FUNDAMENTAL OF COMPUTERS
&
EMERGING TECHNOLOGIES

KCA-101

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What is blockchain technology?

Blockchain technology is an advanced database mechanism that allows transparent information sharing within a business network. A blockchain database stores data in blocks that are linked together in a chain. The data is chronologically consistent because you cannot delete or modify the chain without consensus from the network. As a result, you can use blockchain technology to create an unalterable or immutable ledger for tracking orders, payments, accounts, and other transactions. The system has built-in mechanisms that prevent unauthorized transaction entries and create consistency in the shared view of these transactions.

Blockchain: Overview

A blockchain is a constantly growing **ledger** which keeps a **permanent** record of all the transactions that have taken place in a **secure**, **chronological**, and **immutable** way.
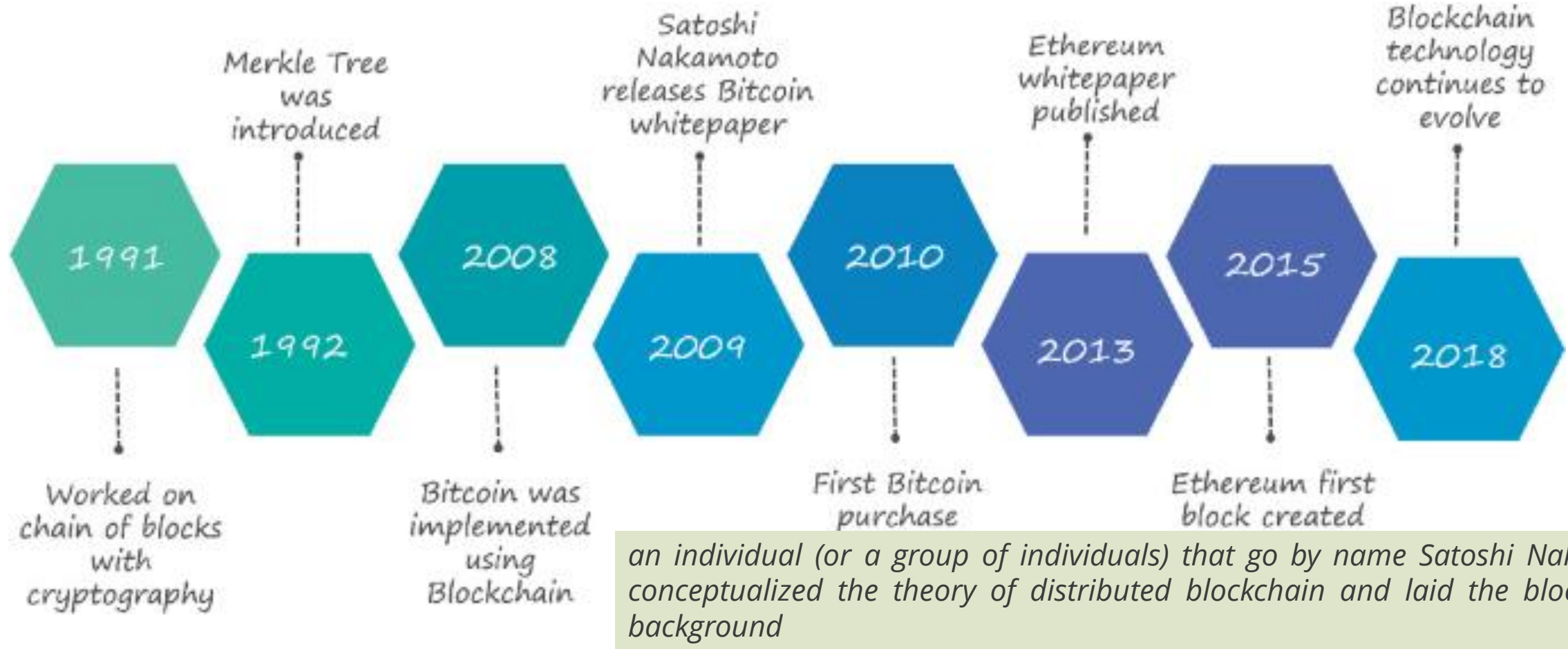
- **Ledger:** It is a file that is constantly growing.
- **Permanent:** It means once the transaction goes inside a blockchain, you can put up it permanently in the ledger.
- **Secure:** Blockchain placed information in a secure way. It uses very advanced cryptography to make sure that the information is locked inside the blockchain.
- **Chronological:** Chronological means every transaction happens after the previous one.
- **Immutable:** It means as you build all the transaction onto the blockchain, this ledger can never be changed.

A blockchain is a chain of blocks which contain information. Each block records all of the recent transactions, and once completed goes into the blockchain as a permanent database. Each time a block gets completed; a new block is generated.

The Blockchain Evolution

Merkle Tree' was named after **Ralph Merkle** who patented them for the first time in 1979.
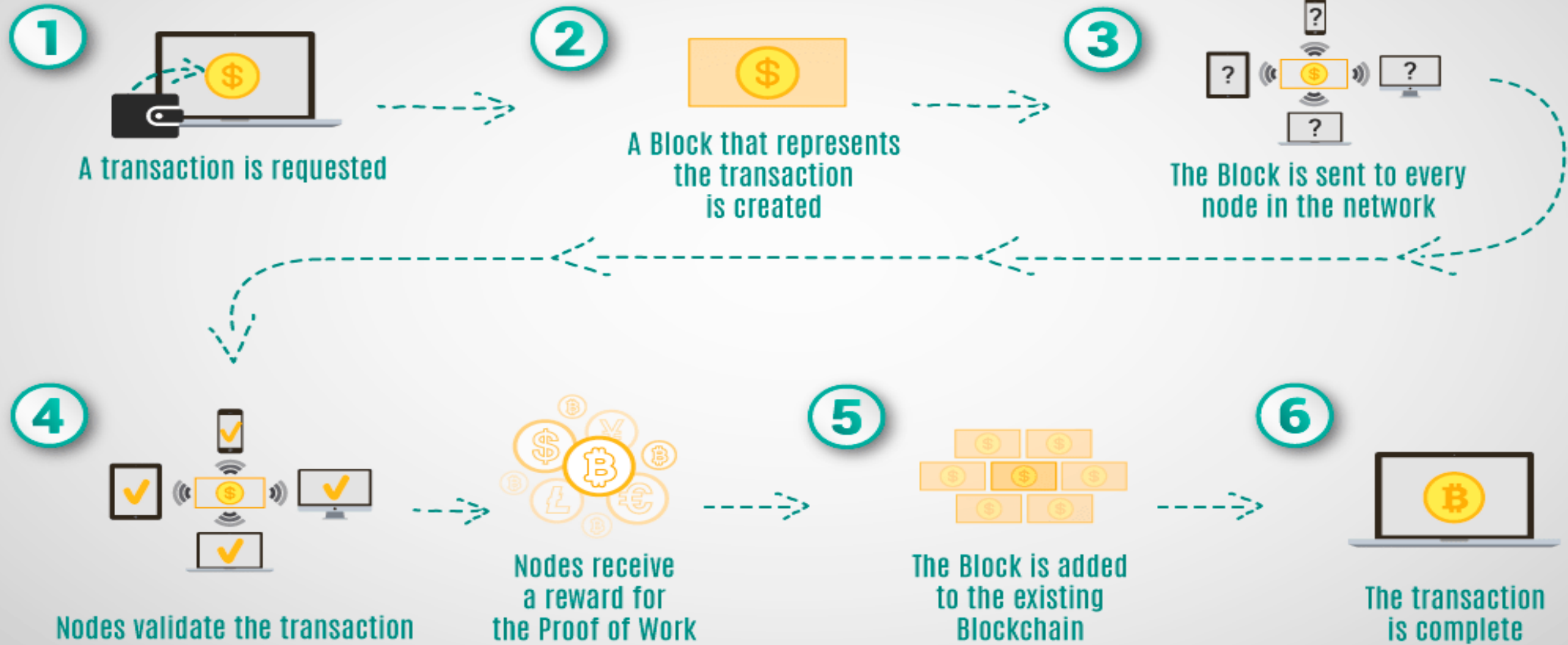
Anyone who wants to add new blocks to the chain must stake at least 32 ETH into the deposit contract and run validator software.

