
EDGE
COMPUTING
Edge
Computing

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- Limitations of Cloud Computing
- What is Edge Computing
- Need For Edge Computing
- Terms and Definition
- IoT and Edge Computing
- Architecture of Edge Computing
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Cloud Computing

- Cloud computing is a infrastructure and software system that allows for access to shared network of storage, server and application over the internet.
- With Cloud Computing users can access database resources via the internet from anywhere for as long as they need without worrying about any maintenance and management of actual resources.

It is a server which is accessed over the internet present at remote location

Storage managing accessing of data and program on remote sensors that are hosted over internet instead of computer hard disks

It is a server which is accessed over the internet present at remote location

Computing service over the internet

Software storage, Server, database, Networking

Cloud Computing

- **Cloud computing** refers to the delivery of computing services over the internet.
- It involves the provision of on-demand access to computing resources such as servers, storage, databases, software, and networking.
- In cloud computing, data processing and storage are centralized in remote data centers, and users access these resources through the internet.

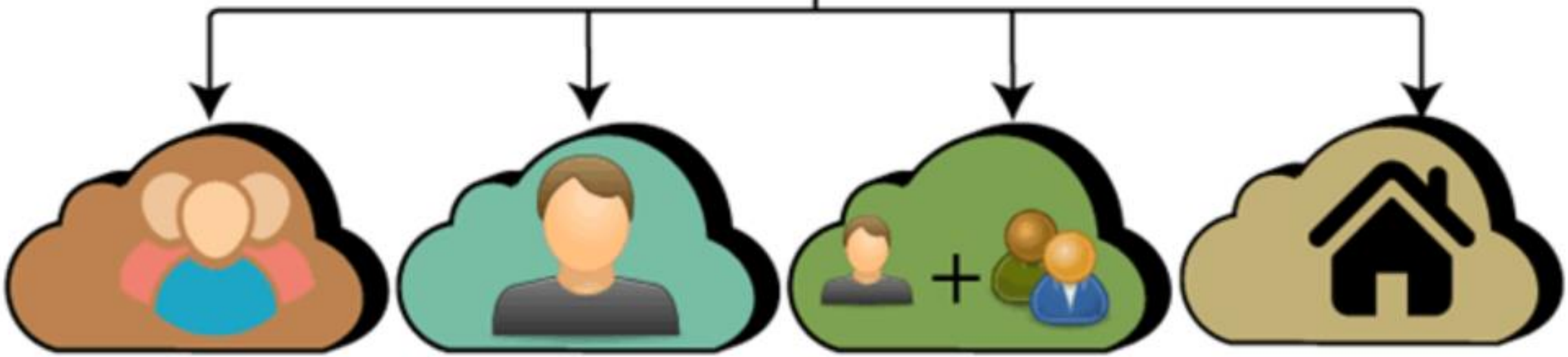
Limitations of Cloud Computing

- **Latency:** In the traditional cloud computing model applications send data to the data Centre and obtain a response, which increases the system latency. For e.g. High speed autonomous driving vehicles require milliseconds of response time.
- **Bandwidth:** Transmitting large amount of data generated by edge devices to the cloud in real time manner will cause great pressure on bandwidth.
- **Availability:** As more and more Internet services are deployed on the cloud, the availability of the services has become an integral part of daily life. Therefore, it is a big challenge for cloud service providers to keep the 24*7 promise.
- **Energy:** With the increasing amount of computation and transmission, energy consumption will become a bottleneck restricting the development of cloud computing centres.

Advantages

- **Cost** : Cloud computing eliminates the ***cost of purchasing hardware and software, setting up and running centres, keeping IT personnel for infrastructure management.***
- **Security :** Cloud service providers have ***rules, policies, regulations and controls*** that ***strengthen your security*** i.e., ***protect your data, apps and infrastructure from potential threats.***
- **Reliability :** Cloud computing has ***data backup, disaster recovery*** etc. to ensure operational continuity. Data is ***mirrored at multiple redundant***

Types of Cloud



PUBLIC CLOUD

Public asses

PRIVATE CLOUD

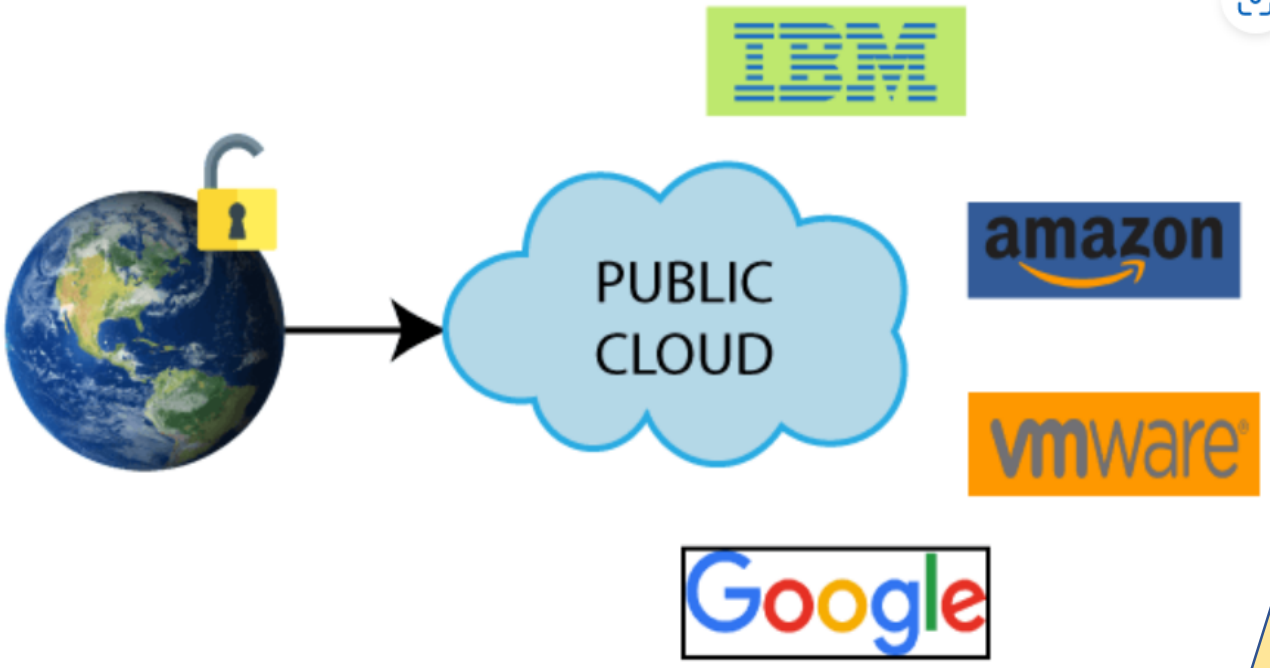
Service assessable within organization

HYBRID CLOUD

Comprises features of both public and private

COMMUNITY CLOUD

Service asses by group of organization



All *hardware, software and other supporting infrastructure* is *owned and managed by the cloud provider*.

- **Private cloud :** A private cloud has *cloud computing resources used exclusively by a single business or organisation*.
- It is generally *physically located on the company's on-site datacenter*. Some companies also *pay third-party service providers to host their private cloud*.
- The *services and infrastructure are maintained on a private network*.

Advantages of Public Cloud

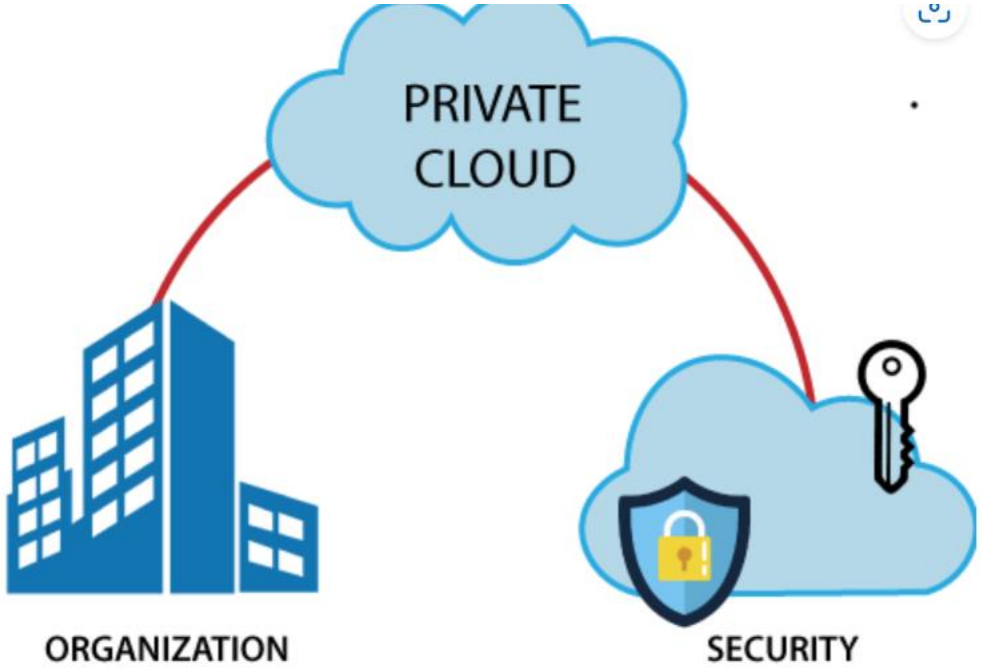
•Public cloud is owned at a lower cost than the private and hybrid cloud.
•Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.
•Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.
•Public cloud is location independent because its services are delivered through the internet.

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.



Advantages of Private Cloud

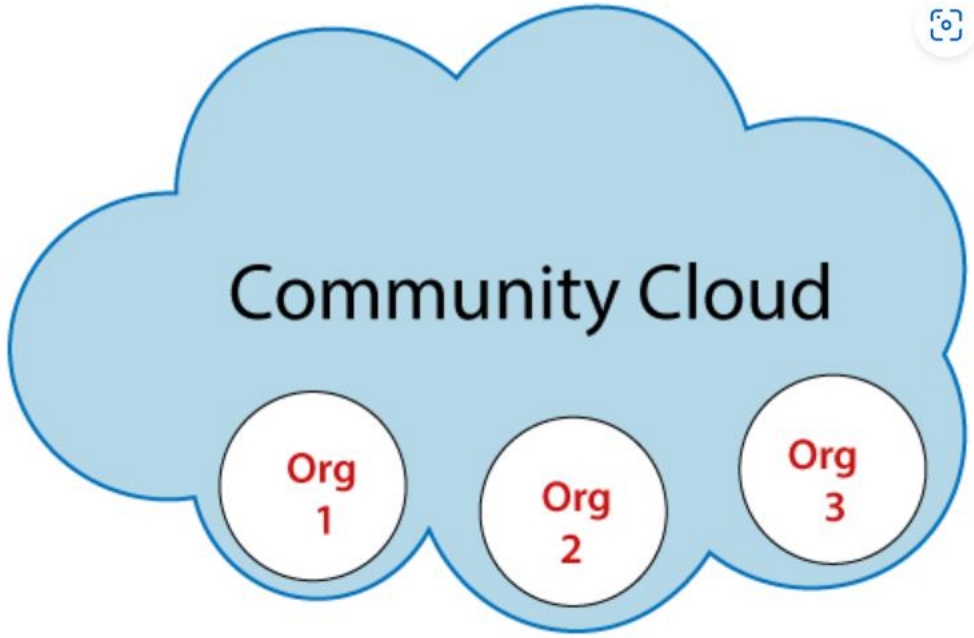
•Private cloud provides a high level of security and privacy to the users.
•Private cloud offers better performance with improved speed and space capacity.
•It allows the IT team to quickly allocate and deliver on-demand IT resources.
•The organization has full control over the cloud because it is managed 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.



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.

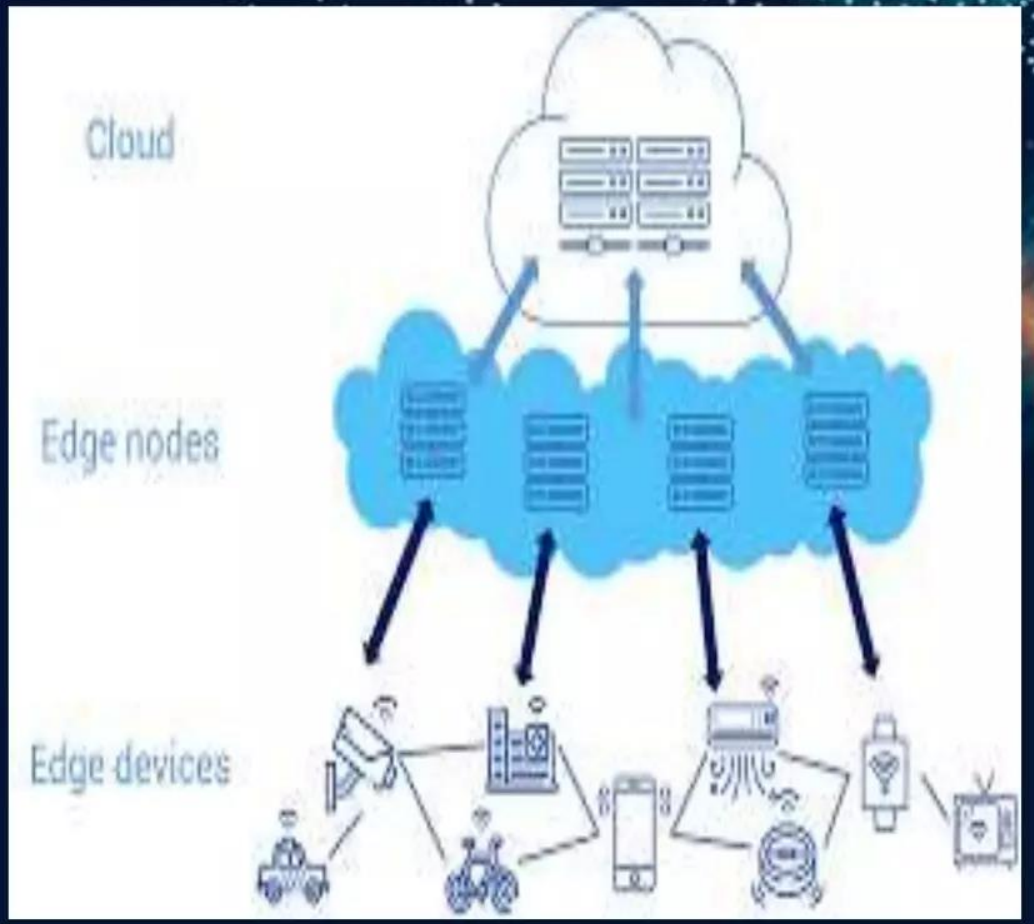
•It is not suitable if there is no collaboration.

