability.
- **Dynamic scalability-**With serverless computing, the infrastructure dynamically scales up and down within seconds to match the demands of any workload.
- **Faster time to market-**Serverless applications reduce the operations dependencies on each development cycle, increasing development teams' agility to deliver more functionality in less time.
- **More efficient use of resources-**Shifting to serverless technologies helps organisations reduce **total cost of ownership (TCO)** and reallocate resources to accelerate the pace of innovation.

Serverless application patterns

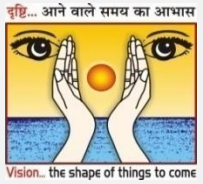
Developers build serverless applications using a variety of application patterns—many of which align with approaches that are already familiar—to meet specific requirements and business needs.

- **Serverless functions**
- **Serverless Kubernetes**
- **Serverless workflows**
- **Serverless application environments**
- **Serverless API gateway**



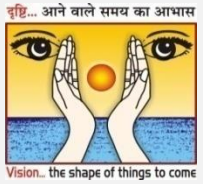
Software as a service (SaaS)

- **Software as a service (SaaS)** allows users to connect to and use cloud-based apps over the Internet. Common examples are email, calendaring and office tools (such as Microsoft Office 365).
- SaaS provides a complete software solution which you purchase on a pay-as-you-go basis from a cloud service provider. You rent the use of an app for your organisation and your users connect to it over the Internet, usually with a web browser. All of the underlying infrastructure, middleware, app software and app data are located in the service provider's data center. The service provider manages the hardware and software and with the appropriate service agreement, will ensure the availability and the security of the app and your data as well. SaaS allows your organisation to get quickly up and running with an app at minimal upfront cost.



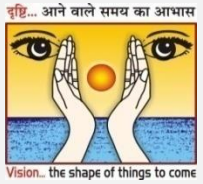
Common SaaS scenarios

- If you have used a web-based email service such as Outlook, Hotmail or Yahoo! Mail, then you have already used a form of SaaS. With these services, you log into your account over the Internet, often from a web browser. The email software is located on the service provider's network and your messages are stored there as well. You can access your email and stored messages from a web browser on any computer or Internet-connected device.
- The previous examples are free services for personal use. For organisational use, you can rent productivity apps, such as email, collaboration and calendaring; and sophisticated business applications such as customer relationship management (CRM), enterprise resource planning (ERP) and document management. You pay for the use of these apps by subscription or according to the level of use.