1991 — Worked on chain of blocks with cryptography

1992 — Merkle Tree was introduced

2008 — Satoshi Nakamoto releases Bitcoin whitepaper

2009 — Bitcoin was implemented using Blockchain

2010 — First Bitcoin purchase

2013 — Ethereum whitepaper published

2015 — Ethereum first block created

2018 — Blockchain technology continues to evolve

an individual (or a group of individuals) that go by name Satoshi Nakamato conceptualized the theory of distributed blockchain and laid the blockchain background

When Stuart Haber and W. Scott Stornetta wanted to implement a system where document timestamps could not be tampered

Florida man negotiated to pay 10,000 BTC for two Papa John's pizzas priced at about $25

HOW BLOCKCHAIN WORKS

1 A transaction is requested

2 A Block that represents the transaction is created

3 The Block is sent to every node in the network

4 Nodes validate the transaction

Nodes receive a reward for the Proof of Work

5 The Block is added to the existing Blockchain

6 The transaction is complete

How does blockchain work?

Step 1 – Record the transaction

A blockchain transaction shows the movement of physical or digital assets from one party to another in the blockchain network. It is recorded as a data block and can include details like these:

- Who was involved in the transaction?
- What happened during the transaction?
- When did the transaction occur?
- Where did the transaction occur?
- Why did the transaction occur?
- How much of the asset was exchanged?
- How many pre-conditions were met during the transaction?

Step 2 – Gain consensus

Most participants on the distributed blockchain network must agree that the recorded transaction is valid. Depending on the type of network, rules of agreement can vary but are typically established at the start of the network.

Step 3 – Link the blocks

Once the participants have reached a consensus, transactions on the blockchain are written into blocks equivalent to the pages of a ledger book. Along with the transactions, a cryptographic hash is also appended to the new block. The hash acts as a chain that links the blocks together. If the contents of the block are intentionally or unintentionally modified, the hash value changes, providing a way to detect data tampering.

Thus, the blocks and chains link securely, and you cannot edit them. Each additional block strengthens the verification of the previous block and therefore the entire blockchain. This is like stacking wooden blocks to make a tower. You can only stack blocks on top, and if you remove a block from the middle of the tower, the whole tower breaks.
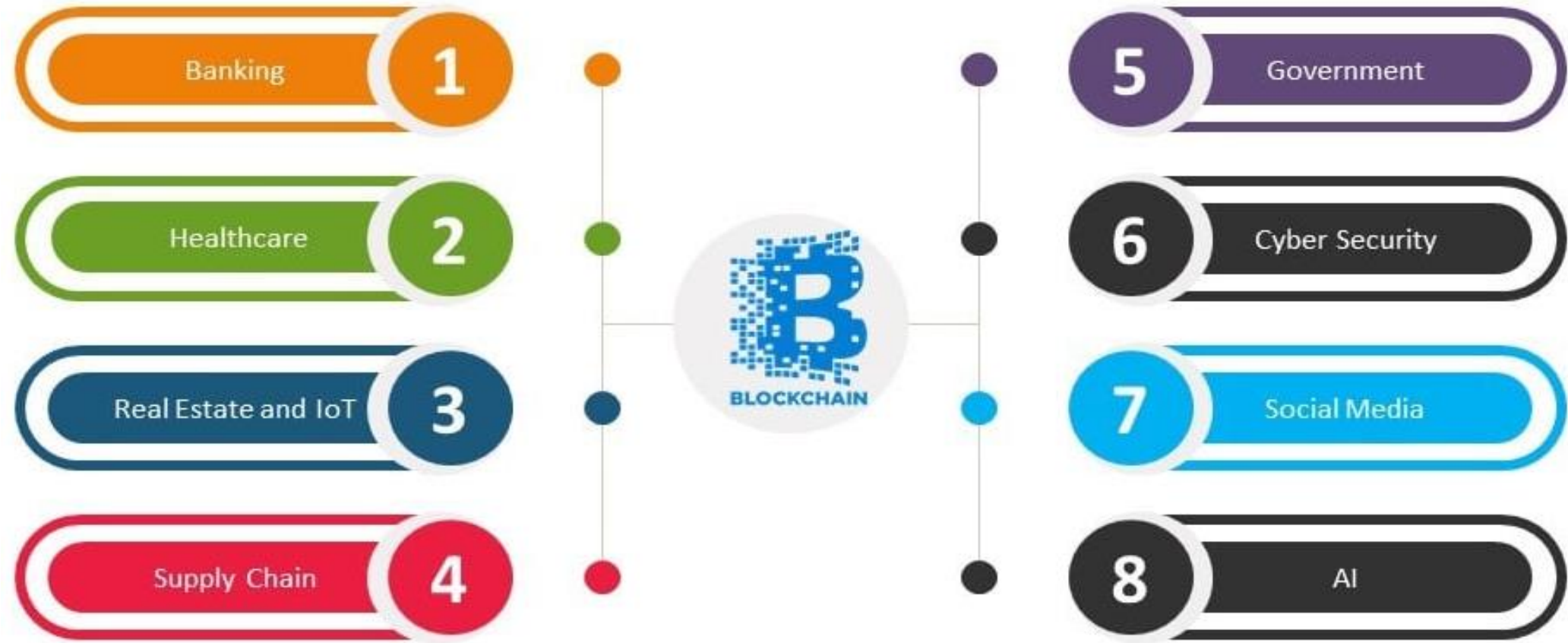
Step 4 – Share the ledger

The system distributes the latest copy of the central ledger to all participants.

Core blockchain architecture components

- Node - user or computer within the blockchain architecture (each has an independent copy of the whole blockchain ledger)
- Transaction - smallest building block of a blockchain system (records, information, etc.) that serves as the purpose of blockchain
- Block - a data structure used for keeping a set of transactions which is distributed to all nodes in the network
- Chain - a sequence of blocks in a specific order
- Miners - specific nodes which perform the block verification process before adding anything to the blockchain structure
- Consensus (consensus protocol) - a set of rules and arrangements to carry out blockchain operations

Blockchain Applications

1. Banking
2. Healthcare
3. Real Estate and IoT
4. Supply Chain

BLOCKCHAIN

5. Government
6. Cyber Security
7. Social Media
8. AI

https://intellipaat.com/blog/tutorial/blockchain-tutorial/blockchain-applications/

Advantages of Blockchain Technology

- **Open:** One of the major advantages of blockchain technology is that it is accessible to all means anyone can become a participant in the contribution to blockchain technology, one does not require any permission from anybody to join the distributed network.

- **Verifiable:** Blockchain technology is used to store information in a decentralized manner so everyone can verify the correctness of the information by using zero-knowledge proof through which one party proves the correctness of data to another party without revealing anything about data.

- **Permanent:** Records or information which is stored using blockchain technology is permanent means one needs not worry about losing the data because duplicate copies are stored at each local node as it is a decentralized network that has a number of trustworthy nodes.

