UNIT-6 EMERGING TECHNOLOGIES WITH CLOUD COMPUTING

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Learning Outcomes

- Serverless Computing
- Edge and Fog Computing
- AI and Machine Learning with Cloud Computing
- Distributed Ledger Technology (DLT) with Cloud Computing
- 5G and Cloud-Native Networking
- Kubernetes and Containers

Serverless Computing

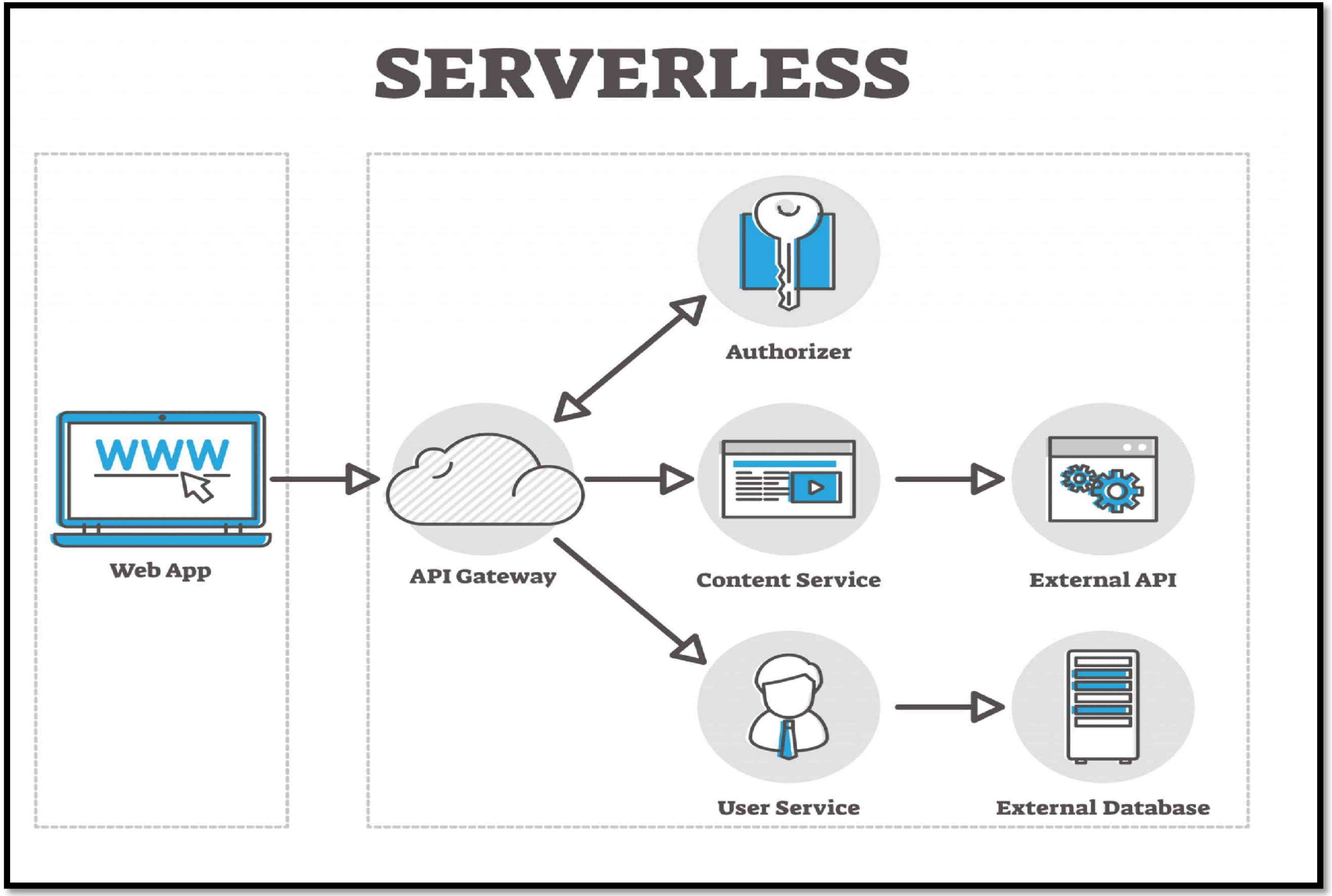
Serverless Computing:-

- *Serverless is an application delivery model where cloud providers automatically intercept user requests and computing events to dynamically allocate and scale compute resources, allowing you to run applications without having to provision, configure, manage, or maintain server infrastructure.*
- *Serverless computing is a cloud computing execution model that lets software developers build and run applications and servers without having to provision or manage the back-end infrastructure.*
- With Serverless, the cloud vendor takes care of all routine infrastructure management and maintenance, including updating the operating system (OS), applying patches, managing security, system monitoring and planning capacity.