•The fixed amount of data storage and bandwidth is shared among all community members

Parameter	Public Cloud	Private Cloud	Hybrid Cloud	Community Cloud
Host	Service provider	Enterprise (Third party)	Enterprise (Third party)	Community (Third party)
Users	General public	Selected users	Selected users	Community members
Access	Internet	Internet, VPN	Internet, VPN	Internet, VPN
Owner	Service provider	Enterprise	Enterprise	Community

What is Edge Computing?

- **Definition:** Edge computing is a distributed information technology (IT) architecture in which client data is processed at the periphery of the network, as close to the originating source as possible.
- No need to move to and fro from cloud centre.
- Here, rather than transmitting data to a central data center for processing and analysis, the work is performed where the data is actually generated whether it's a retail store, a factory floor or across a smart city.



Edge Computing

- Edge computing, is a distributed computing model that brings computation and data storage **closer to the edge of the network, near the source of data generation.**

- In edge computing, data processing and storage occur at or near the device or sensor level, rather than relying solely on centralized cloud servers. This approach enables **faster processing, real-time analytics, reduced latency, and localized decision-making.**

Edge computing is used to process time-sensitive data, and cloud computing is used to process non-time-triggered data.

Cloud Computing	Edge Computing
Cloud computing is centralized servers stored in faraway, large-scale data centers.	On the other hand, it is a highly distributed and global computing infrastructure closer to the devices and users.
It processes data on a central cloud server far from the data sources.	Process data on site quickly and analyze data in real-time. It does not focus on storing data.
It is suited for applications that are not time-sensitive.	It is ideal for low latency, where every millisecond counts.
Cloud computing gives improved and innovative processing capabilities and storage capacity.	As it processes in the device, it has lower processing power and storage capacity.
It is suitable for in-depth and long-term analysis.	It is better for fast and real-time analysis.
It needs internet connectivity.	It can work without internet connectivity.
An expensive and intensive operational activity for the company.	Automated scalability with zero-touch provisioning

Example

- Let's consider a smart surveillance system deployed in a city. The system uses multiple cameras placed across the city to capture live video footage. The goal is to analyze the video feed for various purposes like object detection, face recognition, and anomaly detection.

Example

- **Cloud Computing:** In a cloud-based approach, the video footage from all cameras is transmitted to a centralized cloud server for processing and analysis.
- The video data is sent over the network to the cloud, where it is processed using powerful computing resources and machine learning algorithms.
- The results are then sent back to the user or stored in the cloud for further analysis or archival.

Example

- **Edge Computing:** In an edge computing approach, **each camera in the smart surveillance system is equipped with its own processing capabilities**. The video footage is **analyzed locally at the edge, near the camera itself.** The cameras have built-in machine learning models to edge devices such as gateways or edge servers that perform the analysis. **Only relevant information or alerts are sent to the centralized cloud for further processing or storage**. This reduces the **amount of data transmitted over the network and enables real-time decision-making at the edge**.

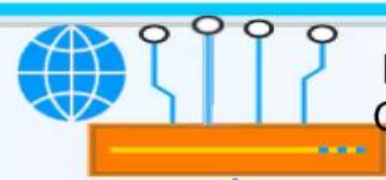
The Edge Computing

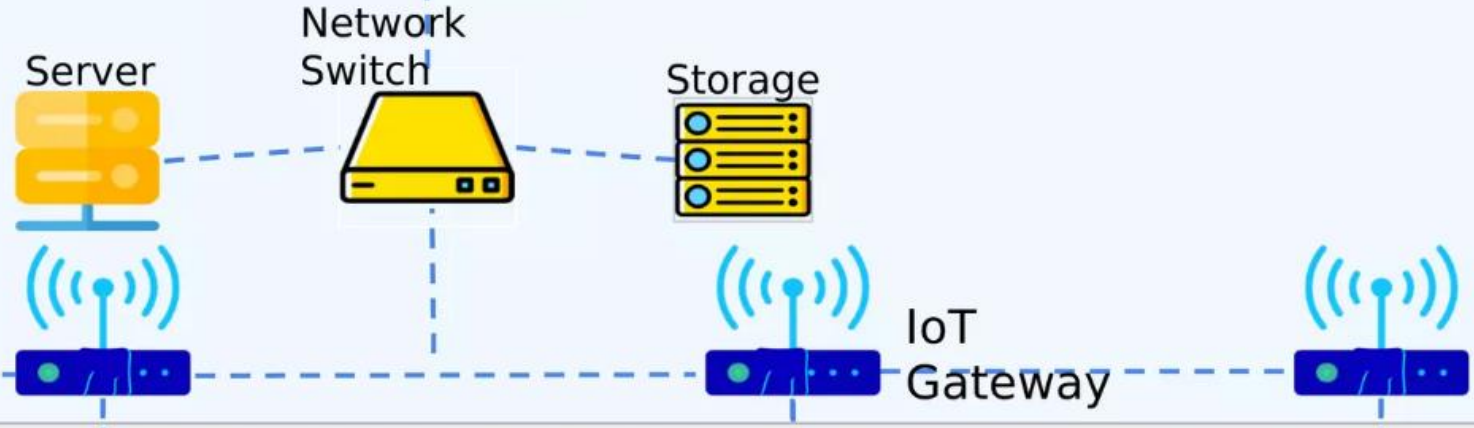
Cloud
- Central processing of summary data
- Big data analysis, complex learning model
- Central control

Internet

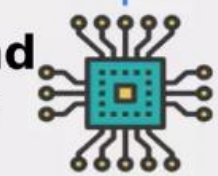
Edge
- Real time data processing
- Real time control (M2M)
- Local data filtering and caching
- At source data visualization