- **Free from Censorship:** Blockchain technology is considered free from censorship as it does not have control of any single party rather it has the concept of trustworthy nodes for validation and consensus protocols that approve transactions by using smart contracts.

- **Tighter Security:** Blockchain uses hashing techniques to store each transaction on a block that is connected to each other, so it has tighter security. It uses SHA 256 hashing technique for storing transactions.
- **Immutability:** Data cannot be tampered with in blockchain technology due to its decentralized structure so any change will be reflected in all the nodes so one cannot do fraud here, hence it can be claimed that transactions are tamper-proof.
- **Transparency**: It makes histories of transactions transparent everywhere all the nodes in the network have a copy of the transaction in the network. If any changes occur in the transaction, it is visible to the other nodes.
- **Efficiency**: Blockchain removes any third-party intervention between transactions and removes the mistake making the system efficient and faster. Settlement is made easier and smooth.
- **Cost Reduction**: As blockchain needs no third man it reduces the cost for the businesses and gives trust to the other partner.

Disadvantages of Blockchain Technology

- **Scalability:** It is one of the biggest drawbacks of blockchain technology as it cannot be scaled due to the fixed size of the block for storing information. The block size is 1 MB due to which it can hold only a couple of transactions on a single block.

- **Immaturity:** Blockchain is only a couple-year-old technology so people do not have much confidence in it, they are not ready to invest in it yet several applications of blockchain are doing great in different industries but still it needs to win the confidence of even more people to be recognized for its complete utilization.

- **Energy Consuming:** For verifying any transaction a lot of energy is used so it becomes a problem according to the survey it is considered that 0.3 percent of the world's electricity had been used by 2018 in the verification of transactions done using blockchain technology.

To Be Continued

- **Time-Consuming:** To add the next block in the chain miners need to compute nonce values many times so this is a time-consuming process and needs to be speed up to be used for industrial purposes.
- **Legal Formalities:** In some countries, the use of blockchain technology applications is banned like cryptocurrency due to some environmental issues they are not promoting to use blockchain technology in the commercial sector.
- **Storage**: Blockchain databases are stored on all the nodes of the network creates an issue with the storage, increasing number of transactions will require more storage.
- **Regulations**: Blockchain faces challenges with some financial institution. Other aspects of technology will be required in order to adopt blockchain in wider aspect.

Block in a Blockchain

- Blockchain is a linear chain of blocks.
- Each block contains a set of transactions and other essential details.
- Blocks are linearly connected and cryptographically secured.
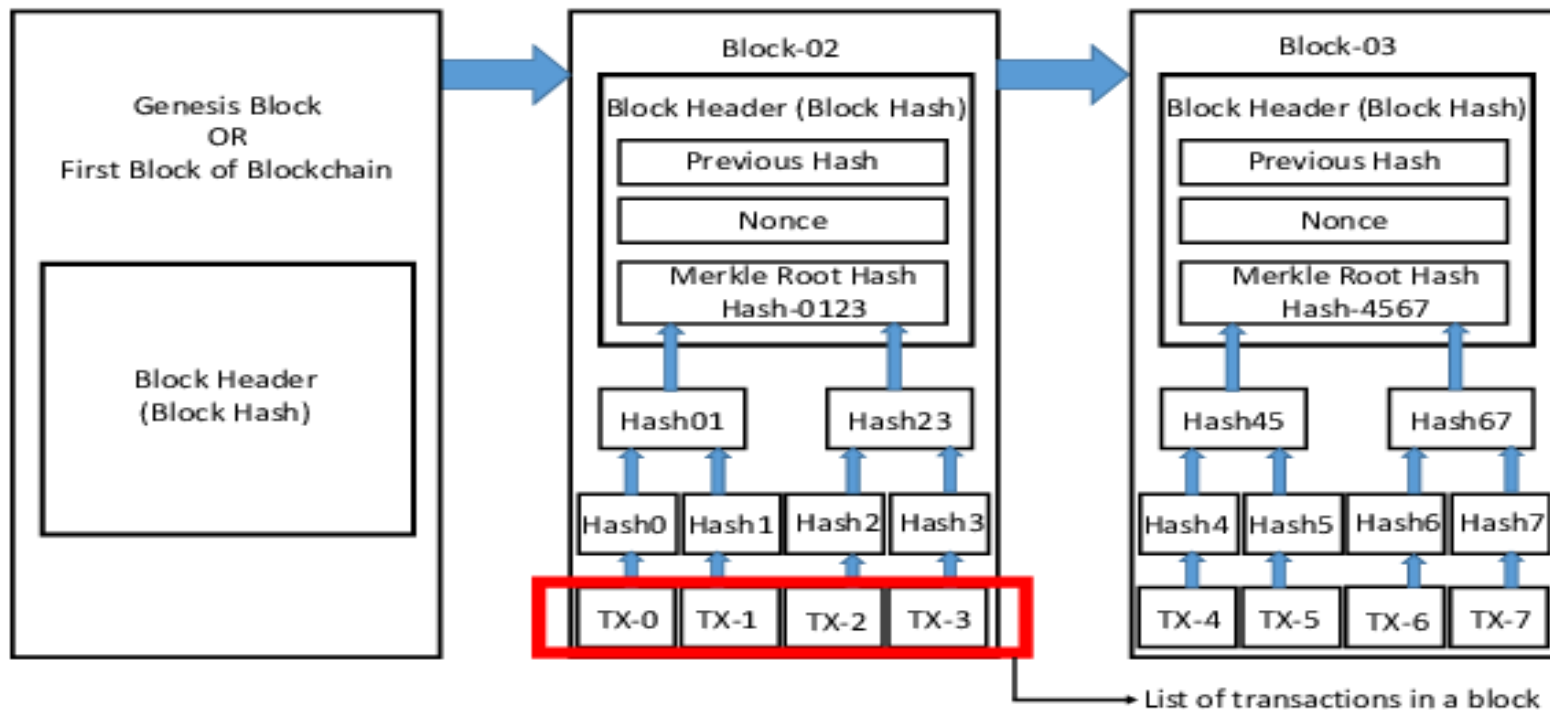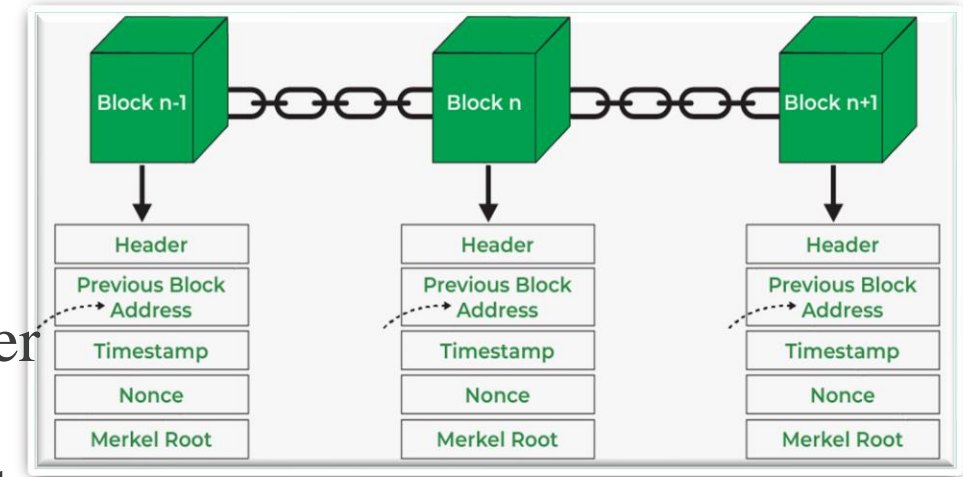
The **genesis block** is the first block in any blockchain-based protocol. It is the basis on which additional blocks are added to form a chain of blocks, hence the term blockchain.