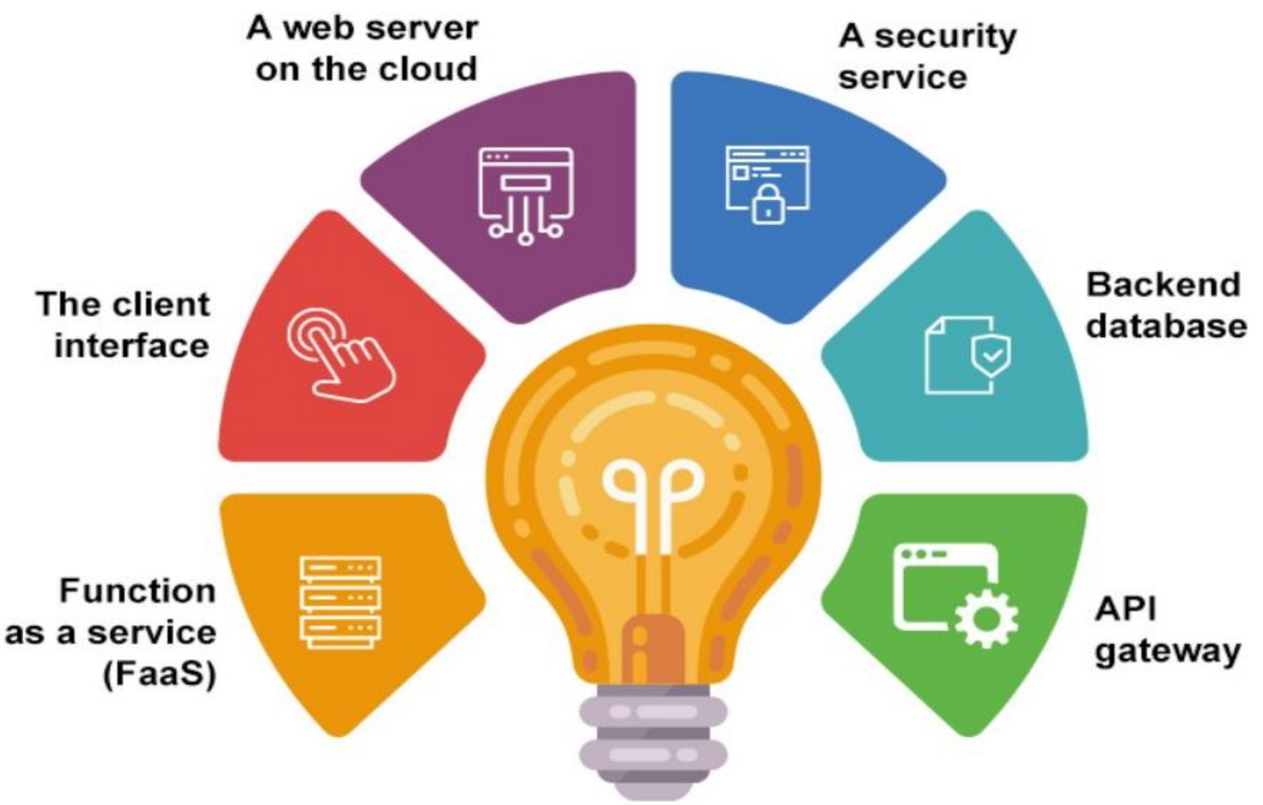
Serverless Computing

- With Serverless computing, developers purchase back-end services from cloud services vendors on a pay-as-you-go basis, which means they pay only for the services used.
- The main goal of Serverless computing is to make it simpler for developers to write code designed to run on cloud platforms and to perform a specific role.
- *Serverless computing, also known as Function as a Service (FaaS),* is a cloud computing execution model where the cloud provider dynamically manages the allocation and provisioning of servers.
- *Serverless allows applications to be hostless (apps aren't hosted on a server), stateless (interactions and data aren't stored), elastic (resources are scaled up and down without limits), distributed (multiple services are linked for seamless functioning), and event-driven (resources are allocated only when triggered by an event).*

Serverless Computing



Serverless Computing



Key Components of Serverless Architecture

Serverless Computing

Working of Serverless Computing:-

- The developer builds an application that includes a function that will determine how the application responds to a particular user action. Typically, cloud providers offer pre-packaged FaaS products to simplify coding for developers and bring in pre-built backend elements.
- An event is defined that specifies how and when the function will be triggered. For example, when the user initiates an HTTP request, the application may want to fetch and deliver certain data. This “if-then” process is called an event.
- Once the application is deployed and accessible to the user, the event is triggered through a user action.
- The application relays the event to the cloud provider, and the provider dynamically allocates the resources necessary to respond to the action as per the predefined function.
- The user receives the data or any other result as defined by the function.

Serverless Computing

Advantages of Serverless Computing:-

- *Cost-effectiveness:-* Users and developers pay only for the time when code runs on a Serverless compute platform. They don't pay for idle virtual machines (VMs).
- *Easy deployment:-* Developers can deploy apps in hours or days rather than weeks or months.
- *Auto scaling:-* Cloud providers handle scaling up or spinning down resources or instances when the code isn't running.
- *Increased developer productivity:-* Developers can spend most of their time writing and developing apps instead of dealing with servers and runtimes.