Intra net





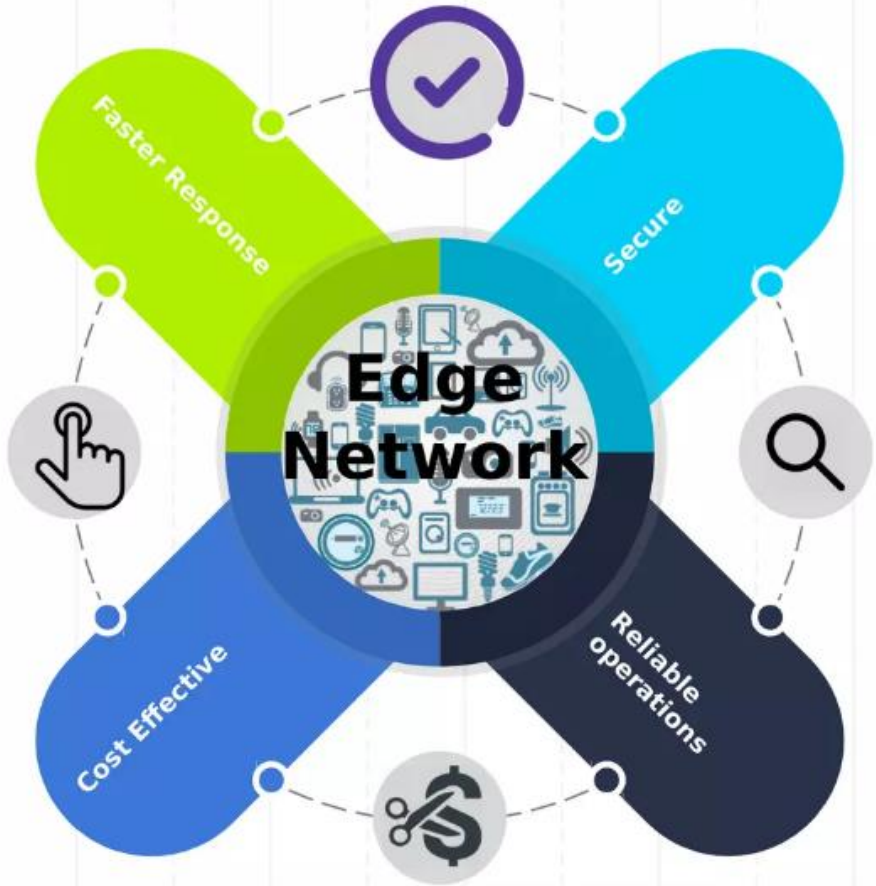
Sensors and controllers



Benefits of Edge Computing

Faster Response

- Operating at the source of data
- Faster response time for triggers



Secure

- Locally stored
- No theft during transport
- Compliance maintained

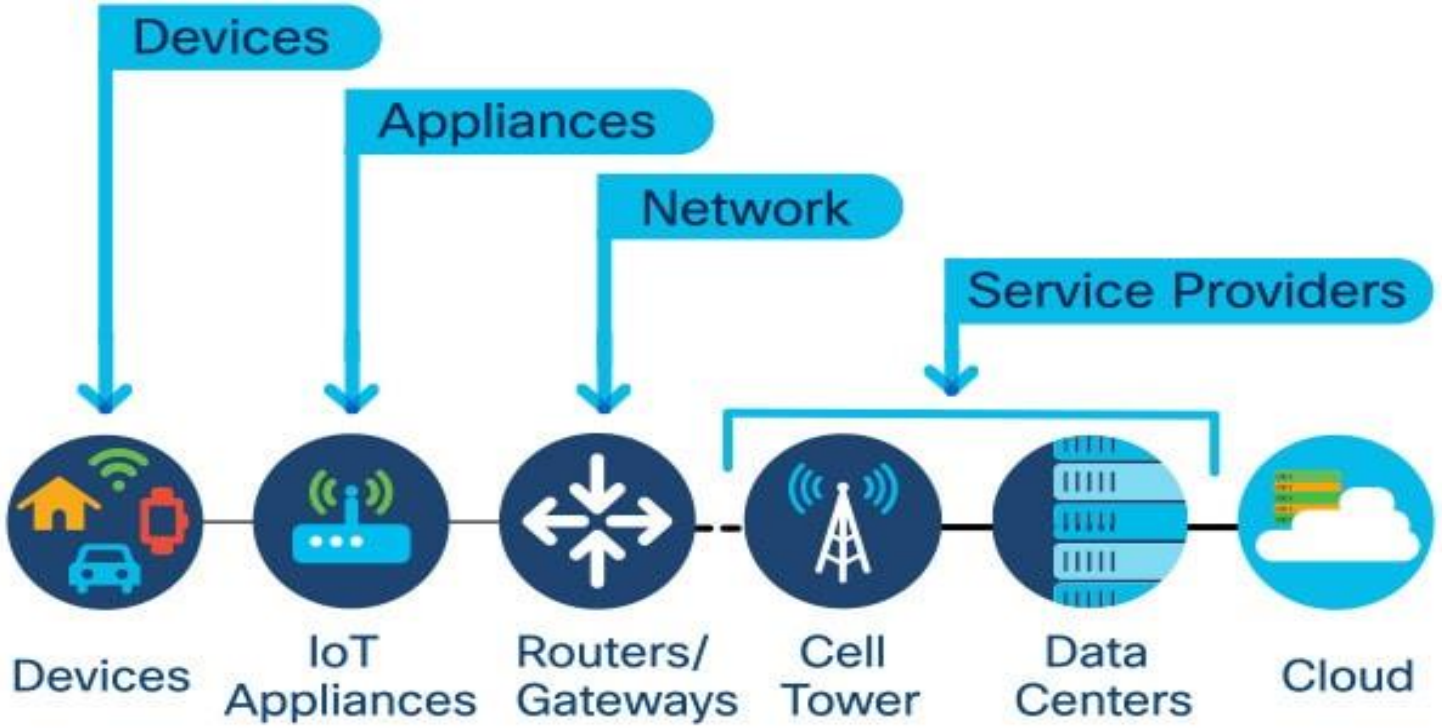
Cost Effective

- No need to transport everything to cloud
- No recurring cost

Reliable Operations

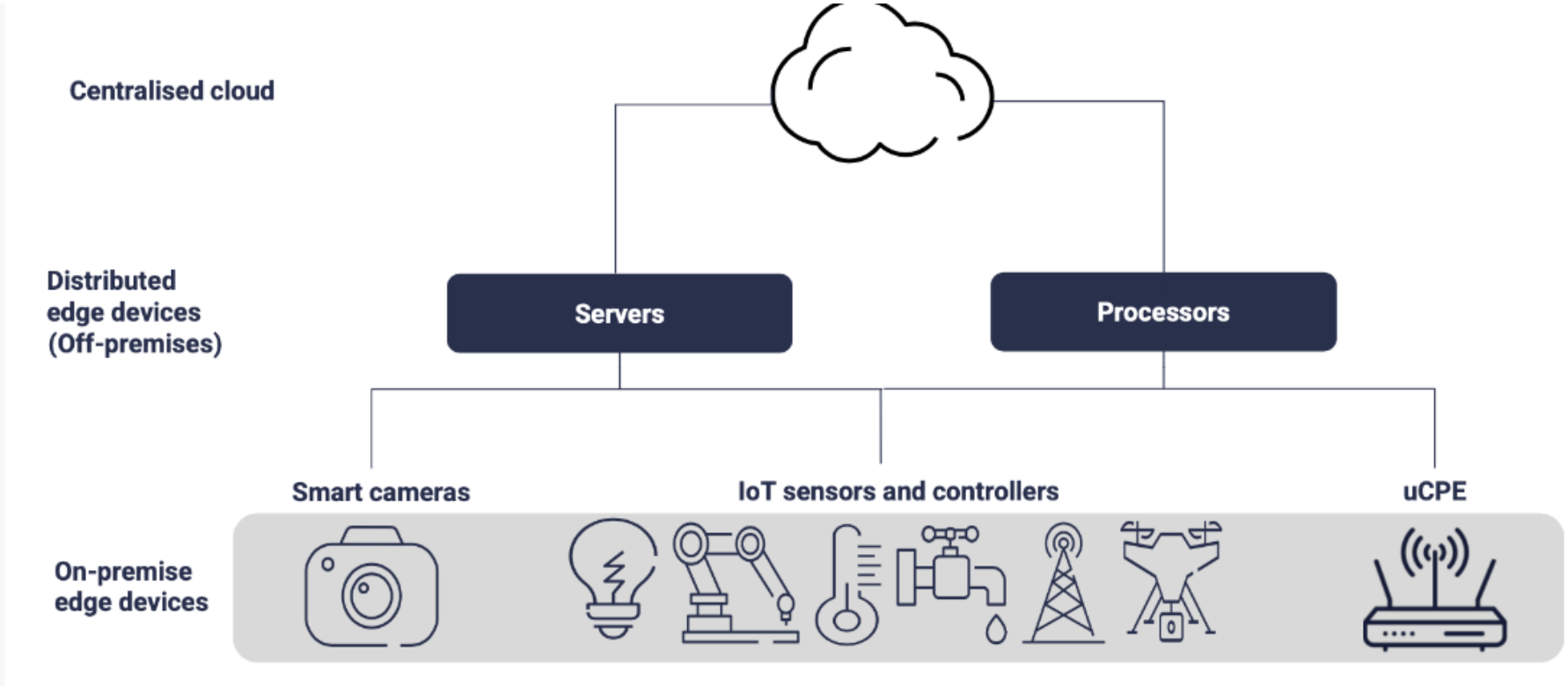
- Can work without connectivity.

- Edge computing is a **distributed information technology (IT) architecture** in which client data is processed at the periphery of the network, as close to the originating source as possible.



Edge computing moves some portion of storage and compute resources out of the central data center and closer to the source of the data itself.

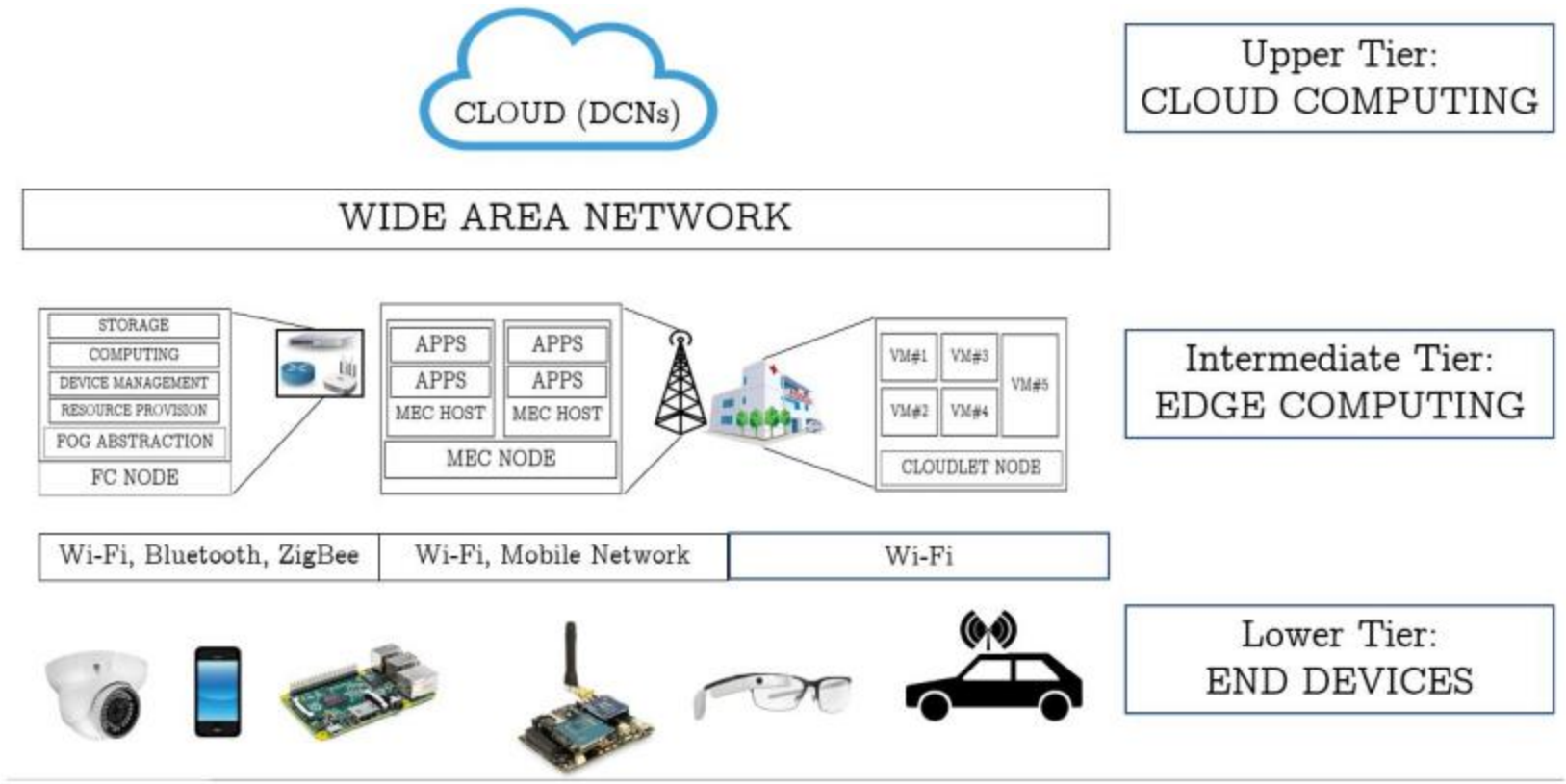
- **Edge computing** is the **computational processing of sensor data away from the centralized nodes and close to the logical edge of the network, toward individual sources of data**.
- **Distributed IT network architecture** that **enables mobile computing for data produced locally**.



Need for Edge Computing?

- **A novel distributed and large-scale computing paradigm is required to effectively treat and analyze such large-scale dataset in a timely manner**.
- **Edge Computing model was introduced idea to bring data storage and compute power closer to the device or data source where it is mostly needed**.
- **Edge Computing paradigm allows computing resources and application services to be distributed along the communication path, via decentralized computing infrastructures organised to treat in a hierarchical fashion the data analytic work flow**.
- The **hierarchy coupled with the distribution of computing capabilities aims at solving the bandwidth bottleneck identified for general Cloud architectures**.

Edge Computing



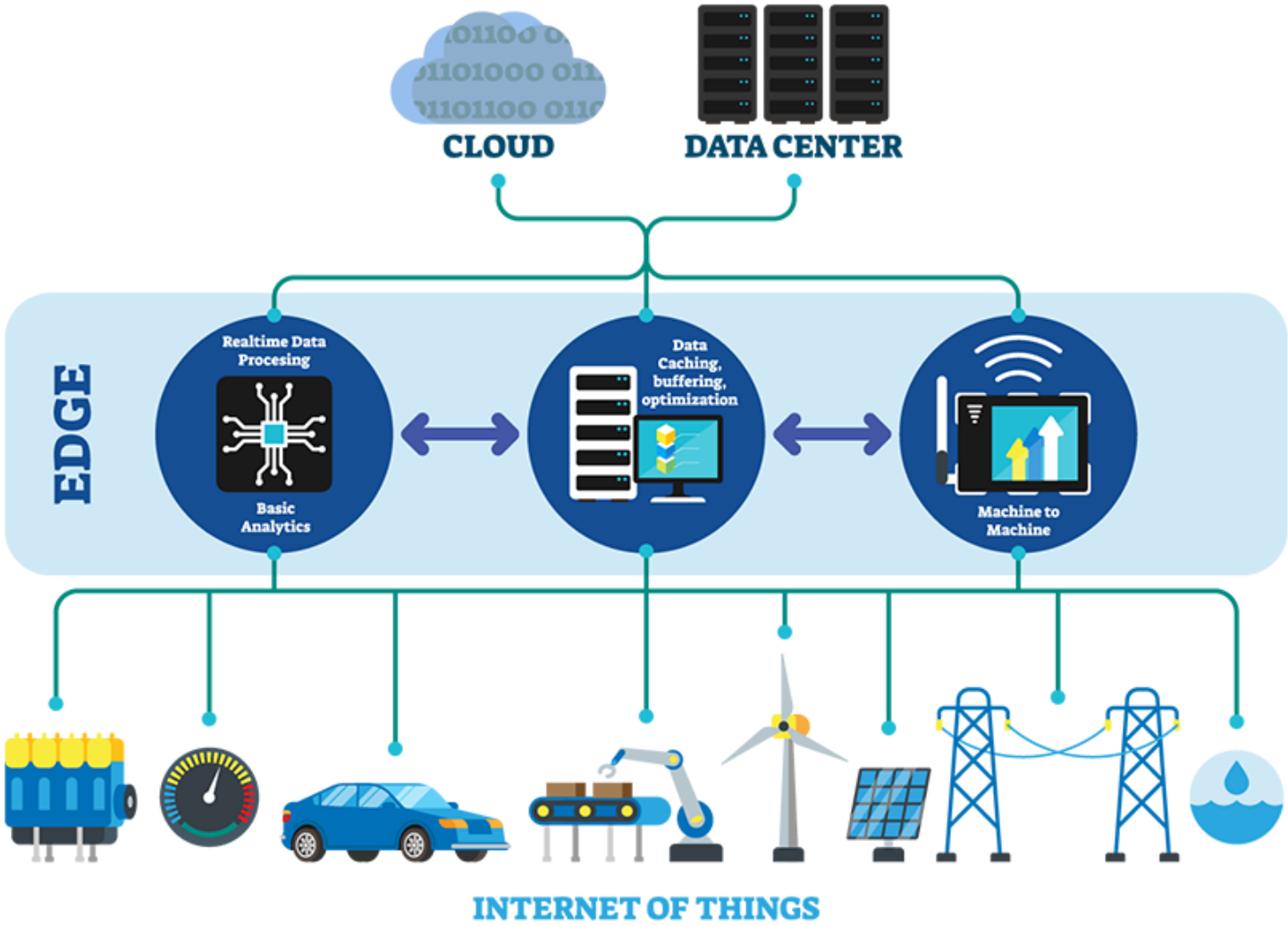
The objective of Edge Computing is to improve the network technology by moving the computation of data close to the edge of the network and away from the data centers.

Edge Computing Architecture

	Edge Computing Architecture Layer			
Characteristics	**IoT**	**Edge**	**Fog**	**Cloud**
Deployment	Distributed	Distributed	Distributed	Centralised
Components	Physical devices	Edge Nodes	Fog Nodes	Virtual resources
Location awareness	Aware	Aware	Aware	Aware
Computational Limits	Limited	Limited	Limited	Unlimited
Storage Limits	Very limited	Limited	Limited	Unlimited
Data	Source	Process	Process	Process
Distance to data source	The source	The nearest	Near	Far
Response time	No response time	The fastest	Fast	Slow
Nodes count	The largest	Very large	Large	Small

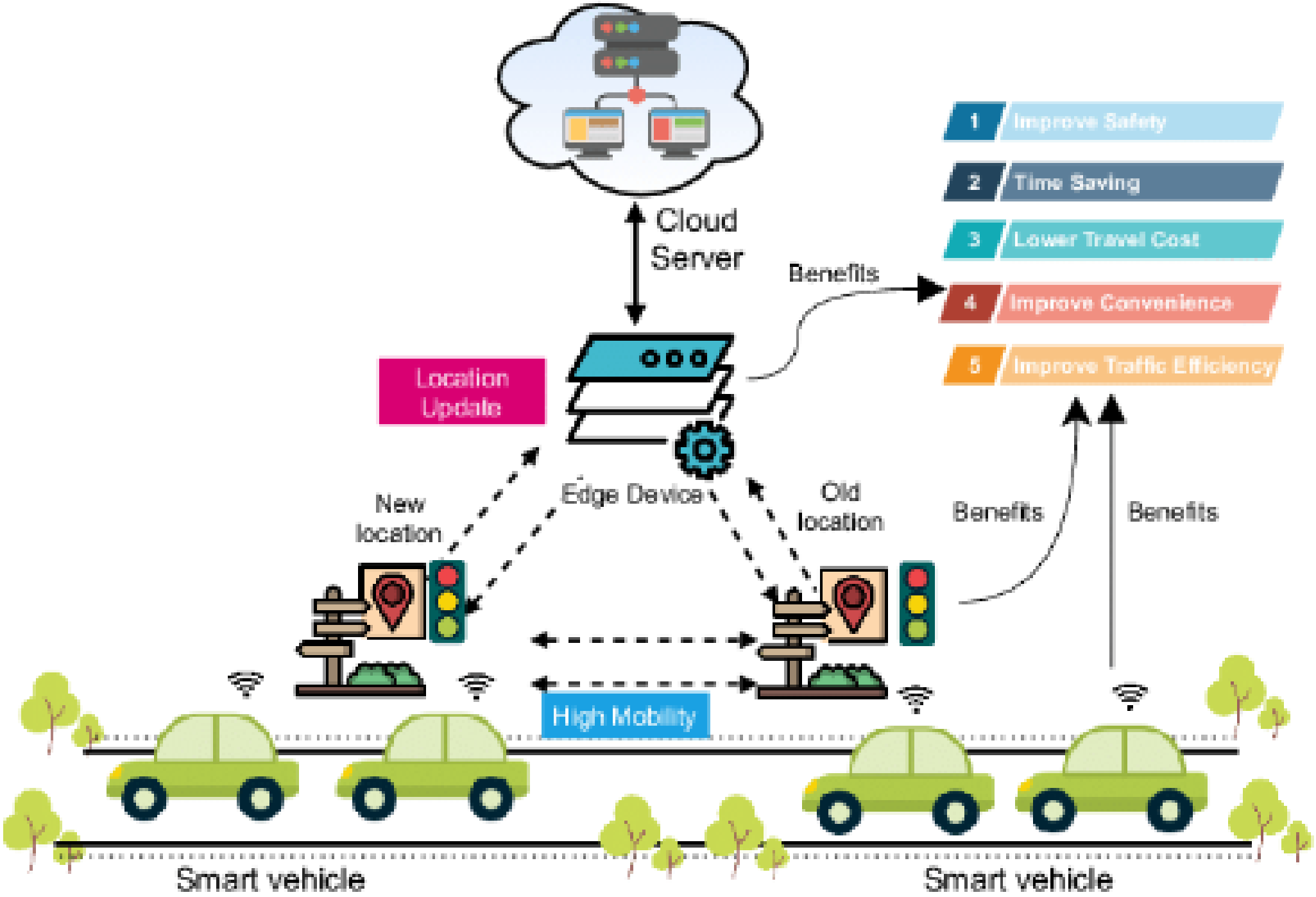
Edge Computing aims to **bring computational power in close proximity** of **IoT sensors, smartphones, and connected technologies.**