- **Header:** The header data contains metadata of the block, i.e information about the block itself. The contents of the block header include-
  - ✓ Hash of the previous block header.
  - ✓ Hash of the current block.
  - ✓ Timestamp.
  - ✓ Cryptographic nonce.
  - ✓ Merkle root.
- **Merkel Root:** A hash tree, also known as a Merkle tree, is a tree in which each leaf node is labeled with the cryptographic hash of a data block, and each non-leaf node is labeled with the cryptographic hash of its child nodes' labels. The majority of hash tree implementations are binary (each node has two child nodes), but they can also have many more child nodes.

- **Previous Block Address/ Hash:** It is used to connect the $i+1^{th}$ block to the ith block using the hash. In short, it is a reference to the hash of the previous (parent) block in the chain.
- **Timestamp:** It is a system verify the data into the block and assigns a time or date of creation for digital documents. The timestamp is a string of characters that uniquely identifies the document or event and indicates when it was created.
- **Nonce:** A nonce refers to a number or value that can only be used once. Nonces are often used on authentication protocols and cryptographic hash functions. In the context of blockchain technology, a nonce refers to a pseudo-random number that is utilized as a counter during the process of mining.

Key Characteristics of Blockchain Architecture

- **Decentralization:** In centralized transaction systems, each transaction needs to be validated in the central trusted agency (e.g., the central bank), naturally resulting in cost and the performance jam at the central servers. In contrast to the centralized mode, a third party is not needed in the blockchain. Consensus algorithms in blockchain are used to maintain data stability in a decentralized network.

- **Persistency:** Transactions can be validated quickly, and invalid transactions would not be admitted by persons or miners who mining the crypto. It is not possible to delete or roll back transactions once they are included in the blockchain network. Invalid transactions do not carry forward further.

- **Anonymity:** Each user can interact with the blockchain with a generated address, which does not disclose the real identity of the miner. Note that blockchain cannot guarantee perfect privacy preservation due to the permanent thing.

To Be Continued

Key Characteristics of Blockchain Architecture
- **Auditability:** Blockchain stores data of users based on the Unspent Transaction Output (UTXO) model. Every transaction has to refer to some previous unspent transactions. Once the current transaction is recorded into the blockchain, the position of those referred unspent transactions switches from unspent to spent. Due to this process, the transactions can be easily tracked and not harmed between transactions.
- **Transparency:** The transparency of blockchain is like cryptocurrency, in bitcoin for tracking every transaction is done by the address. And for security, it hides the person's identity between and after the transaction. All the transactions are made by the owner of the block associated with the address, this process is transparent and there is no loss for anyone who is involved in this transaction.
- **Cryptography:** The blockchain concept is fully based on security and for that, all the blocks on the blockchain network want to be secure. And for security, it implements cryptography and secures the data using the cipher text and ciphers.

Categories of Blockchain Structure

All blockchain structures fall into three categories:

- Public blockchain architecture: A public blockchain architecture means that the data and access to the system is available to anyone who is willing to participate (e.g., Bitcoin, Ethereum, and Litecoin blockchain systems are public).
- Private blockchain architecture: As opposed to public blockchain architecture, the private system is controlled only by users from a specific organization or authorized users who have an invitation for participation.
- Consortium blockchain architecture: This blockchain structure can consist of a few organizations. In a consortium, procedures are set up and controlled by the preliminary assigned users.

Property	Public blockchain	Consortium blockchain	Private blockchain
Consensus determination	All miners	Selected set of nodes	Within one organization
Read permission	Public	Public or restricted	Public or restricted
Immutability level	Almost impossible to tamper	Could be tampered	Could be tampered
Efficiency (use of resources)	Low	High	High
Centralization	No	Partial	Yes
Consensus process	Permissionless	Needs permission	Needs permission

Cryptocurrencies

Cryptocurrencies are a digital form of money that run on a totally new monetary system, one that is not regulated by any centralized authority or tracked by a formal institution. There are many types of cryptocurrency with various functions. Regardless of each function, each digital currency is supported by a decentralized peer-to-peer network called the **blockchain**.

Types of Cryptocurrency: Bitcoin (1BTC = 17 Lakhs), Ethereum (1ETC = 1 Lakh), Tether, Litecoin (1LTC = Rs. 7000/-), Monero, Dogecoin, and Bitcoin Cash.

The maximum number of bitcoins that can be issued—mined—is 21 million.

Advantages of Cryptocurrency

CryptoCurrencies solve a lot of the problems which are connected to centralized nature of assets/currencies.