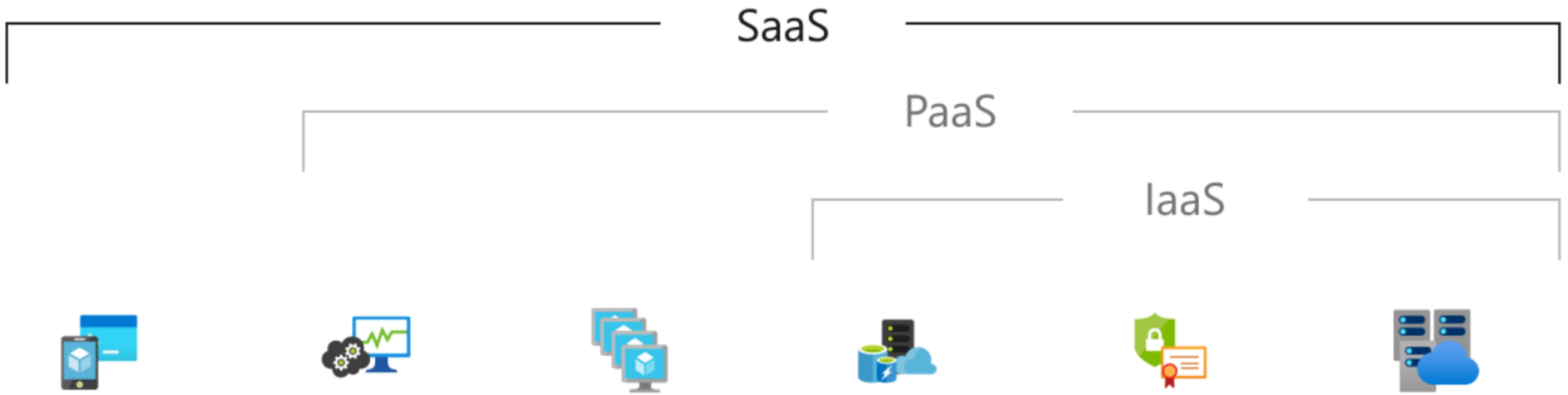


Advantages of SaaS

- **Gain access to sophisticated applications.** To provide SaaS apps to users, you don't need to purchase, install, update or maintain any hardware, middleware or software. SaaS makes even sophisticated enterprise applications, such as ERP and CRM, affordable for organisations that lack the resources to buy, deploy and manage the required infrastructure and software themselves.
- **Pay only for what you use.** You also save money because the SaaS service automatically scales up and down according to the level of usage.
- **Use free client software.** Users can run most SaaS apps directly from their web browser without needing to download and install any software, although some apps require plugins. This means that you don't need to purchase and install special software for your users.
- **Mobilise your workforce easily.** SaaS makes it easy to "mobilise" your workforce because users can access SaaS apps and data from any Internet-connected computer or mobile device. You don't need to worry about developing apps to run on different types of computers and devices because the service provider has already done so. In addition, you don't need to bring special expertise onboard to manage the security issues inherent in mobile computing. A carefully chosen service provider will ensure the security of your data, regardless of the type of device consuming it.
- **Access app data from anywhere.** With data stored in the cloud, users can access their information from any Internet-connected computer or mobile device. And when app data is stored in the cloud, no data is lost if a user's computer or device fails.



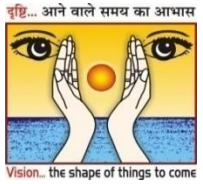
Types of cloud services: IaaS, PaaS, serverless and SaaS



Hosted applications/apps	Development tools, database management, business analytics	Operating systems	Servers and storage	Networking firewalls/security	Data center physical plant/building