Real-Life Use Cases for Edge Computing



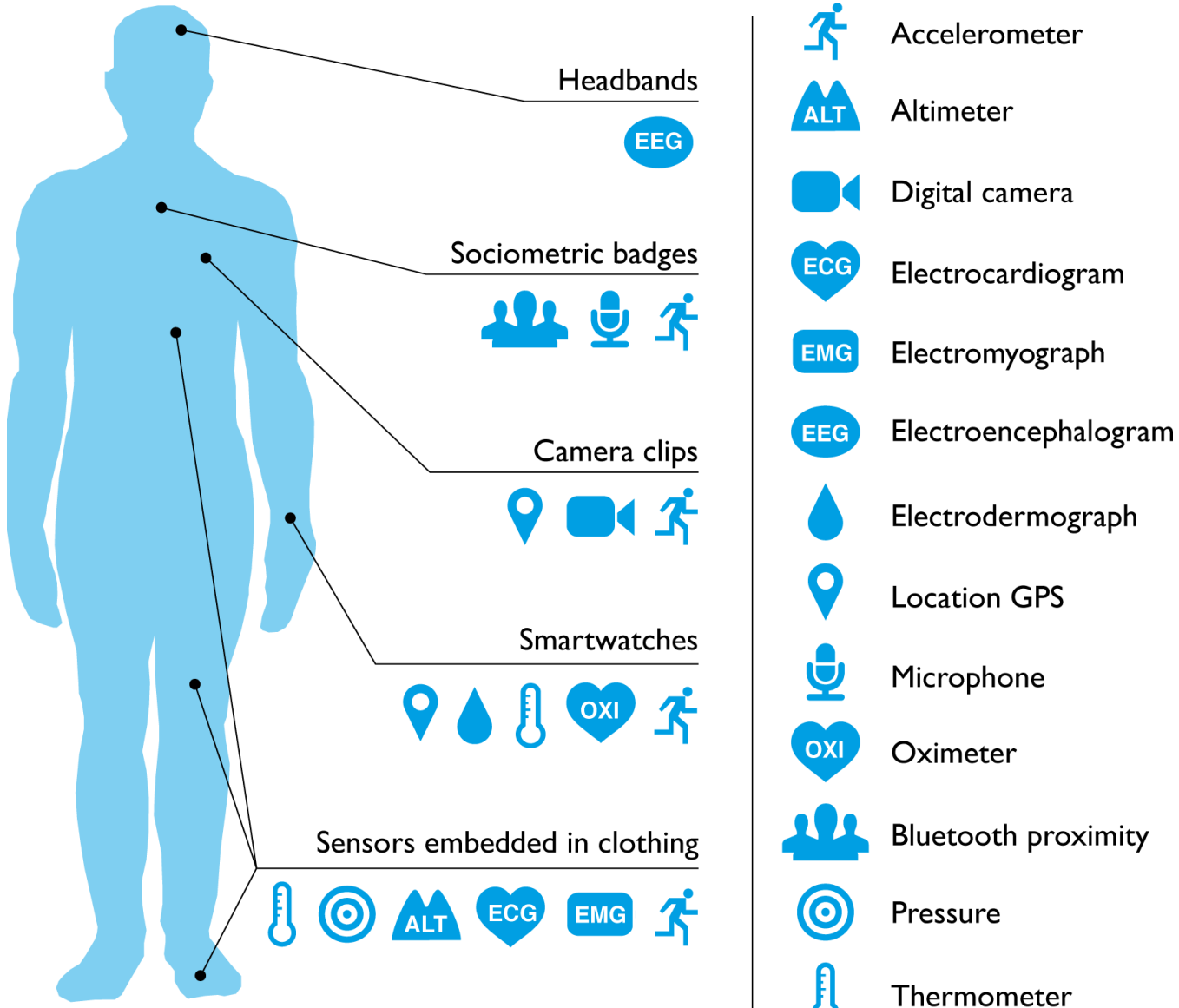
Real-Life Use Cases for Edge Computing

Autonomous vehicle (AV)


Cloud Server
Benefits
1 Improve Safety
2 Time Saving
3 Lower Travel Cost
4 Improve Convenience
5 Improve Traffic Efficiency
Location Update
Edge Device
New location
Old location
Benefits
Benefits
High Mobility
Smart vehicle
Smart vehicle