Serverless Computing

Disadvantages of Serverless Computing:-

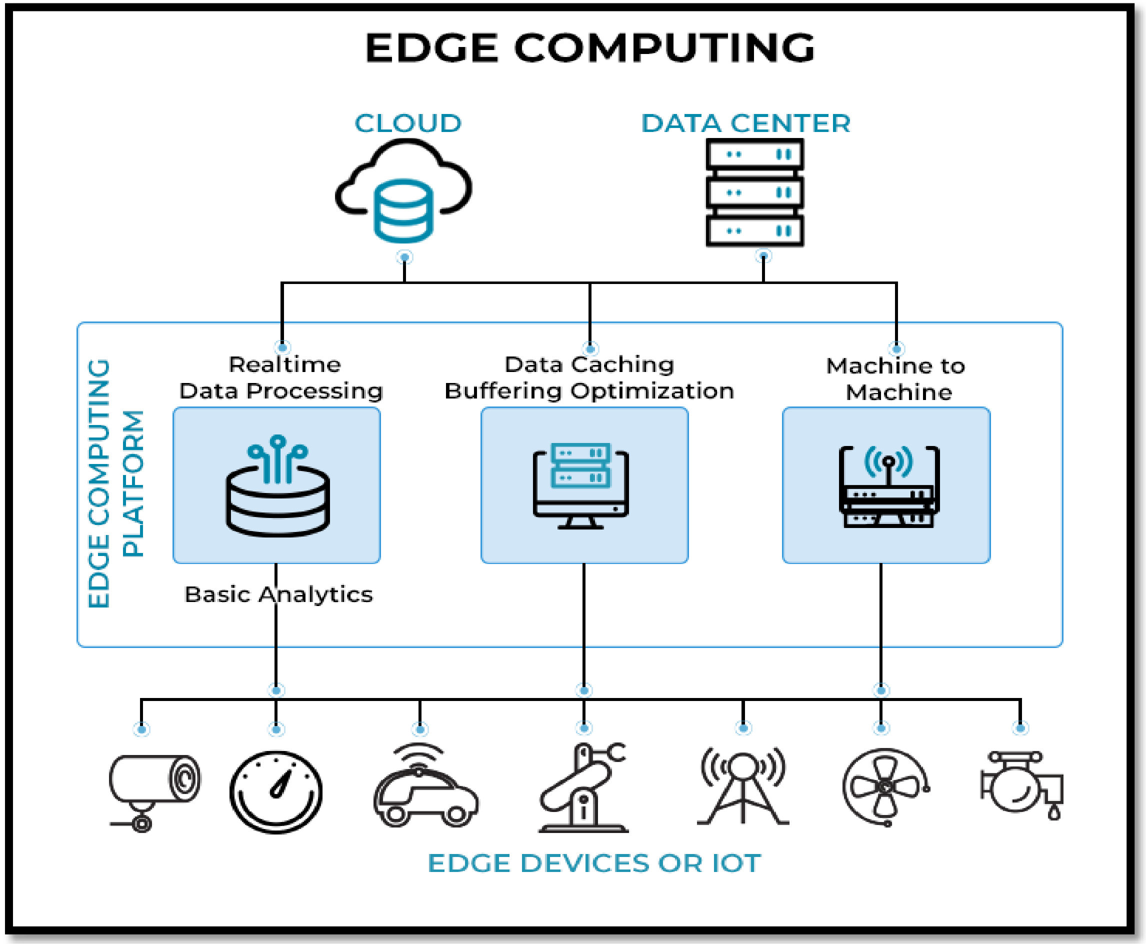
- *Vendor lock-in:-* Switching cloud providers might be difficult because the way Serverless services are delivered can vary from one vendor to another.
- *Inefficient for long-running apps:-* Sometimes using long-running tasks can cost much more than running a workload on a VM or dedicated server.
- *Latency:-* There's a delay in the time it takes for a scalable serverless platform to handle a function for the first time, often known as a cold start.
- *Debugging is more difficult:-* Because a Serverless instance creates a new version of itself each time it spins up, it's hard to amass the data needed to debug and fix a Serverless function.