No Fraud

No Identity Theft

Immediate Settlement
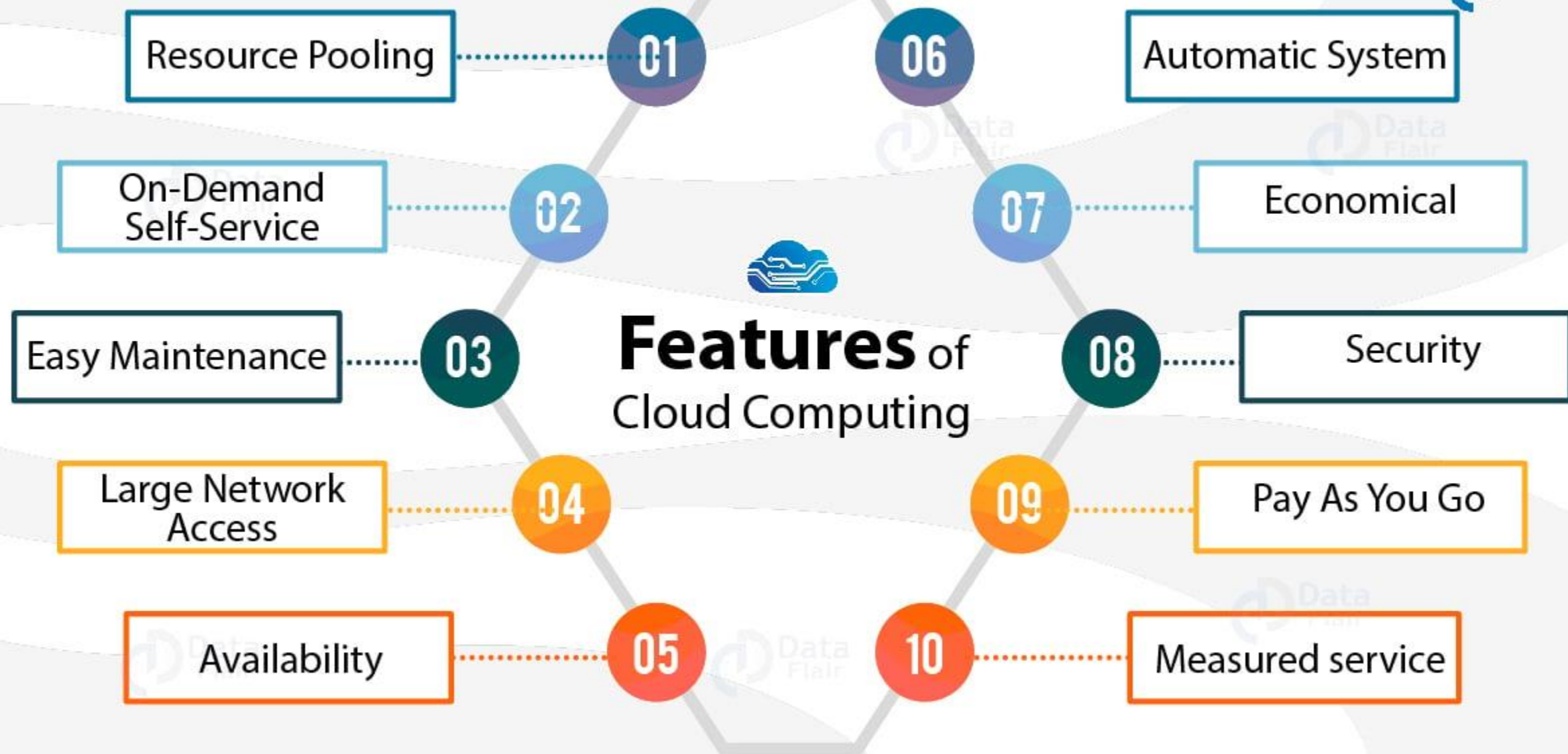
Access to Everyone

Lower Fees

Cloud Computing

What is Cloud Computing

The term cloud refers to a network or the internet. It is a technology that uses remote servers on the internet to store, manage, and access data online rather than local drives. The data can be anything such as files, images, documents, audio, video, and more. There are the following operations that we can do using cloud computing:

- Developing new applications and services
- Storage, back up, and recovery of data
- Hosting blogs and websites
- Delivery of software on demand
- Analysis of data
- Streaming videos and audios

Features of Cloud Computing

01 Resource Pooling

02 On-Demand Self-Service

03 Easy Maintenance

04 Large Network Access

05 Availability

06 Automatic System

07 Economical

08 Security

09 Pay As You Go

10 Measured service

DataFlair

1. Resources Pooling: It means that the **Cloud provider** pulled the computing resources to provide services to multiple customers with the help of a multi-tenant model. There are different physical and virtual resources assigned and reassigned which depends on the demand of the customer. The customer generally has no control or information over the location of the provided resources but is able to specify location at a higher level of abstraction

2. On-Demand Self-Service: It is one of the important and valuable features of Cloud Computing as the user can continuously monitor the server uptime, capabilities, and allotted network storage. With this feature, the user can also monitor the computing capabilities.

3. Easy Maintenance: The servers are easily maintained, and the downtime is very low and even in some cases, there is no downtime. Cloud Computing comes up with an update every time by gradually making it better. The updates are more compatible with the devices and perform faster than older ones along with the bugs which are fixed.

Features of Cloud Computing

4. Large Network Access: The user can access the data of the cloud or upload the data to the cloud from anywhere just with the help of a device and an internet connection. These capabilities are available all over the network and accessed with the help of internet.
5. Availability: The capabilities of the Cloud can be modified as per the use and can be extended a lot. It analyzes the storage usage and allows the user to buy extra **Cloud storage** if needed for a very small amount.
6. Automatic System: Cloud computing automatically analyzes the data needed and supports a metering capability at some level of services. We can monitor, control, and report the usage. It will provide transparency for the host as well as the customer.
7. Economical: It is the one-time investment as the company (host) has to buy the storage and a small part of it can be provided to the many companies which save the host from monthly or yearly costs. Only the amount which is spent is on the basic maintenance and a few more expenses which are very less.

Features of Cloud Computing

8. Security: **Cloud Security**, is one of the best features of cloud computing. It creates a snapshot of the data stored so that the data may not get lost even if one of the servers gets damaged. The data is stored within the storage devices, which cannot be hacked and utilized by any other person. The storage service is quick and reliable.

9. Pay as you go: In cloud computing, the user has to pay only for the service or the space they have utilized. There is no hidden or extra charge which is to be paid. The service is economical and most of the time some space is allotted for free.

10. Measured Service: Cloud Computing resources used to monitor, and the company uses it for recording. This resource utilization is analyzed by supporting charge-per-use capabilities. This means that the resource usages which can be either virtual server instances that are running in the cloud are getting monitored measured and reported by the service provider. The model pay as you go is variable based on actual consumption of the manufacturing organization.

Features of Cloud Computing

Applications of Cloud Computing

<u>Online Data Storage</u>: Cloud Computing allows storage and access to data like files, images, audio, and videos on the cloud storage. In this age of big data, storing huge volumes of business data locally requires more and more space and escalating costs. This is where cloud storage comes into play, where businesses can store and access data using multiple devices. Example: DropBox, iCloud, Google Drive, Microsoft One Drive, Idrive, MegaBox, pCloud, Tresorit, Amazon Drive

<u>Backup and Recovery</u>: Cloud service providers offer safe storage and backup facility for data and resources on the cloud. In a traditional computing system, data backup is a complex problem, and often, in case of a disaster, data can be permanently lost. But with cloud computing, data can be easily recovered with minimal damage in case of a disaster. Example: Google Cloud, Rackspace, Amazon AWS.

Big Data Analysis: One of the most important applications of cloud computing is its role in extensive data analysis. The extremely large volume of big data makes it impossible to store using traditional data management systems. Due to the unlimited storage capacity of the cloud, businesses can now store and analyze big data to gain valuable business insights. Example: Microsoft AZURE

Testing and Development: Cloud computing applications provide the easiest approach for testing and development of products. In traditional methods, such an environment would be time-consuming, expensive due to the setting up of IT resources and infrastructure and needed manpower. However, with cloud computing, businesses get scalable and flexible cloud services, which they can use for product development, testing, and deployment. Example: Otava Cloud Solutions

Antivirus Applications: With Cloud Computing comes cloud antivirus software which is stored in the cloud from where they monitor viruses and malware in the organization's system and fixes them. Earlier, organizations had to install antivirus software within their system and detect security threats. Example: Amazon AWS, SAP

Applications of Cloud Computing

E-commerce Application: Ecommerce applications in the cloud enable users and e-businesses to respond quickly to emerging opportunities. It offers a new approach to business leaders to make things done with minimum amount and minimal time. They use cloud environments to manage customer data, product data, and other operational systems. Example: Amazon Cloud

Cloud Computing in Education: E-learning, online distance learning programs, and student information portals are some of the key changes brought about by applications of cloud computing in the education sector. In this new learning environment, there's an attractive environment for learning, teaching, experimenting provided to students, teachers, and researchers so they can connect to the cloud of their establishment and access data and information. SlideRocket, Ratatype, Amazon Web Services, Google Classroom