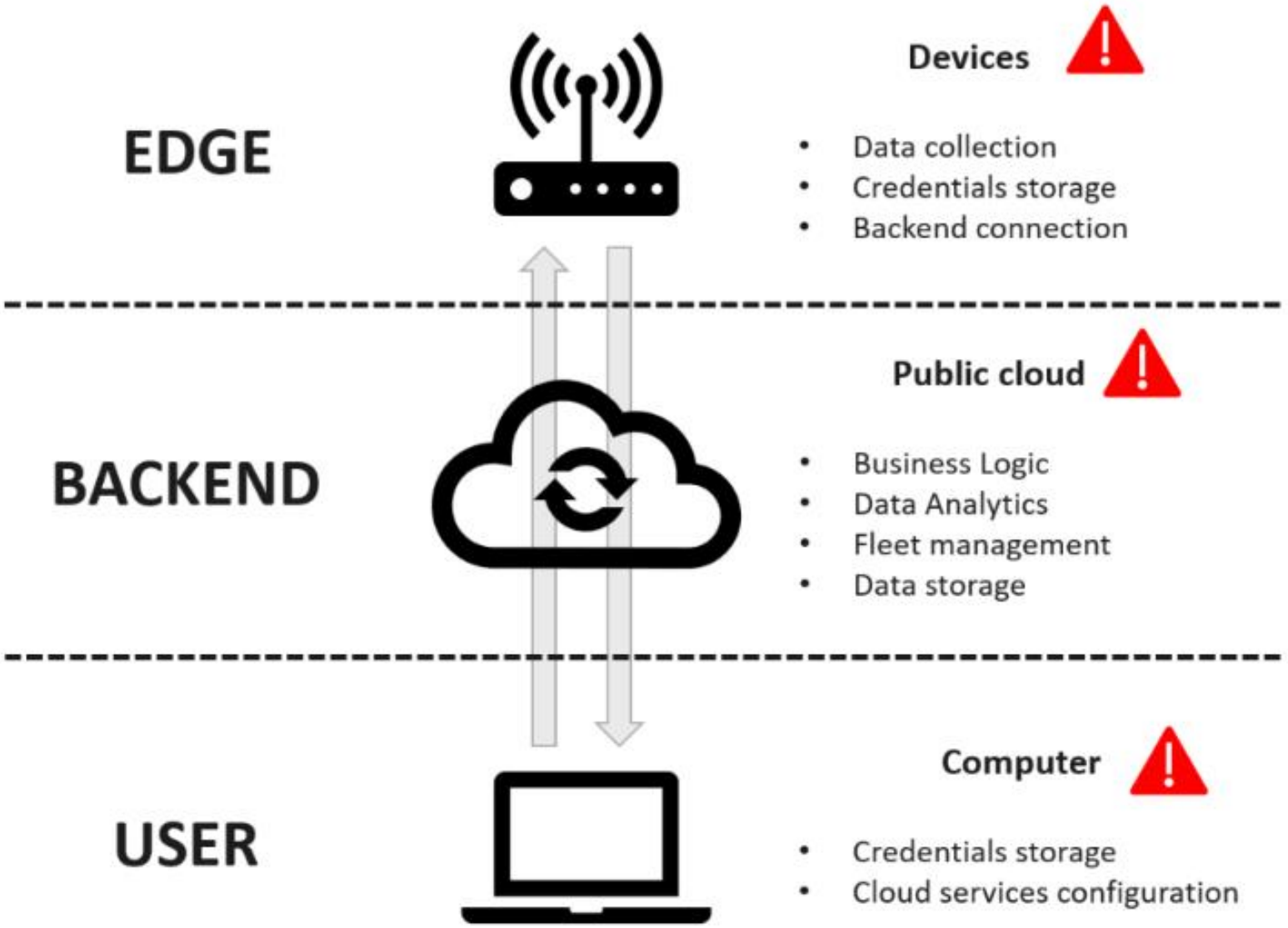
Real-Life Use Cases for Edge Computing

Healthcare Devices



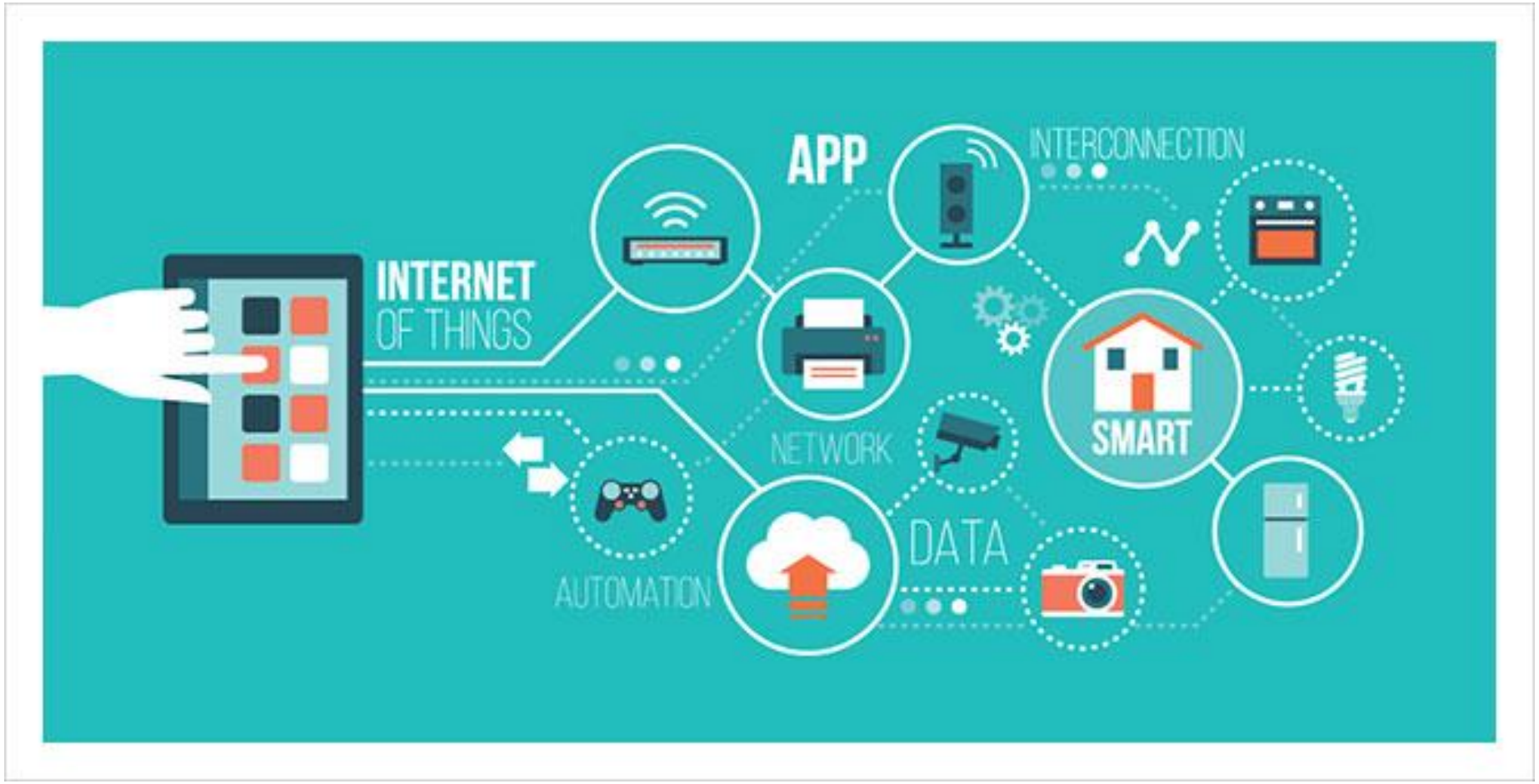
Real-Life Use Cases for Edge Computing

Security Solutions



Real-Life Use Cases for Edge Computing

Retail Advertising

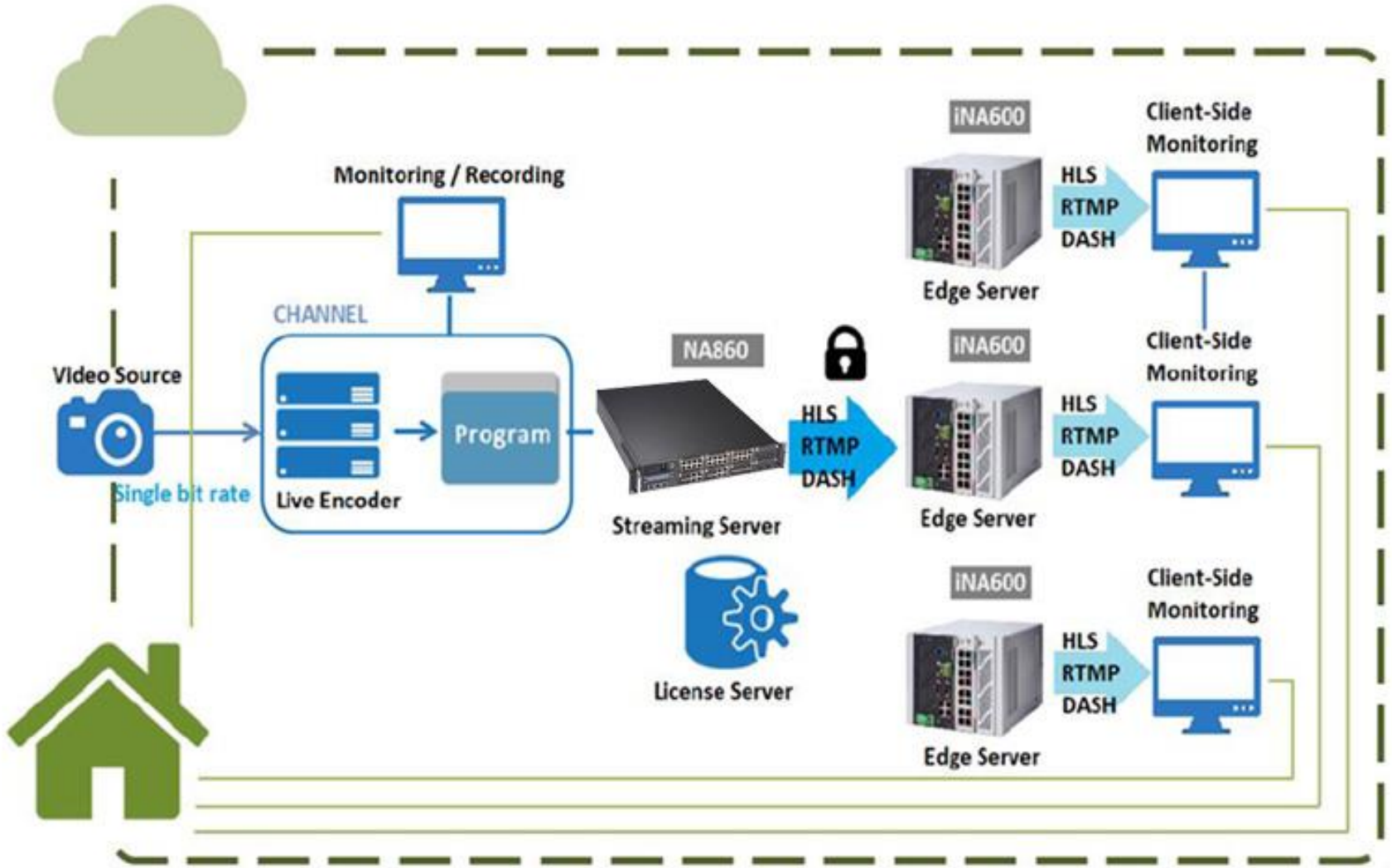


Real-Life Use Cases for Edge Computing

Smart Speakers

Real-Life Use Cases for Edge Computing

Video Conferencing



Edge ML

- Machine learning (ML) is a branch of artificial intelligence (AI) that focuses on developing algorithms and **models that can learn and make predictions or decisions without explicit programming**. ML algorithms analyze and interpret large amounts of data to identify patterns, extract insights, and make decisions based on the learned patterns.
- Edge machine learning (Edge ML), also known as on-device ML, refers to **the deployment of ML algorithms and models directly on edge devices, such as smartphones, IoT devices, and embedded systems,** rather than relying on cloud-based servers for processing. In edge ML, the data is processed locally on the device itself, enabling real-time analysis and decision-making at the edge of the network, close to where the data is generated.

- **Edge ML** brings several advantages:

- **It reduces the reliance on cloud connectivity**, as the processing and inference happen on the device itself, enabling offline or low-latency operation.
- It also enhances **privacy and data security** by keeping sensitive data on the device and minimizing data transmission to the cloud.
- Edge ML **enables faster response** times, as the data does not need to travel to a remote server for processing, making it ideal for time-sensitive applications.
- Additionally, **edge ML can reduce the bandwidth requirements and costs** associated with transmitting large amounts of data to the cloud.

- By deploying ML models at the edge**, devices can perform tasks such as image recognition, speech processing, anomaly detection, and predictive analytics locally, bringing intelligence and decision-making capabilities directly to the edge.**

- This opens up various use cases in areas such as smart homes, autonomous vehicles, healthcare, industrial automation, and more, where real-time processing, privacy, and low-latency operations are critical.

Edge ML for Industry automation.

- One of the use cases of edge machine learning (ML) in the manufacturing industry is predictive maintenance.
- In manufacturing facilities, machinery and equipment are subject to wear and tear, which can lead to breakdowns and unplanned downtime.
- Edge ML can be applied to predict maintenance requirements and detect potential failures in real time, improving operational efficiency and reducing costly downtime.

Edge ML for Industry automation

- By deploying ML models directly on edge devices within the **manufacturing environment, data from sensors and monitoring systems can be continuously analyzed to identify patterns and anomalies that indicate impending equipment failure.**

- **The ML algorithms can learn from historical data and sensor readings to detect early signs of equipment degradation or abnormal behavior**.

AR/ VR (Augmented and virtual reality) for field workers in industry

- **Augmented Reality (AR)** is a technology for viewing in 3D, real-time and through a device (such as a cell phone or tablet) a part of reality with graphics or other visual elements.

- It refers to technology that overlays information and virtual objects on real-world scenes in real-time. It allows users to see and interact with virtual elements integrated into their actual surroundings. **AR typically involves the use of devices like smartphones, tablets, or smart glasses to display the augmented content.**


86%
73%
64%
5
DAY
VERIFICATION
IN PROGRESS


80

VR

- Virtual Reality (VR), on the other hand, **refers to a simulated environment that completely replaces the real world**. VR immerses users in a computer-generated environment, usually experienced through specialized headsets or goggles. **Users can explore and interact with this virtual environment as if they were physically present within it.**
- **For example, medical training, games, etc., which are explored without borders and boundaries in 360 degrees. VR creates a virtual, simulated environment where people interact in simulated environments using VR goggles or other devices.**

AR/VR

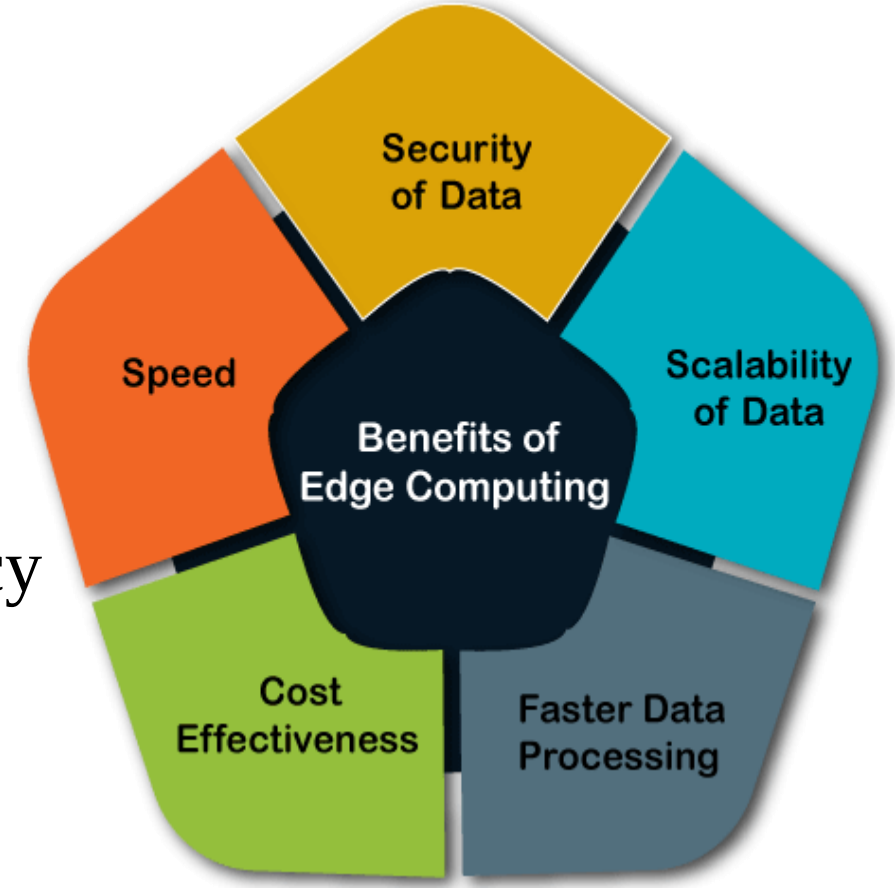
- Field workers often have to perform complex tasks on the factory floor. **The equipment they interact with can be dangerous due to high temperatures or voltages.** Sometimes, field workers lack the skills to complete specific tasks.
- AR/VR can be used to help both these problems. **For instance, AR/VR can provide field workers remote expert assistance, or environmental information about equipment to increase safety.** The former involves a field worker in the factory receiving AR assistance to perform complex assembly tasks. **A field worker wears AR glasses which provide an overlay of detailed instructions from a remote expert who is able to see the visual environment of the field worker.**
- Edge computing will be crucial to support this technology. Streaming AR/VR from an edge server eliminates the need for heavy compute on the AR/VR device, something that would make it impractical for reasons to do with battery and weight.

Smart cities (Practical Scenario)

- Civic authorities are also using edge computing to create smart communities and run their roadways with capabilities such as **intelligent traffic controls.**
- Edge supports a host of areas within this broad category. It helps civic authorities, such as traffic agencies, public transformation departments and private transportation companies better manage their vehicle fleets and overall traffic flow by enabling rapid adjustments based on real-time, on-the-ground conditions.
- For example, **edge computing platforms** deployed to process vehicle data can **determine which areas are experiencing congestion** and then **reroute vehicles to lighten traffic**.

Advantages of Edge Computing

- Increasing data security and privacy
- Better, more responsive and robust application performance
- Reducing operational costs
- Improving business efficiency and reliability
- Unlimited scalability
- Conserving network and computing resources
- Reducing latency



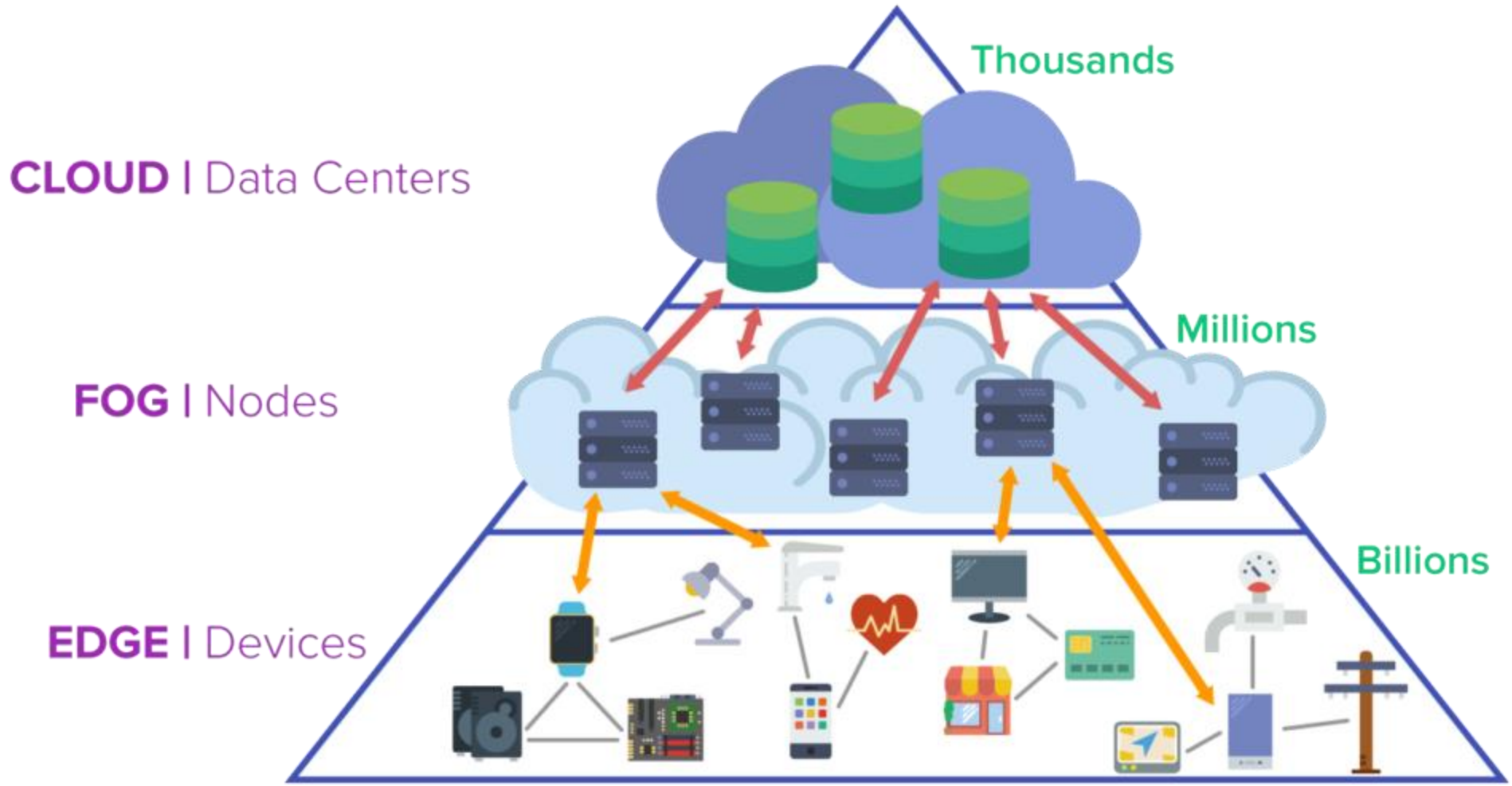
Disadvantages of Edge Computing

- Requires more storage as data will be placed and processed at different and various locations.
- Data is kept on distributed locations, and security becomes a challenging task in such an environment. It often becomes risky to identify thefts and cybersecurity issues. Also, if some new IoT devices are added, it can open gates for the attackers for harming the data.
- It is known that edge computing saves many expenses in purchasing new devices, but edge computing is also expensive. It means the cost is too high.
- It needs advanced infrastructure for processing data in an advanced way.
- Not capable of performing resource pooling.