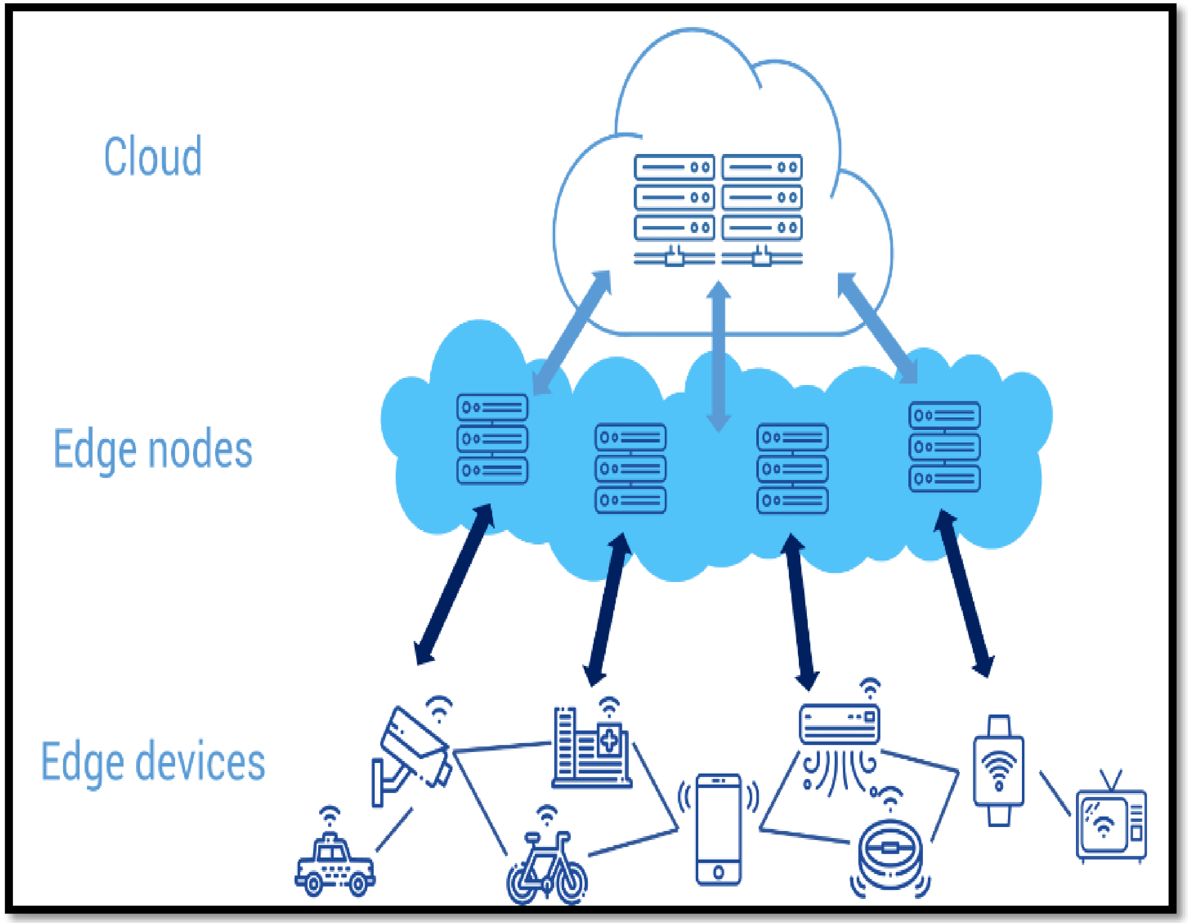
Edge and Fog Computing

- *Edge computing is a distributed computing paradigm that brings computation and data storage closer to the sources of data, rather than relying entirely on a central location like a cloud or data center.*
- The idea behind edge computing is to process and analyze data near the edge of the network, where the data is being generated or collected.
- *Edge computing is the process of bringing information storage and computing abilities closer to the devices that produce that information and the users who consume it.*
- Traditionally, applications have transmitted data from smart devices like sensors and smartphones to a central data center for processing.
- However, the unprecedented complexity and scale of data have outpaced network capabilities. By shifting processing capabilities closer to users and devices, edge computing systems significantly improve application performance, reduce bandwidth requirements, and give faster real-time insights.

Edge and Fog Computing

- Edge computing is becoming more popular because it allows enterprises to collect and analyze their raw data more efficiently.





Edge and Fog Computing

Working of edge computing:-

- *Edge Devices:* These are the physical devices or sensors that generate data at the edge of the network. Examples include IoT sensors, cameras, industrial machines, smartphones, and embedded systems.
- *Edge Gateways or Edge Nodes:* These are small, localized computing devices or servers that are placed near the edge devices. They have processing power, storage, and networking capabilities. Edge gateways collect, process, and filter data from the edge devices before sending it to the cloud or a data center.
- *Data Processing at the Edge:* The edge gateways perform various data processing tasks locally, such as filtering, aggregating, and analyzing the data generated by the edge devices. This includes tasks like data cleansing, format conversion, and running machine learning models or analytics algorithms.

Edge and Fog Computing

Some common use cases for edge computing include:

- IoT applications, such as smart cities, connected vehicles, and industrial automation
- Real-time data processing and analysis, such as video analytics or predictive maintenance
- Content delivery networks (CDNs) for streaming media and web content
- Mobile data processing for apps and augmented reality (AR) applications

Edge and Fog Computing

Advantages of edge computing:

- Reduced latency/increased speed:-
- In many industries, technology demands almost instant transfer of data.
- Improved data security
- With edge computing, the majority of data is processed and stored locally. Any information that needs to be sent back to the data center can be encrypted before transmission.
- Increased productivity
- Enterprises improve operational and employee productivity by responding more quickly to information. By analyzing data collected at the source, organizations can improve areas of their facilities, infrastructure, or equipment that are underperforming.