Types of Cloud
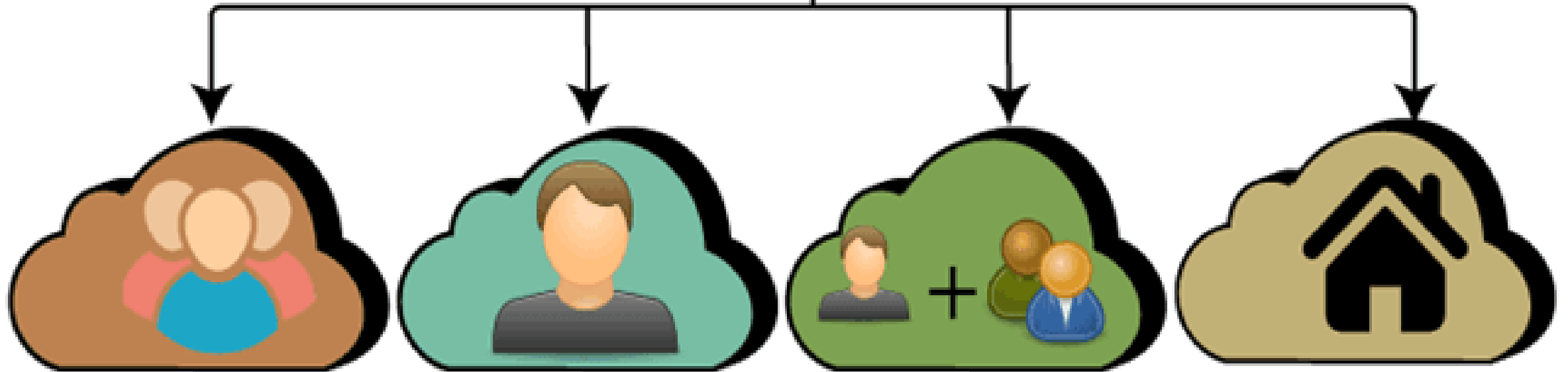
PUBLIC CLOUD

PRIVATE CLOUD

HYBRID CLOUD

COMMUNITY CLOUD

Public Cloud
- Public Cloud provides a shared platform that is accessible to the general public through an Internet connection.
- Public cloud operated on the pay-as-per-use model and administrated by the third party, i.e., Cloud service provider.
- In the Public cloud, the same storage is being used by multiple users at the same time.
- Public cloud is owned, managed, and operated by businesses, universities, government organizations, or a combination of them.
- Some of the largest public cloud providers include Alibaba Cloud, Amazon Web Services (AWS), Google Cloud, IBM Cloud, and Microsoft Azure.

Advantages of Public Cloud
- Public cloud is owned at a lower cost than the private and hybrid cloud.
- Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.
- Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.
- Public cloud is location independent because its services are delivered through the internet.
- Public cloud is highly scalable as per the requirement of computing resources.
- It is accessible by the general public, so there is no limit to the number of users.

Disadvantages of Public Cloud
- Public Cloud is less secure because resources are shared publicly.
- Performance depends upon the high-speed internet network link to the cloud provider.
- The Client has no control of data.

Private Cloud

- Private cloud is also known as an **internal cloud** or **corporate cloud**.
- Private cloud provides computing services to a **private internal network (within the organization)** and **selected users** instead of the general public.
- It is used by organizations to build and manage their own data centers internally or by the third party.
- All clouds become private clouds when the underlying IT infrastructure is dedicated to a single customer with completely isolated access.
- Example: HP Data Centers, Microsoft, Elastra-private cloud, and Ubuntu are the example of a private cloud.

Advantages of Private Cloud

- Private cloud provides a high level of security and privacy to the users.
- Private cloud offers better performance with improved speed and space capacity.
- It allows the IT team to quickly allocate and deliver on-demand IT resources.
- The organization has full control over the cloud because it is managed by the organization itself. So, there is no need for the organization to depends on anybody.
- It is suitable for organizations that require a separate cloud for their personal use and data security is the first priority.

Disadvantages of Private Cloud

- Skilled people are required to manage and operate cloud services.
- Private cloud is accessible within the organization, so the area of operations is limited.
- Private cloud is not suitable for organizations that have a high user base, and organizations that do not have the prebuilt infrastructure, sufficient manpower to maintain and manage the cloud.

Hybrid Cloud
- Hybrid Cloud is a combination of the public cloud and the private cloud. we can say:

Hybrid Cloud = Public Cloud + Private Cloud

- Hybrid cloud is partially secure because the services which are running on the public cloud can be accessed by anyone, while the services which are running on a private cloud can be accessed only by the organization's users.
- **Example:** Google Application Suite (Gmail, Google Apps, and Google Drive), Office 365 (MS Office on the Web and One Drive), Amazon Web Services.

Advantages of Hybrid Cloud
- Hybrid cloud is suitable for organizations that require more security than the public cloud.
- Hybrid cloud helps you to deliver new products and services more quickly.
- Hybrid cloud provides an excellent way to reduce the risk.
- Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.

Disadvantages of Hybrid Cloud
- In Hybrid Cloud, security feature is not as good as the private cloud.
- Managing a hybrid cloud is complex because it is difficult to manage more than one type of deployment model.
- In the hybrid cloud, the reliability of the services depends on cloud service providers.

Community Cloud

Community cloud allows systems and services to be accessible by a group of several organizations to share the information between the organization and a specific community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.

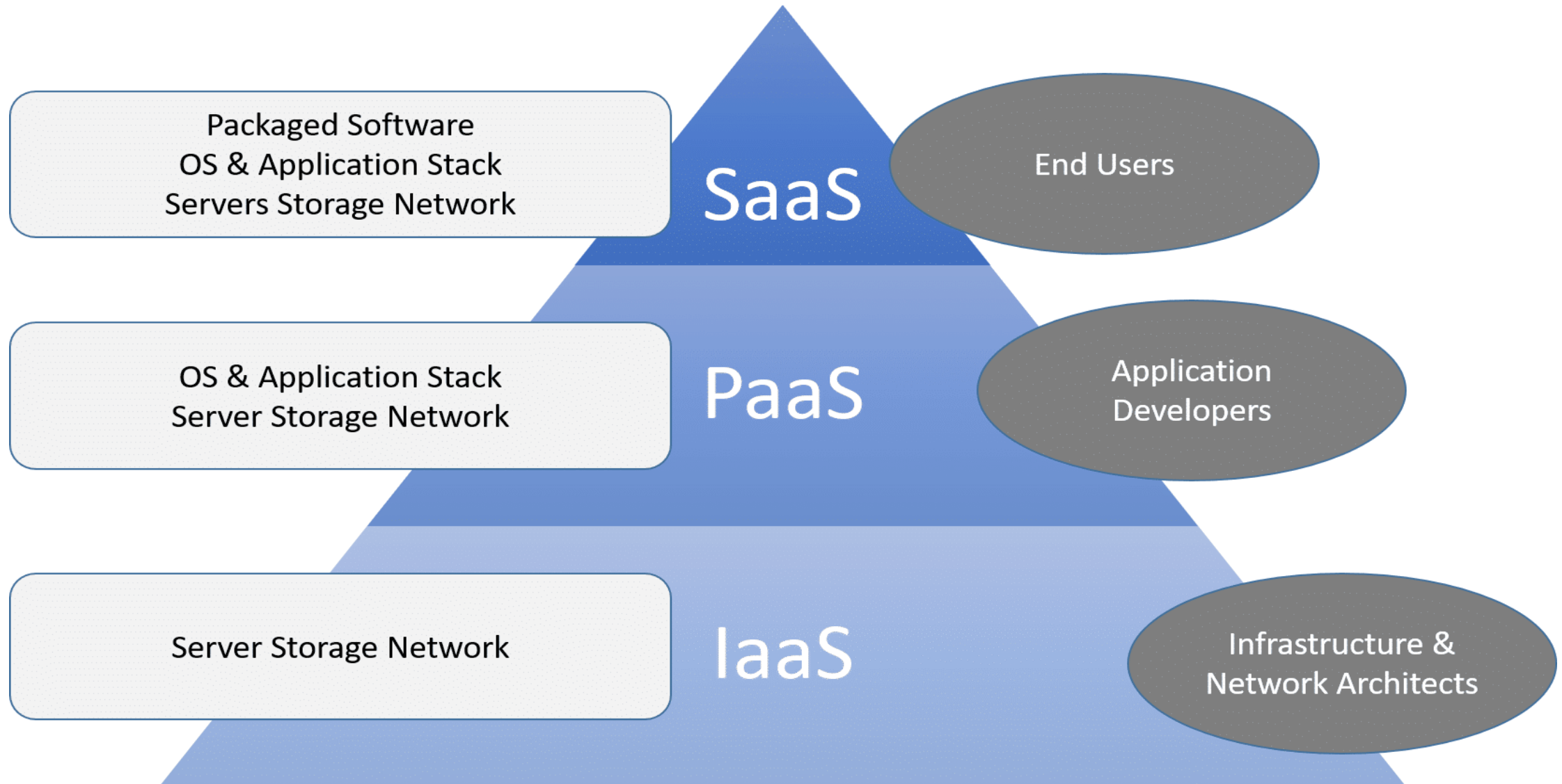**Example:** Health Care community cloud

Advantages of Community Cloud
- Community cloud is cost-effective because the whole cloud is being shared by several organizations or communities.
- Community cloud is suitable for organizations that want to have a collaborative cloud with more security features than the public cloud.
- It provides better security than the public cloud.
- It provides collaborative and distributive environment.
- Community cloud allows us to share cloud resources, infrastructure, and other capabilities among various organizations.