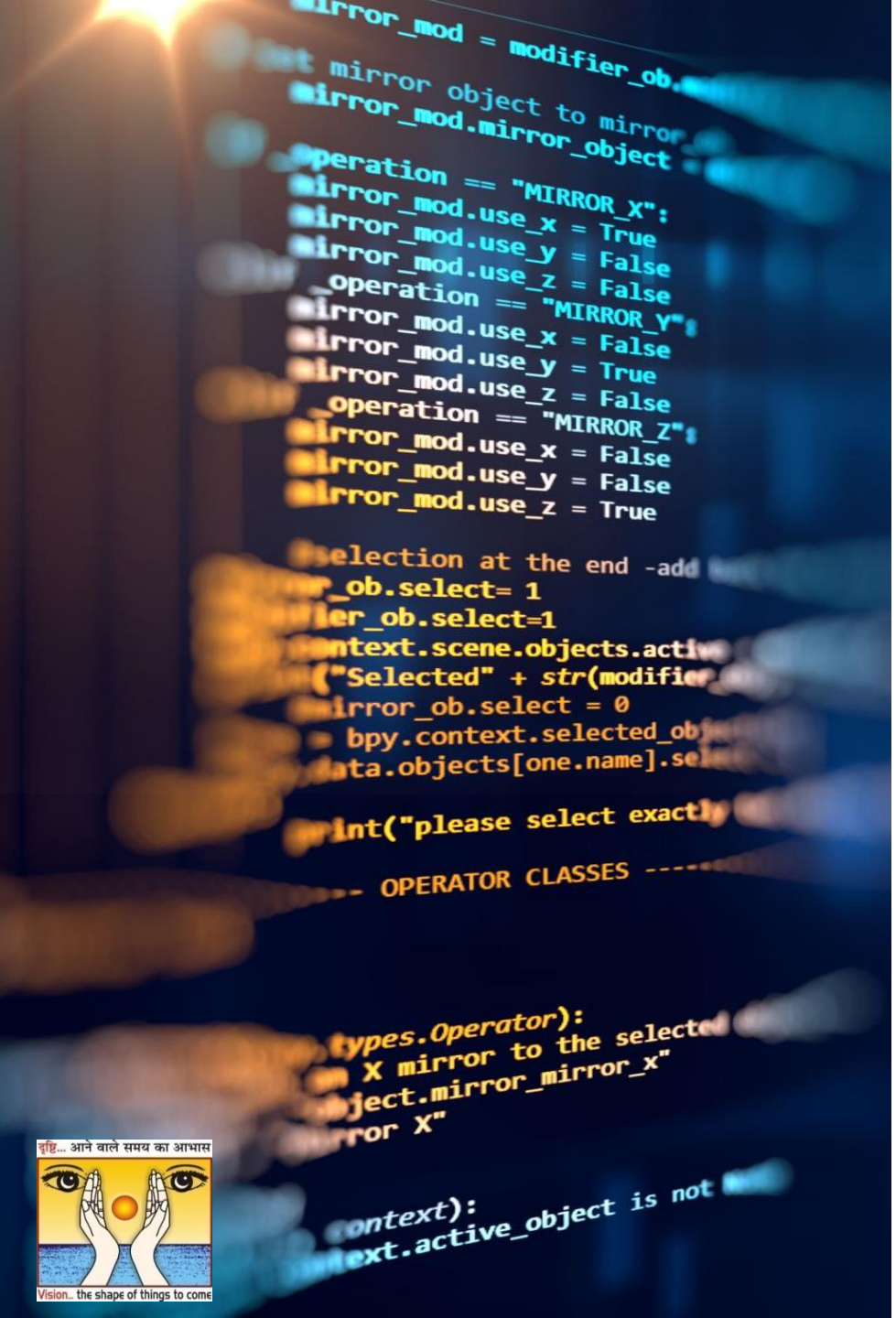
Uses of Cloud Application

- You are probably using cloud computing right now, even if you don’t realise it. If you use an online service to send email, edit documents, watch movies or TV, listen to music, play games or store pictures and other files, it is likely that cloud computing is making it all possible behind the scenes.
- The first cloud computing services are barely a decade old, but already a variety of organisations—from tiny startups to global corporations, government agencies to non-profits—are embracing the technology for all sorts of reasons.



Uses of Cloud Computing-examples

- **Create cloud-native applications-**Quickly build, deploy and scale applications—web, mobile and API.
- **Test and build applications-**Reduce application development cost and time by using cloud infrastructures that can easily be scaled up or down.
- **Store, back up and recover data-**Protect your data more cost-efficiently—and at massive scale—by transferring your data over the Internet to an offsite cloud storage system that is accessible from any location and any device

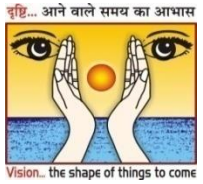


Uses of Cloud Computing-examples (2)

- **Analyse data-**Unify your data across teams, divisions and locations in the cloud. Then use cloud services, such as machine learning and artificial intelligence, to uncover insights for more informed decisions.
- **Stream audio and video-**Connect with your audience anywhere, anytime, on any device with high-definition video and audio with global distribution.
- **Embed intelligence-**Use intelligent models to help engage customers and provide valuable insights from the data captured.
- **Deliver software on demand-**Also known as software as a service (SaaS), on-demand software lets you offer the latest software versions and updates around to customers—anytime they need, anywhere they are.

Few Important terms related to Cloud Computing

- **Edge Computing-** here the data is processed and analyzed closer to the point where it's created. Because data does not traverse over a network to a cloud or data center to be processed, latency is significantly reduced.
- **Cloud Native apps-** Cloud native applications are built from the ground up—optimised for cloud scale and performance. They are based on microservices architectures, use managed services and take advantage of continuous delivery to achieve reliability and faster time to market.
- **What are the intelligent cloud and the intelligent edge?**
  The intelligent cloud is ubiquitous computing, enabled by the public cloud and artificial intelligence (AI) technology, for every type of intelligent application and system you can envision.
  The intelligent edge is a continually expanding set of connected systems and devices that gather and analyse data—close to your users, the data or both. Users get real-time insights and experiences, delivered by highly responsive and contextually aware apps.



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