Edge and Fog Computing

Advantages of edge computing:

- Remote data collection:-
- It is challenging to collect data from places with unreliable connectivity and bandwidth.
- Reduced costs:-
- Sending large quantities of data from its origin to centralized data centers is expensive because it requires more bandwidth. The edge computing model allows you to decrease the amount of data being sent from sites to data centers because end users only send critical data.

Edge and Fog Computing

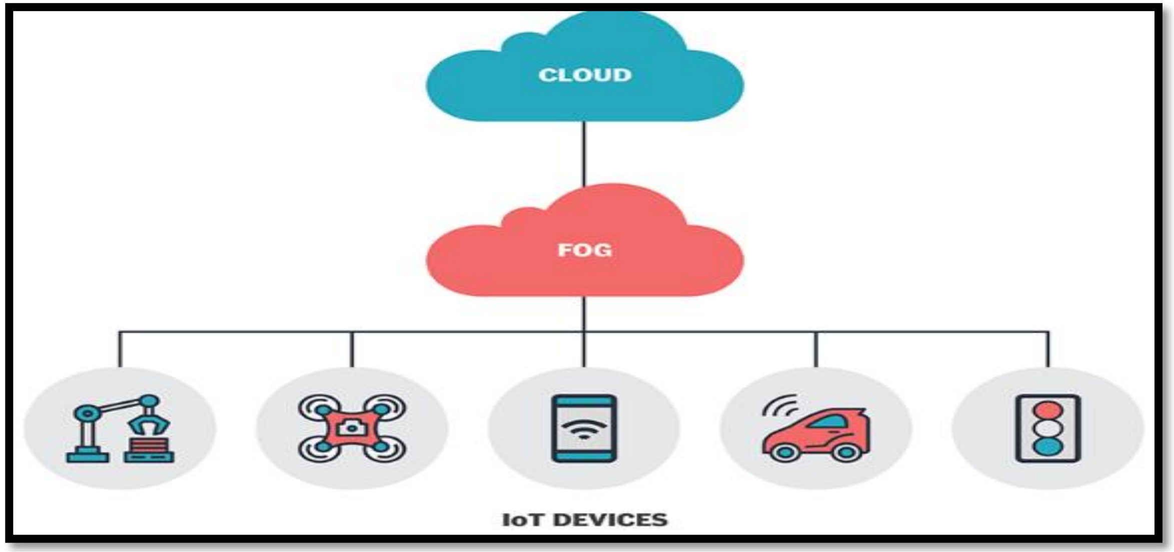
Fog computing:

- Fog computing is a decentralized computing infrastructure in which data, compute, storage and applications are located somewhere between the data source(e.g., IoT devices or edge devices) and the cloud.
- It extends the capabilities of cloud computing by bringing the computing resources closer to the edge devices or data sources.
- Like edge computing, fog computing brings the advantages and power of the cloud closer to where data is created and acted upon.
- Many people use the terms fog computing and edge computing interchangeably because both involve bringing intelligence and processing closer to where the data is created.
- This is often done to improve efficiency, though it might also be done for security and compliance reasons.

Edge and Fog Computing

Fog computing:

- The fog metaphor comes from the meteorological term for a cloud close to the ground, just as fog concentrates on the edge of the network.
- The term is often associated with Cisco; the company's product line manager, Ginny Nichols, is believed to have coined the term.
- Cisco Fog Computing is a registered name; fog computing is open to the community at large.



Edge and Fog Computing

Working of Fog computing:

- ❑Fog networking complements -- doesn't replace -- cloud computing; fogging enables short-term analytics at the edge, while the cloud performs resource-intensive, longer-term analytics.
- ❑Although edge devices and sensors are where data is generated and collected, they sometimes don't have the compute and storage resources to perform advanced analytics and machine learning tasks.
- ❑Though cloud servers have the power to do this, they are often too far away to process the data and respond in a timely manner.
- ❑In addition, having all endpoints connecting to and sending raw data to the cloud over the internet can have privacy, security and legal implications, especially when dealing with sensitive data subject to regulations in different countries.

Edge and Fog Computing

Advantages of Fog computing:

- Bandwidth conservation:- Fog computing reduces the volume of data that is sent to the cloud, thereby reducing bandwidth consumption and related costs.
- Improved response time:- Because the initial data processing occurs near the data, latency is reduced, and overall responsiveness is improved. The goal is to provide millisecond-level responsiveness, enabling data to be processed in near-real time.
- Network-agnostic:- Although fog computing generally places compute resources at the LAN level -- as opposed to the device level, which is the case with edge computing -- the network could be considered part of the fog computing architecture.

Edge and Fog Computing

Disadvantages of Fog computing:

- Physical location:- Because fog computing is tied to a physical location, it undermines some of the "anytime/anywhere" benefits associated with cloud computing.
- Potential security issues:- Under the right circumstances, fog computing can be subject to security issues, such as Internet Protocol (IP) address spoofing or man in the middle (MitM) attacks.
- Startup costs:- Fog computing is a solution that utilizes both edge and cloud resources, which means that there are associated hardware costs.
- Ambiguous concept:- Even though fog computing has been around for several years, there is still some ambiguity around the definition of fog computing with various vendors defining fog computing differently.