Disadvantages of Community Cloud
- Community cloud is not a good choice for every organization.
- Security features are not as good as the private cloud.
- It is not suitable if there is no collaboration.
- The fixed amount of data storage and bandwidth is shared among all community members.

Cloud Service Models

Packaged Software OS & Application Stack Servers Storage Network	SaaS	End Users
OS & Application Stack Server Storage Network	PaaS	Application Developers
Server Storage Network	IaaS	Infrastructure & Network Architects

Infrastructure as a Service (IaaS)

IaaS is also known as **Hardware as a Service (HaaS)**. It is a computing infrastructure managed over the internet. The main advantage of using IaaS is that it helps users to avoid the cost and complexity of purchasing and managing the physical servers.

IaaS provider provides the following services –

- Compute: Computing as a Service includes virtual central processing units and virtual main memory for the VMS that is provisioned to the end- users.
- Storage: IaaS provider provides back-end storage for storing files.
- Network: Network as a Service (NaaS) provides networking components such as routers, switches, and bridges for the VMS.
- Load balancers: It provides load balancing capability at the infrastructure layer.

Example: DigitalOcean, Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Rackspace, and Cisco Metacloud.

Platform as a Service (PaaS)

PaaS cloud computing platform is created for the programmer to develop, test, run, and manage the applications.

Characteristics of PaaS

- Accessible to various users via the same development application.
- Integrates with web services and databases.
- Builds on virtualization technology, so resources can easily be scaled up or down as per the organization's need.
- Support multiple languages and frameworks.
- Provides an ability to "**Auto-scale**".

Example: AWS Elastic Beanstalk, Windows Azure, Heroku, Force.com, Google App Engine, Apache Stratos, Magento Commerce Cloud, and OpenShift.
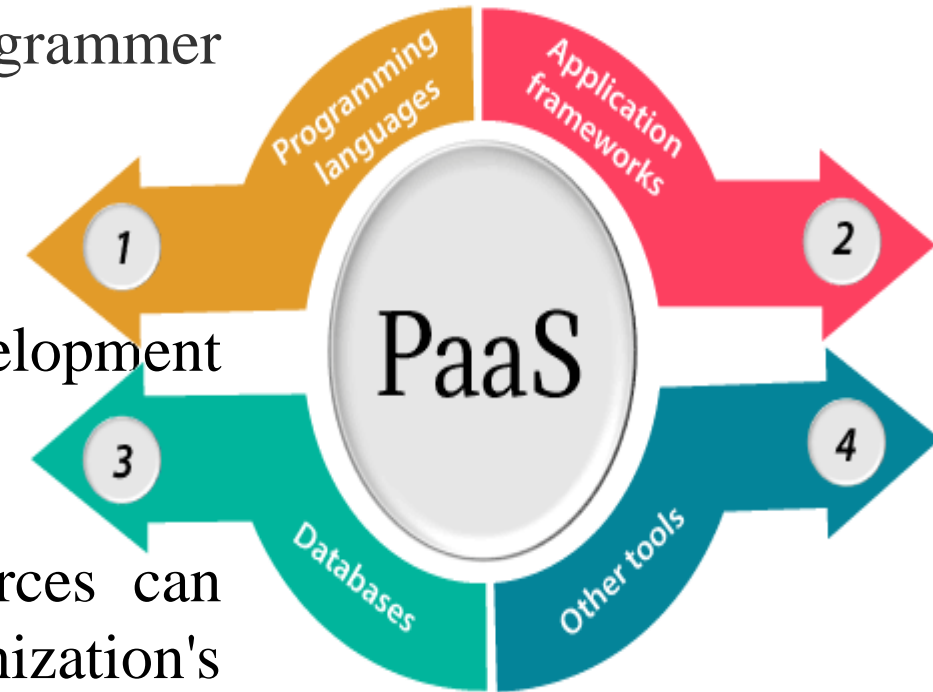
Software as a Service (SaaS)

SaaS is also known as **"on-demand software"**. It is a software in which the applications are hosted by a cloud service provider. Users can access these applications with the help of internet connection and web browser.

Characteristics of SaaS

There are the following characteristics of SaaS -

- Managed from a central location
- Hosted on a remote server
- Accessible over the internet
- Users are not responsible for hardware and software updates. Updates are applied automatically.
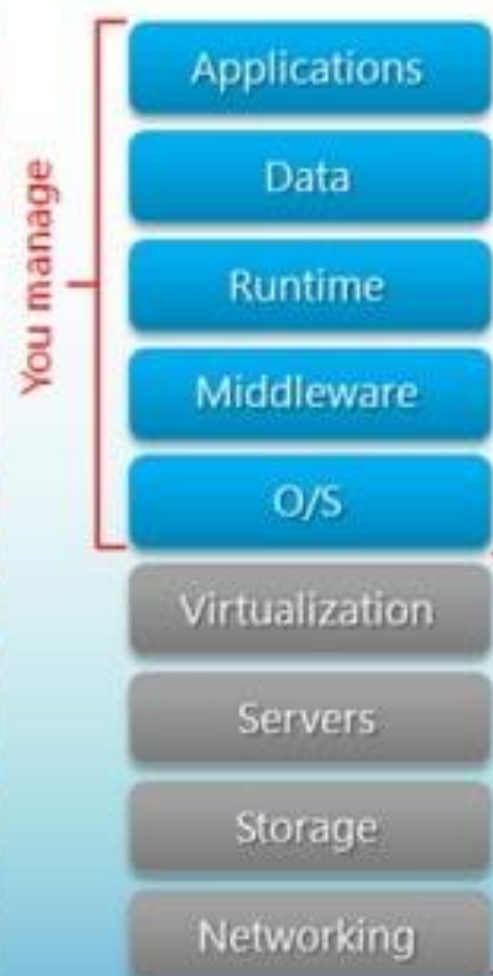- The services are purchased on the pay-as-per-use basis