Challenges in Edge Computing

Fog Computing:

- Fog computing is an extension of edge computing that focuses on bringing computation and storage capabilities closer to the network edge, beyond just the edge devices.
- In fog computing, data processing, storage, and analytics occur not only on the edge devices but also on intermediate fog nodes or fog servers located in the network.
- Fog computing aims to address the limitations of edge computing by providing additional computational resources, scalability, and coordination among edge devices.
- Example: In a smart city deployment, fog computing can be applied to process data from multiple edge devices such as **traffic sensors, surveillance cameras, and environmental sensors. The fog nodes or servers at various points in the city network can collect and analyze the data, enabling real-time traffic management, video analytics, and environmental monitoring.**


CLOUD | Data Centers
FOG | Nodes
EDGE | Devices
Thousands
Millions
Billions

- **Edge computing primarily focuses on processing data at or near the edge devices, often limited to a single device or immediate proximity**. Fog computing expands the scope to include intermediate nodes or servers distributed across the network, beyond just the edge devices.

- **Edge computing is commonly used in scenarios that demand immediate response, low latency, and real-time processing, such as industrial automation and IoT applications.** Fog computing is often applied in more complex environments where data from multiple edge devices needs to be aggregated, analyzed, and coordinated, such as smart cities or large-scale IoT deployments.

Front-end edge devices

- Front-end edge devices, refer to the devices located at the network's edge, closest to the data sources. These devices serve as the initial point of data collection and play a crucial role in the edge computing infrastructure. They typically gather data from sensors, actuators, cameras, or other sources and transmit it to the edge gateway or perform initial processing tasks.

Example

- Imagine a smart home automation system that aims to control various aspects of a house, such as lighting, temperature, and security. In this scenario, the front-end edge devices could include:

- **Smart Light Bulbs**
- **Smart Thermostat**
- **Surveillance Cameras**
- **Motion Sensor**

What is edge computing?

- Edge computing, as the name implies, brings data computation closer to the “edge” of the network where data is produced. This can help to lessen or even eliminate the need for a remote data center since all of the data is processed on-site. Latency is also reduced, allowing for real-time decision making since there’s no need to wait for the data to be processed in another location.

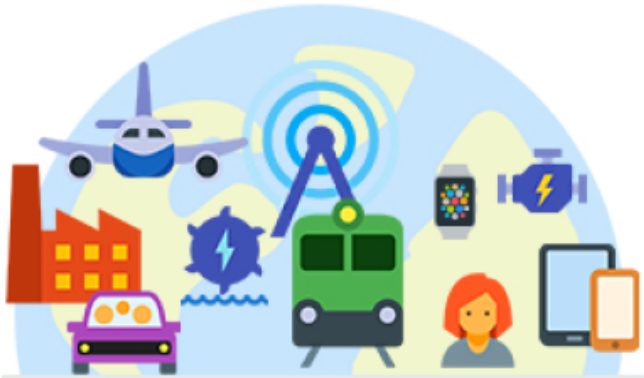
- To better understand edge computing, let’s look at a real-life example of predictive maintenance in a manufacturing environment. With sensors embedded in the manufacturing equipment, data can be continuously sent to a nearby edge server.

- Using AI algorithms based on historical data, this data can then be processed and analyzed to determine the likelihood of a system malfunction. This, in turn, can help to prevent unplanned downtime. In fact, predictive maintenance can help to reduce unplanned downtime by as much as 70%.

Operations Technology

Information Technology

THE EDGE



The Things

- Wearables
- Cars
- Motors
- Buildings
- Mobile Devices
- Meters
- Robotics
- Generators

Sensors & Actuators

Data Aggregation & Gateways

Edge IT

Data Center & Cloud IT

DATA GENERATION

DATA SENSING

DATA COLLECTION AGGREGATION

EARLY DATA ANALYTICS

DEEP DATA ANALYTICS

Need For Edge Computing

Powers the next industrial revolution, transforming manufacturing and services

Optimizes data capture and analysis at the edge to create actionable business intelligence.

Creates a flexible, scalable, secure, and more automated technology, systems, and core business process environment.

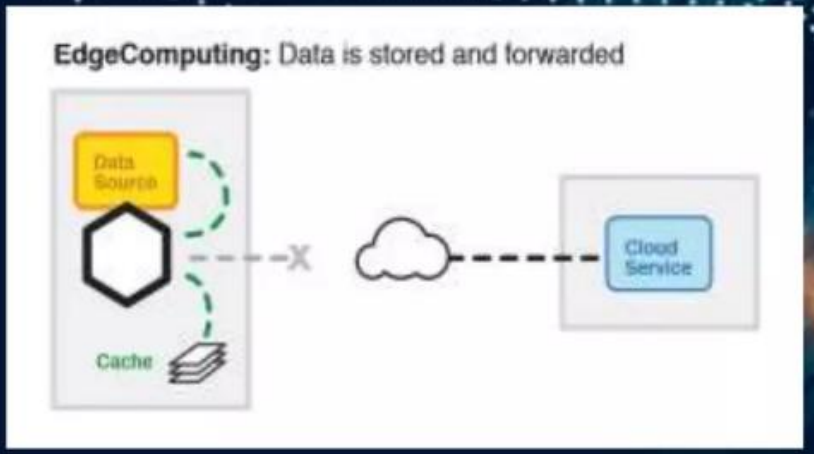
Developed due to the exponential growth of IoT devices, which connect to the internet for managing information over cloud.

Promotes an agile business ecosystem that is more efficient, performs faster, saves costs, and is easier to manage and maintain

Edge Computing Terms and Definitions

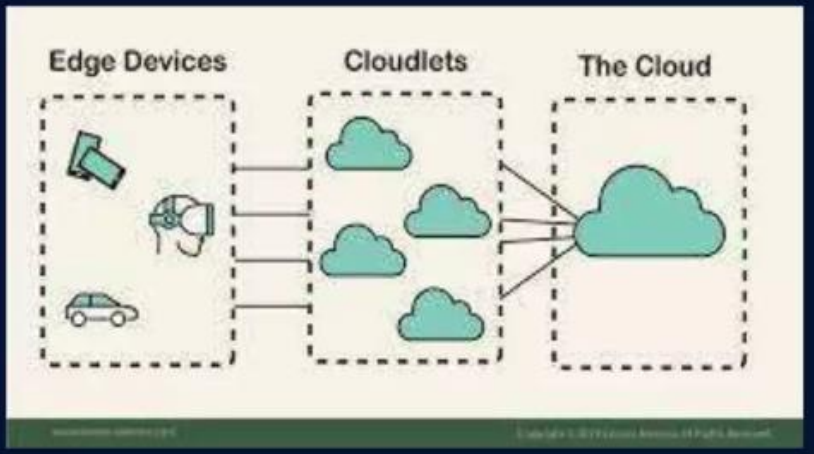
Edge

- It highly depends on the use cases.
- Like in telecommunication, it may be a cell phone or cell tower.
- Similarly, in the automotive example, it could be a car.
- In manufacturing, it could be a machine, and
- In the Information Technology field, it could be a laptop.



Edge Devices

A device which produces data is edge devices like machines and sensors, or any devices through which information is collected and delivered.



Edge Gateway

- It's a buffer where edge computing processing is done.
- The gateway is the window into the environment beyond the edge of the network.

Edge Server

A computer located in a facility close to the edge device. These machines run application workloads and shared services, so they need more computing power than edge devices

Edge node

- An edge node is a computer that acts as an end user portal for communication with other nodes in cluster computing.
- Any device, server, or gateway that performs edge computing.

Cloud

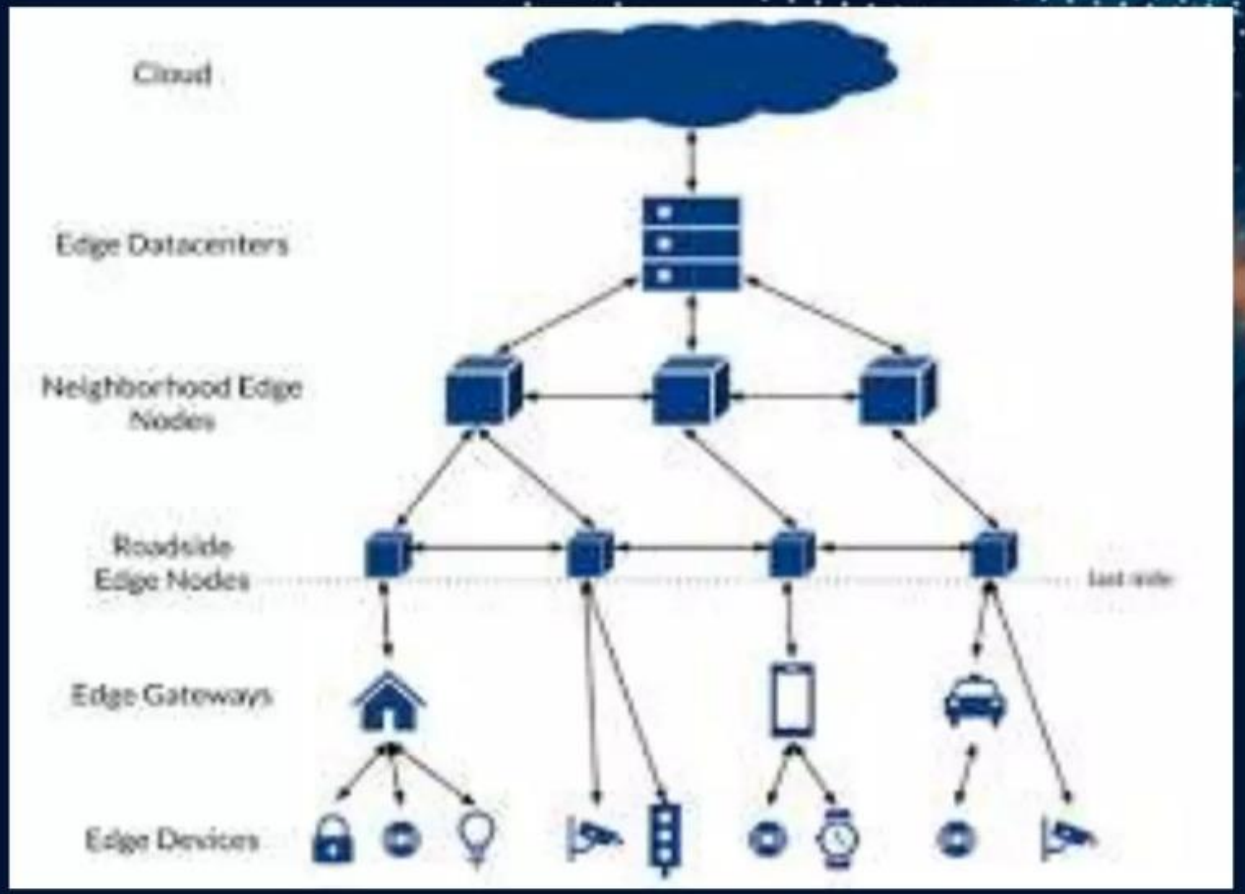
A public or private cloud that acts as a repository for containerized workloads like applications and machine learning models. The cloud also hosts and runs apps that manage edge nodes