Edge and Fog Computing

Aspect	Edge Computing	Fog Computing
Location	At the very edge of the network, close to the data sources (e.g., sensors, devices)	Between the edge and the cloud, forming an intermediate layer
Computing Resources	Limited computing power, typically embedded systems or single-board computers	More powerful computing resources compared to edge devices, but less than cloud
Data Processing	Data processing and analysis happen at the edge device itself	Data can be processed at the fog nodes and also sent to the cloud for further processing
Latency	Extremely low latency due to on-device processing	Low latency, but higher than edge computing
Use Cases	Real-time applications, privacy-sensitive data processing, remote monitoring, predictive maintenance	IoT applications, smart cities, industrial automation, content delivery networks (CDNs)
Scalability	Limited scalability due to constraints of individual edge devices	More scalable than edge computing due to distributed fog nodes
Example Devices	Smartphones, sensors, industrial controllers, smart home devices	Gateways, routers, servers, micro data centers

AI and Machine Learning with Cloud Computing

- At the core of AI systems are machine learning (ML) models that are trained on vast amounts of data to perform tasks such as image recognition, natural language processing, predictive analytics, and decision-making.
- These AI models require significant computational resources, storage capacity, and specialized hardware accelerators like GPUs and TPUs to train and deploy effectively.
- Machine Learning (ML) and cloud computing have formed a powerful synergy, enabling organizations to unlock the full potential of data-driven insights and intelligent systems.
- Cloud computing provides the necessary infrastructure, scalability, and services to support the demanding requirements of machine learning workloads.
- Cloud computing plays a crucial role in enabling AI by providing the necessary infrastructure and services to support the demanding requirements of AI workloads.

AI and Machine Learning with Cloud Computing

How AI and ML working With Cloud Computing:-

- Scalable Computing Power:
- AI models, especially deep learning models, are computationally intensive and require massive parallel processing power.
- Cloud providers offer access to virtually unlimited computing resources, including high-performance CPUs, GPUs, and specialized accelerators like Google's TPUs and Amazon's Inferentia chips.
- This computing power can be dynamically scaled up or down based on the demands of the AI workload, ensuring efficient resource utilization and cost optimization.

AI and Machine Learning with Cloud Computing

How AI and ML working With Cloud Computing:-

- Elastic Storage and Data Management:
- AI systems rely on large datasets for training and inference, often involving structured, unstructured, and streaming data from various sources.
- Cloud storage services, such as Amazon S3, Google Cloud Storage, and Azure Blob Storage, provide scalable, durable, and highly available storage for these massive datasets.
- Cloud data management services like Amazon Athena, Google BigQuery, and Azure Data Lake Analytics enable efficient querying, processing, and analysis of large datasets, facilitating data preparation for AI workloads.

AI and Machine Learning with Cloud Computing

How AI and ML working With Cloud Computing:-

- Distributed Training and Inference:
- Training large AI models can take weeks or even months on a single machine.
- Cloud platforms enable distributed training, where the training workload is parallelized across multiple machines or accelerators, significantly reducing training time.
- Similarly, inference (making predictions with a trained model) can be distributed across multiple nodes or regions, ensuring low latency and high availability for AI applications.

AI and Machine Learning with Cloud Computing

How AI and ML working With Cloud Computing:-

- Managed AI/ML Services:
- Cloud providers offer fully managed AI/ML services that simplify the entire machine learning lifecycle, from data preparation to model deployment and monitoring.
- Examples include Amazon SageMaker, Google Cloud AI Platform, Azure Machine Learning, and IBM Watson Studio.
- These services abstract away the complexities of setting up and managing the underlying infrastructure, allowing developers to focus on building and fine-tuning their AI models.

AI and Machine Learning with Cloud Computing

How AI and ML working With Cloud Computing:-

- Cost Optimization and Pay-as-you-go:
- Building and maintaining on-premises infrastructure for AI can be costly and inflexible.
- Cloud computing offers a pay-as-you-go model, allowing organizations to scale resources up or down based on their needs, reducing capital expenditures and operational costs.
- Cloud providers also offer cost optimization tools and reserved instance pricing models to further reduce costs for AI workloads.

AI and Machine Learning with Cloud Computing

The Applications of AI in Cloud Computing:-

- IoT – Cloud architectures and services that power the internet of things can store and process data generated by AI platforms on IoT devices.
- Chatbots – Chatbots are ubiquitous AI-based software that use natural language processing to carry out conversations with users – a boon for customer service in the age of instant gratification.
- Business Intelligence – BI is another mainstream application where AI cloud computing can gather data on the market, target audience, and competitors of customers.
- AI as a Service (AIaaS) – Public cloud vendors now offer AI outsourcing services, allowing companies to test out software and ML algorithms without risking their primary infrastructure.