Example: BigCommerce, Google Apps, Salesforce, Dropbox, ZenDesk, Cisco WebEx, ZenDesk, Slack, and GoToMeeting.
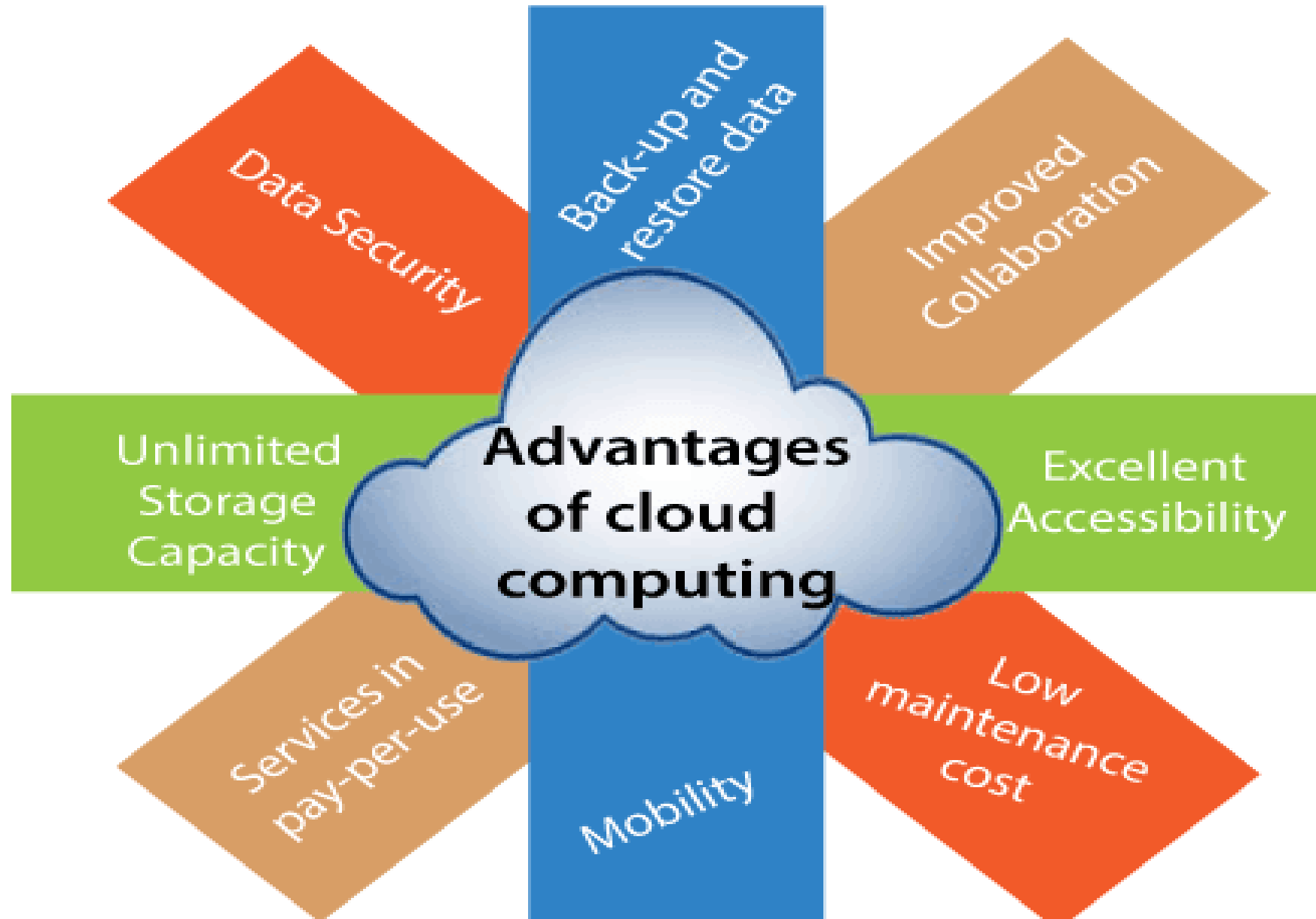
On-Premises	Infrastructure (as a Service)	Platform (as a Service)	Software (as a Service)
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware
O/S	O/S	O/S	O/S
Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking

You manage — On-Premises (all layers)

You manage — Infrastructure (Applications, Data, Runtime, Middleware, O/S)
Other Manages — Infrastructure (Virtualization, Servers, Storage, Networking)

You manage — Platform (Applications, Data)
Other Manages — Platform (Runtime, Middleware, O/S, Virtualization, Servers, Storage, Networking)

Other Manages — Software (all layers)

Advantages of cloud computing

- Data Security
- Back-up and restore data
- Improved Collaboration
- Unlimited Storage Capacity
- Excellent Accessibility
- Services in pay-per-use
- Mobility
- Low maintenance cost

Disadvantages of Cloud Computing

- Internet Connectivity: In cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.

- Vendor lock-in: Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

- Limited Control: Cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

- Security: Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

Amazon Web Services (AWS)

- AWS is a secure cloud services platform, offering compute power, database storage, content delivery and other functionality to help businesses scale and grow.

- The AWS service is provided by the Amazon that uses distributed IT infrastructure to provide different IT resources available on demand. It provides different services such as infrastructure as a service (IaaS), platform as a service (PaaS) and packaged software as a service (SaaS).

- Amazon launched AWS, a cloud computing platform to allow the different organizations to take advantage of reliable IT infrastructure.

- Based on the concept of Pay-As-You-Go, AWS provides the services to the customers.

- AWS provides services to customers when required without any prior commitment or upfront investment. Pay-As-You-Go enables the customers to procure services from AWS.

Google Cloud Platform (GCP)

- GCP, offered by Google, is a suite of cloud computing services that runs on the same infrastructure that Google uses internally for its end-user products, such as Google Search, Gmail, file storage, and YouTube.

- Google Cloud Compute Services, Google Cloud Storage Services, Networking, Big Data Services, Security and Identity Management, Management Tools, Cloud AI, IoT

- Google Cloud Platform provides infrastructure as a service, platform as a service, and serverless computing environments.

- GCP allows you to choose between computing, storage, big data, machine learning, and application services for your web, mobile, analytics, and back-end solutions.

- One of the simplest free layers within the industry. $300 free credit to start with any GCP product during the primary year. Afterward, 5 GB of Storage to use forever without any charges.

Microsoft Cloud

- Microsoft Azure, commonly referred to as Azure, is a cloud computing service created by Microsoft for building, testing, deploying, and managing applications and services through Microsoft-managed data centers.

- Azure is configured to develop open-source software, mobile platforms, multiple operating systems and programming languages, devices, databases, and frameworks.

- Azure's on-premises and hybrid cloud models provide maximum security and ease of management for application development.

- Its built-in AI enables development of data-driven, intelligent apps creating new user experiences based on real-time analytics.

IBM Cloud

- IBM Cloud is a set of cloud computing services for business offered by the information technology company IBM.

- IBM Cloud is a suite of cloud computing services from IBM that offers both **platform as a service (PaaS) and infrastructure as a service (IaaS).**

- With IBM Cloud IaaS, organizations can deploy and access virtualized IT resources -- such as compute power, storage and networking -- over the internet.

- With IBM Cloud PaaS -- which is based on the open-source cloud platform.

- IBM Cloud supports various programming languages, such as Java, Node.js, PHP and Python and extends to support other languages.

Features	Amazon Web Services (AWS)	Microsoft	Google	IBM
Serverless Compute Offerings	Lambda	Azure Functions	Google Cloud Functions	IBM Cloud Functions
Maximum Functions	Unlimited	Unlimited	1,000 per project	Unlimited
Scalability & Availability	Transparent – Automatic Scaling	Automatic Scaling	Automatic	Automatic
Languages Supported	Node.js, Python, Java, C#, Go, Ruby	C#, JavaScript, F#, Python, TypeScript	Node.js, Python, Go	Node.js, Go, Swift, PHP, Java, .NET, Python, Ruby
Concurrent Executions	1,000 concurrent executions per account per region	10 concurrent executions per function	400 per function	1,000 per project
Deployments	.ZIP to S3 or Lambda	GitHub, Visual Studio, Local git, Dropbox, Bitbucket	Google Cloud Source, .ZIP to cloud storage	GitHub, Bluemix DevOps
Concurrent Executions	1,000 concurrent executions per account per region	10 concurrent executions per function	400 per function	1,000 per project
Max Code Size	50MB compressed 250MB uncompressed	None, user pays the storage cost	100MB compressed 500MB uncompressed	48MB