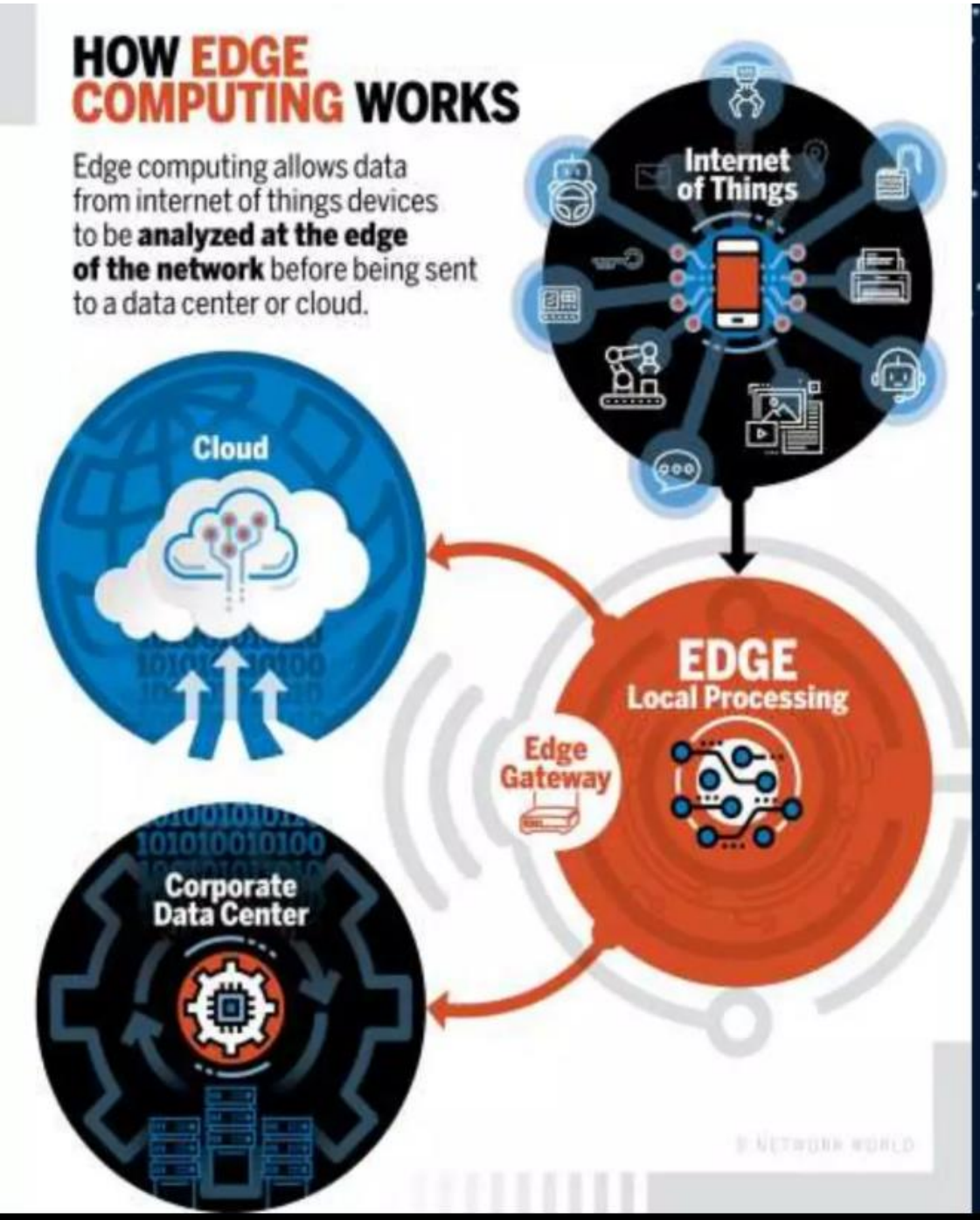
Internet of Things (IoT) and Edge Computing

- The Internet of Things (IoT) refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention.
- In IoT, with the help of edge computing, intelligence moves to the edge.
- There are various scenarios where speed and high-speed data are the main components for management, power issues, analytics, and real-time need, etc. helps to process data with edge computing in IoT.

Architecture of Edge Computing

Edge solutions are usually multi-layered distributed architectures encompassing and balancing the workload between the Edge layer, the Edge cloud or Edge network, and the enterprise layer. Furthermore, when we talk about the edge, there are the Edge devices and the local Edge servers.





More on Edge

- A network of micro data centres that store or process critical data locally and push received data to a centralized data centre or repository of cloud storage.
- Typically in IoT use cases, a massive chunk of data goes through the data center, but edge computing processes the data locally results in reduced traffic in the central repository.
- This is done by IoT devices, transferring the data to the local device, which includes storage, compute and network security.
- After that, data is processed at the edge while another portion is sent to storage repository or central processing in data centre.

Example: CCTV System

Consider a building secured with dozens of high-definition IoT video cameras. These are "dumb" cameras that simply output a raw video signal and continuously stream that signal to a cloud server.

Traditional Cloud Computing System

- On the cloud server, the video output from all the cameras is put through a motion-detection application to ensure that only clips featuring activity are saved to the server's database.
- This means there is a constant and significant strain on the building's Internet infrastructure, as significant bandwidth gets consumed by the high volume of video footage being transferred

Edge Computing System

- Now the motion sensor computation is moved to the network edge
- Each camera use its own internal computer to run the motion-detecting application and then sent footage to the cloud server as needed .
- This results in a significant reduction in bandwidth use, because much of the camera footage will never have to travel to the cloud server.

Advantages:

Speed

Edge computing has the capability to increase network speed by reducing latency. It greatly reduces the distance it should travel by processing data closer to the source of information.

Scalability

The edge can be used to scale your own IoT network without needing to worry about the storage requirements.

Reliability

Edge computing handles reliability part very well. Since most at times the edge computing does not depend on internet connection and servers it offers an uninterruptible service.

Security

The information present on the cloud has the tendency to get hacked easily. Since the edge computing only sends the relevant information to the cloud this can be prevented

Cost Effectiveness

Using edge computing for IoT allows users to reduce the bandwidth and data storage requirement and replace datacenters with device solutions. So, overall cost gets reduced.

Application: Use Cases

- **Manufacturing:** An industrial manufacturer deployed edge computing to monitor manufacturing, enabling real-time analytics and machine learning at the edge to find production errors and improve product manufacturing quality.

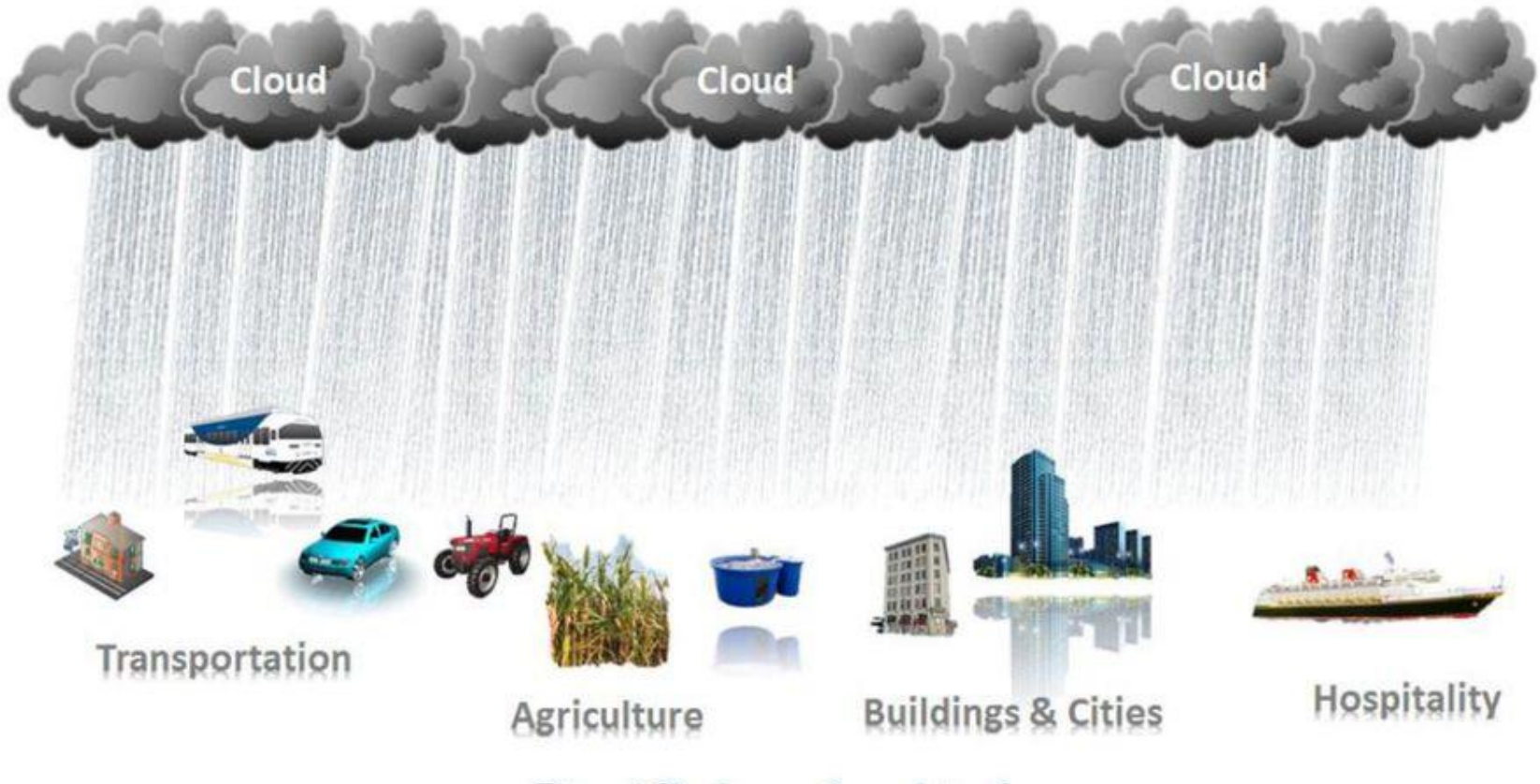
- **Farming:** Using sensors enables the business to track water use, nutrient density and determine optimal harvest. Data is collected and analyzed to find the effects of environmental factors and therefore produce good yield.

- **Improved healthcare:** The healthcare industry has dramatically expanded the amount of patient data collected from devices, sensors and other medical equipment. That enormous data volume requires edge computing to apply automation and machine learning to access the data

- **Traffic Management:** Edge computing can enable more effective city traffic management. Examples of this include optimizing bus frequency given fluctuations in demand, managing the opening and closing of extra lanes, and, in future, managing autonomous car flows.

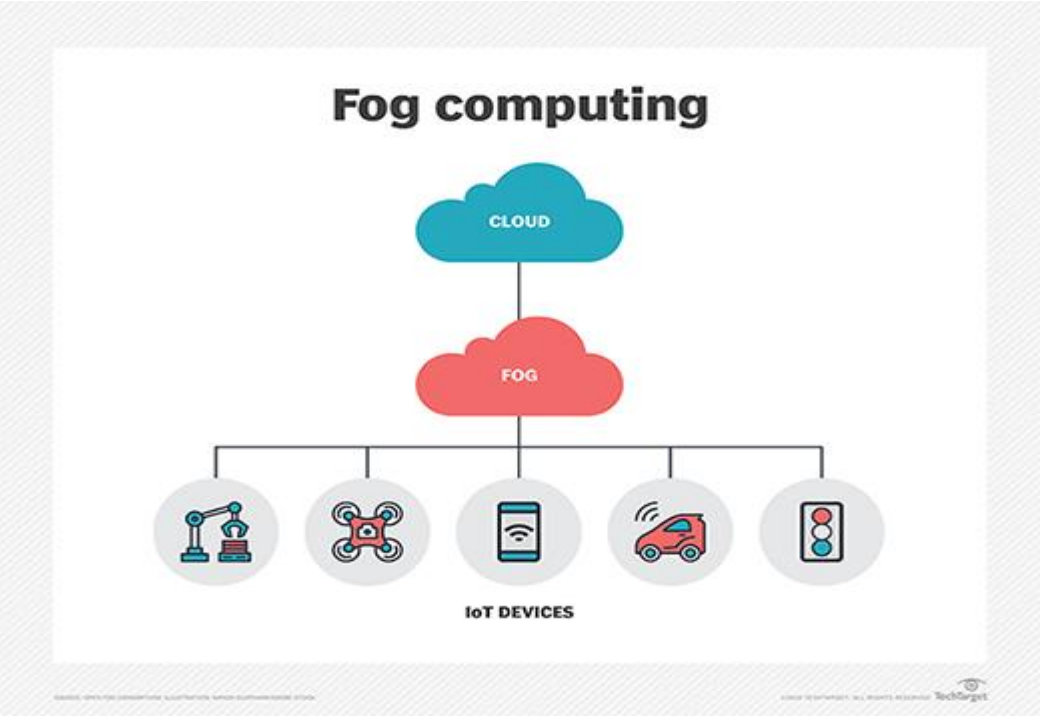
- **Smart Homes:** Smart homes rely on IoT devices collecting and processing data from around the house. As an example, the time taken for voice-based assistant devices such as Amazon's Alexa to respond would be much faster.