AI and Machine Learning with Cloud Computing

The Applications of ML in Cloud Computing:-

- Cognitive cloud computing – Cognitive computing is the use of AI models to replicate and simulate human thought processes in complex situations.
- IBM and Google have built cognitive cloud platforms that provide cognitive insights-as-a-service to enterprises and facilitate the application of this technology in finance, retail, healthcare, and other industries.
- Internet of Things (IoT):-Internet of Things (IoT) is a stage that offers cloud offices, including information stockpiling and handling through Web. As of late, cloud-based ML models are getting famous.
- Personal Assistant: Because it provides support to customers like a human being, a personal virtual assistant becomes a requirement for growing an organization's business. These days, all ventures like banking, medical services, training, foundation, and so forth., are using catboats-also known as personal virtual assistants-in their businesses to complete a variety of tasks.

Distributed Ledger Technology (DLT) with Cloud Computing

- Distributed Ledger Technology (DLT) is centered around an encoded and distributed database where records regarding transactions are stored.
- A distributed ledger is a database that is spread across various computers, nodes, institutions, or countries accessible by multiple people around the globe.
- Distributed ledgers use independent nodes to record, share, and synchronize transactions in their respective electronic ledgers instead of keeping them in one centralized server.
- A block chain uses several technologies like digital signatures, distributed networks, and encryption/ decryption methods including distributed ledger technology to enable blockchain applications.

Distributed Ledger Technology (DLT) with Cloud Computing

Features of DLT:-

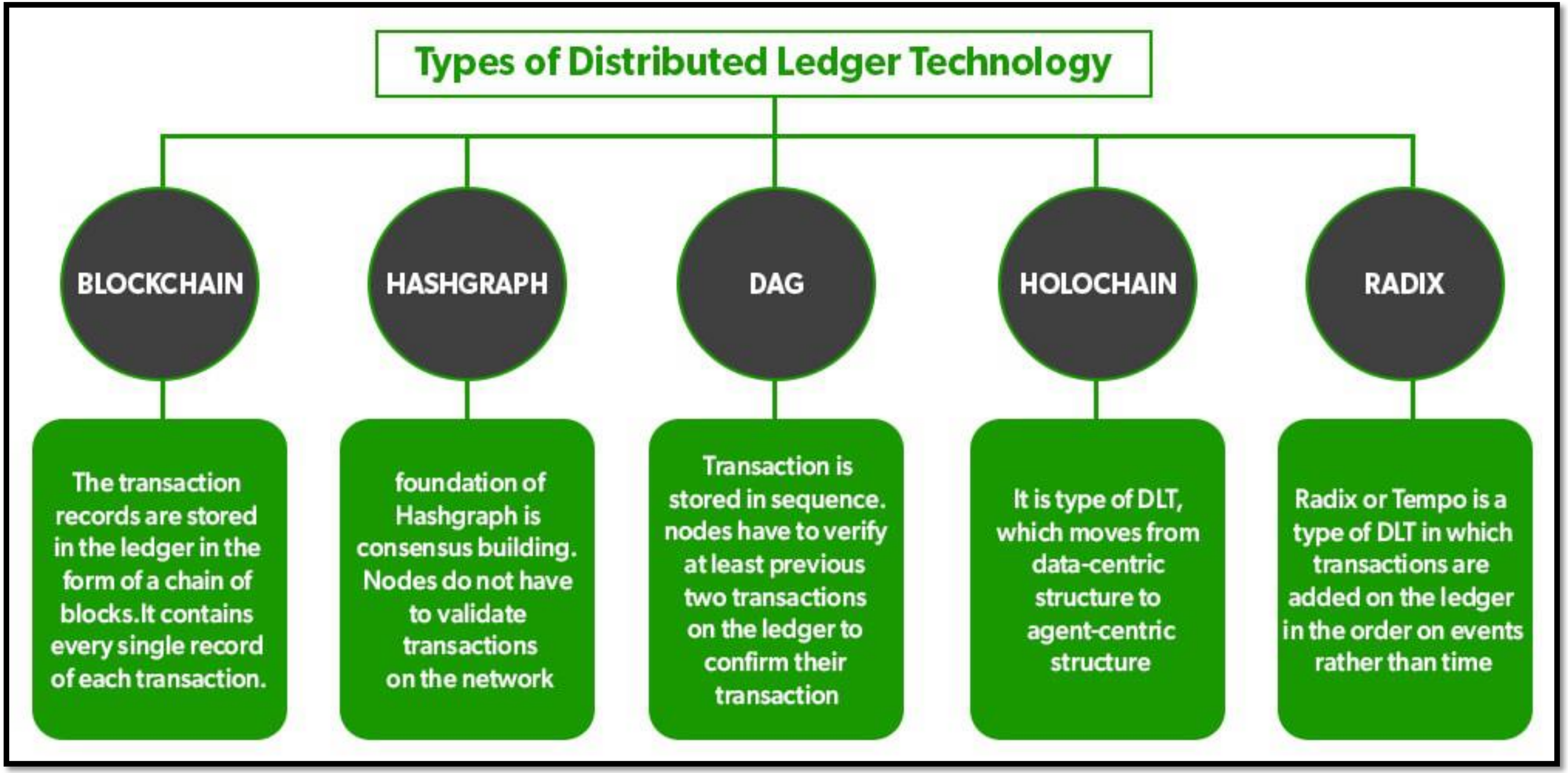
- Decentralized: It is a decentralized technology and every node will maintain the ledger, and if any data changes happen, the ledger will get updated. The process of updating takes place independently at each node.
- Immutable: Distributed ledger uses cryptography to create a secure database in which data once stored cannot be altered or changed.
- Distributed: In this technology, there is no central server or authority managing the database, which makes the technology transparent.
- In this process, every node or contributor of the ledger will try to verify the transactions with the various consensus algorithms or voting. the voting or participation of all the nodes depends on the rules of that ledger.

Distributed Ledger Technology (DLT) with Cloud Computing

Features of DLT:-

- **Shared:** The distributed ledger is not associated with any single entity. It is shared among the nodes on the network where some nodes have a full copy of the ledger while some nodes have only the necessary information that is required to make them functional and efficient.
- **Transparency:** Distributed ledgers are transparent because every participant can see the transactions that occur on the ledger. This transparency helps in creating trust among the participants.
- **Efficiency:** The distributed nature of ledgers makes them highly efficient. Transactions can be processed and settled in a matter of seconds, making them much faster than traditional methods.
- **Security:** Distributed ledgers are highly secure because of their cryptographic nature. Every transaction is recorded with a cryptographic signature that ensures that it cannot be altered. This makes the technology highly secure and resistant to fraud.

Distributed Ledger Technology (DLT) with Cloud Computing



Distributed Ledger Technology (DLT) with Cloud Computing

Types of DLT:-

- Block chain: In this type of DLT, transactions are stored in the form chain of blocks and each block produces a unique hash that can be used as proof of valid transactions. Each node has a copy of the ledger which makes it more transparent.

- Directed Acyclic Graphs (DAG):In this type of DLT, validation of transactions mostly requires the majority of support from the nodes in the network. Every node on the network has to provide proof of transactions on the ledger and then can initiate transactions.

- In this nodes have to verify at least two of the previous transactions on the ledger to confirm their transaction.

Distributed Ledger Technology (DLT) with Cloud Computing

Types of DLT:-

- Hash graph: In this type of DLT, records are stored in the form of a directed acyclic graph. It uses a different consensus mechanism, using virtual voting as the form consensus mechanism for gaining network consensus. Hence nodes do not have to validate each transaction on the network.
- Holochain: Holochain is termed as the next level of blockchain by some people because it is much more decentralized than blockchain.
- It is a type of DLT that simply proposes that each node will run on a chain of its own. Therefore nodes or miners have the freedom to operate autonomously.
- Tempo or Radix: Tempo uses the method of making a partition of the ledger this is termed sharding and then all the events that happened in the network are ordered properly. Basically, transactions are added to the ledger on basis of the order of events than the timestamp.

Distributed Ledger Technology (DLT) with Cloud Computing

Uses of DLT:-

- Banking: In the banking sector right now transfer of money can be both expensive and time-consuming. Also sending money overseas becomes even more complex due to exchange rates and other hidden fees included. Here DLT can provide a decentralized secure network that will help to reduce the time, complexity, and costs required to transfer money. This decentralized network will eliminate the need for third parties which makes this system more complex and time-consuming.

- Cyber Security: Nowadays cyber security has been emerging as a big threat to governments, enterprises, and individual people also. So it is essential to find an effective solution to secure our data and privacy against unauthorized access. In DLT, all information is authorized and securely encrypted by various cryptographic algorithms. This provides a transparent and secure environment and none of the data can be tempered by any entity.

Distributed Ledger Technology (DLT) with Cloud Computing

Uses of DLT:-

- Supply chain management: Supply chain is one of the complex structures itself. In this structure, it is hard to trace where the fault happened. So here Distributed ledger technology comes into the picture, Using DLT, you can easily trace the supply chain from the beginning to the end and can easily find out where a mistake or fault has happened. All the data added to the DLT is validated and permanent and can not be altered. This transparency of data enables us to trace from the beginning to the end of the ledger.

- Healthcare: Distributed Ledger eliminates central authority and ensures rapid access to secured and untempered data. Here important medical can be stored securely and no one can change this data, even if someone tries to change it will be reflected everyone immediately. DLT can be used in the insurance sector to trace false claims because of its decentralized system.

Distributed Ledger Technology (DLT) with Cloud Computing

Uses of DLT:-

- Governance: DLT can be used in the government system to make it transparent among citizens.
- Many governments have adopted block chain in the governance system because of the robustness of this system. It can be used as a voting system too.
- The traditional voting system has many flaws and sometimes it is found that there are many false voting and illegal activities that happen during voting.
- Online voting systems can be used to vote and with security and fake votes can be easily checked. everyone will have their own identity. So that any person sitting anywhere in the world can cast his vote.