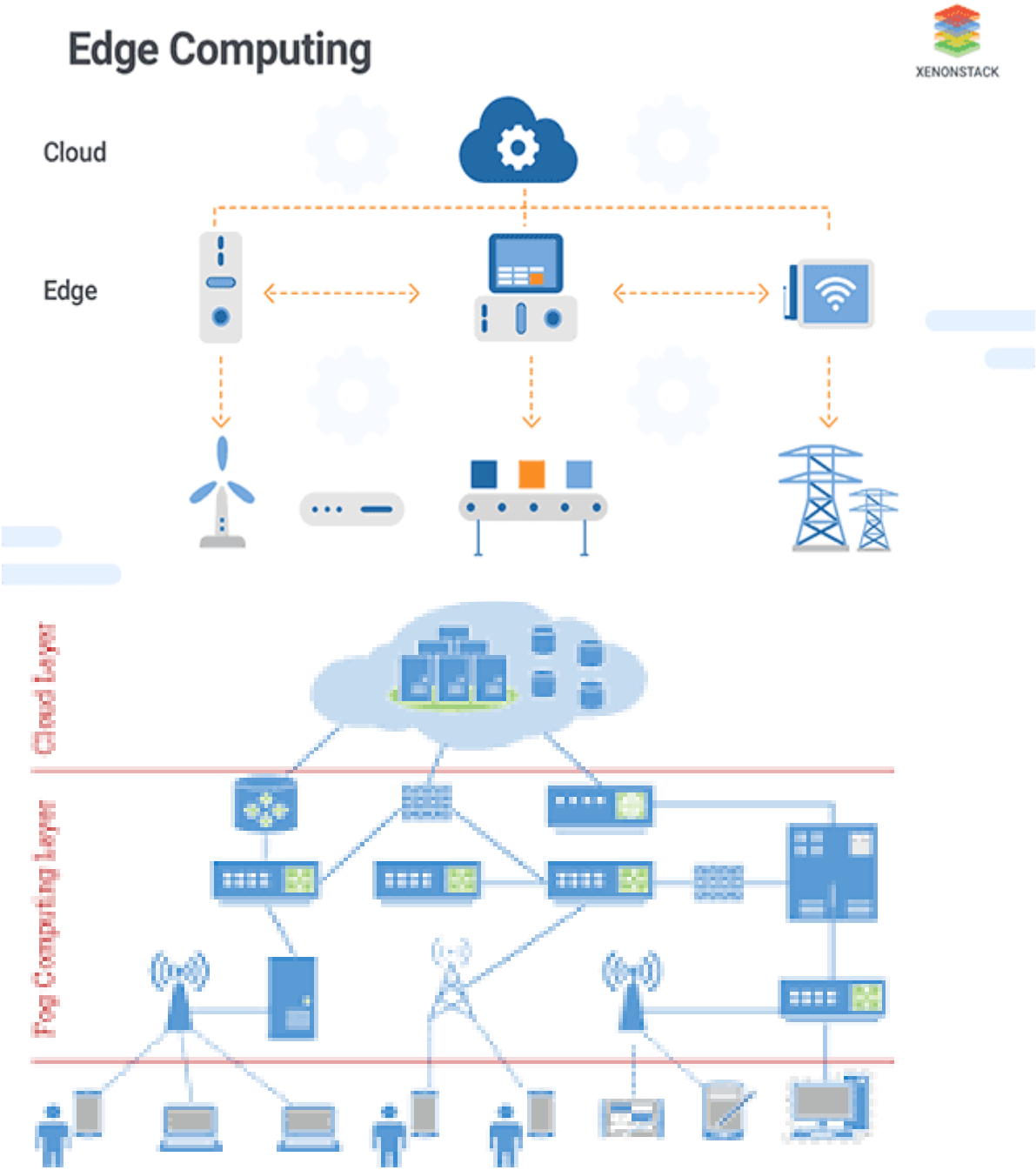
Cloud and IoT: Fog can develop anywhere in-between the two



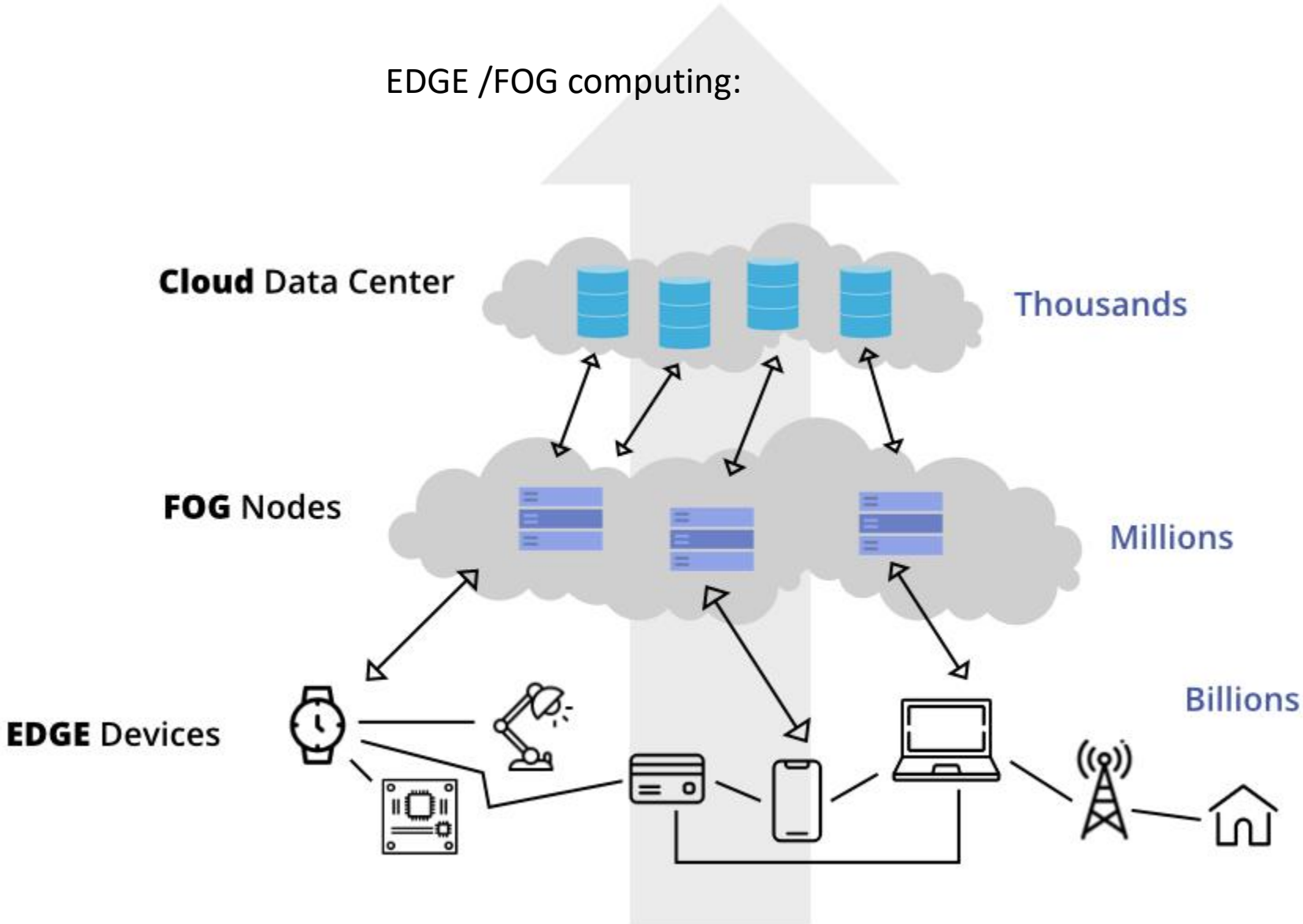
What is edge computing and fog computing in IoT?

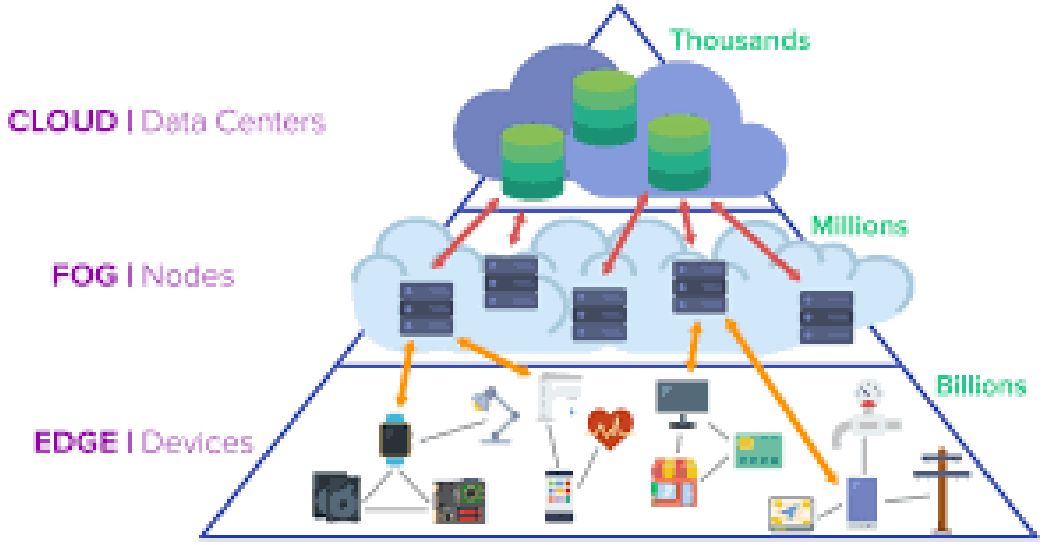
With a name coined from meteorological origins, fog computing focuses on the space of data area between the source and the cloud.
Edge computing, on the other hand, centers where data is collected. The key difference between edge and fog is in the location of intelligence and computing power.

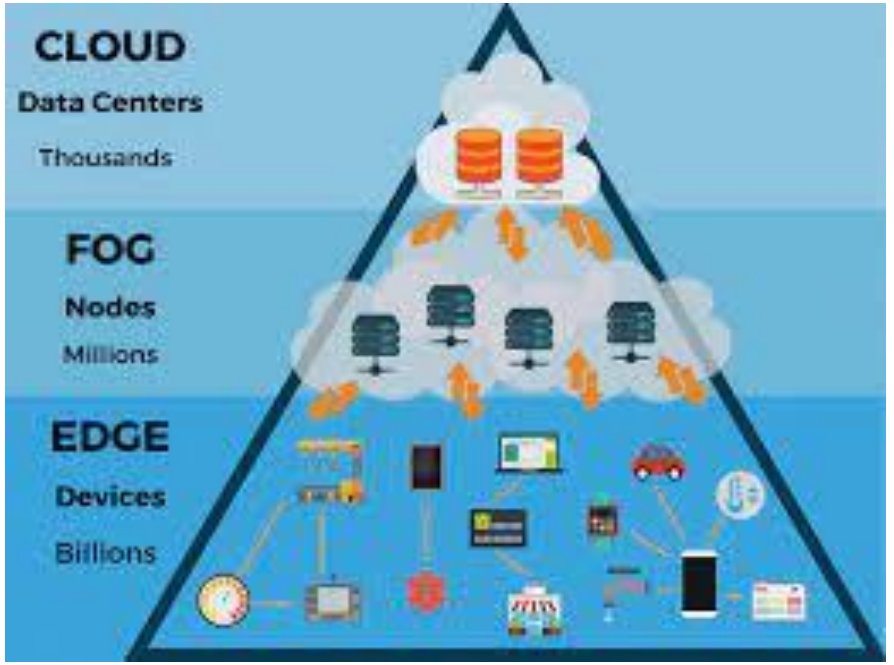




EDGE /FOG computing:




CLOUD | Data Centers
Thousands
FOG | Nodes
Millions
EDGE | Devices
Billions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What is fog computing?

Fog computing, also called fog networking, is a compute layer between the cloud and the edge. Where edge computing might send huge streams of data directly to the cloud, fog computing can receive the data from the edge layer before it reaches the cloud and then decide what is relevant and what isn't. The relevant data gets stored in the cloud, while the irrelevant data can be deleted or analyzed at the fog layer for remote access or to inform localized learning models.

A real-life example of fog computing would be an embedded application on a production line, where a temperature sensor connected to an edge server would measure the temperature every single second. This data would then be forwarded to the cloud application for monitoring of temperature spikes. Imagine that all of the temperature measurements, every single second of a 24/7 measurement cycle, are sent to the cloud.

With a fog layer, the edge server would first send the data to the fog layer over a localized network. The fog server would receive this data and, according to certain parameters, decide whether it is worth sending on to the cloud. The end result is reduced traffic.

For simple temperature readings, these data savings might seem negligible. But imagine if you were constantly streaming complex information or large files like images or video. The impact on bandwidth and latency could be massive depending on the application.

What are the benefits of fog computing?

Now that we know that fog computing is an extra layer between the edge layer and the cloud layer, what are the benefits of having that extra layer? The initial benefit is efficiency of data traffic and a reduction in latency. By implementing a fog layer, the data that the cloud receives for your specific embedded application is a lot less cluttered. Where a cloud would have to first weed through a pile of unnecessary data before taking any action or returning results, it can now act directly upon the data that it receives from the fog layer.
When looking at the bigger picture, there are a lot more benefits. The amount of storage you would need for your cloud application would be considerably lower. This is because the cloud would only store and process relevant data. The data transfer would also be faster because the volume of data being sent to the cloud would be significantly reduced.

What are the disadvantages of fog computing?

One thing that should be clear is that fog computing can't replace edge computing. However, edge computing can definitely live without fog computing. Thus, the downside is that fog computing requires an investment. It is a more complex system that needs to be integrated with your current infrastructure. This costs money, time, and knowledge about the best solution for your infrastructure. Fog computing isn't an ideal solution in every scenario, but the benefits can be attractive for those currently using a direct edge to cloud data architecture.

How Fog Computing Works?

- While edge devices and sensors are where data is generated and collected, they don’t have the compute and storage resources to perform advanced analytics and machine-learning tasks. Though cloud servers have the power to do these, 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.

- In a fog environment, the processing takes place in a data hub on a smart device, or in a smart router or gateway, thus reducing the amount of data sent to the cloud. It is important to note that fog networking complements — not replaces — cloud computing; fogging allows for short-term analytics at the edge, and the cloud performs resource-intensive, longer-term analytics.

S.NO.	EDGE COMPUTING	FOG COMPUTING
01.	Less scalable than fog computing.	Highly scalable when compared to edge computing.
02.	Billions of nodes are present.	Millions of nodes are present.
03.	Nodes are installed far away from the cloud.	Nodes in this computing are installed closer to the cloud(remote database where data is stored).
04.	Edge computing is a subdivision of fog computing.	Fog computing is a subdivision of cloud computing.
05.	The bandwidth requirement is very low. Because data comes from the edge nodes themselves.	The bandwidth requirement is high. Data originating from edge nodes is transferred to the cloud.
06.	Operational cost is higher.	Operational cost is comparatively lower.
07.	High privacy. Attacks on data are very low.	The probability of data attacks is higher.
08.	Edge devices are the inclusion of the IoT devices or client's network.	Fog is an extended layer of cloud.
09.	The power consumption of nodes is low.	The power consumption of nodes filter important information from the massive amount of data collected from the device and saves it in the filter high.
10.	Edge computing helps devices to get faster results by processing the data simultaneously received from the devices.	Fog computing helps in filtering important information from the massive amount of data collected from the device and saves it in the cloud by sending the filtered data.