Cloud Computing

Module 1

Issues/Challenges

- The distance between the cloud and the data
- Network Bandwidth latency and cost
- Response time
- Processing speed
- Operational cost
- Security

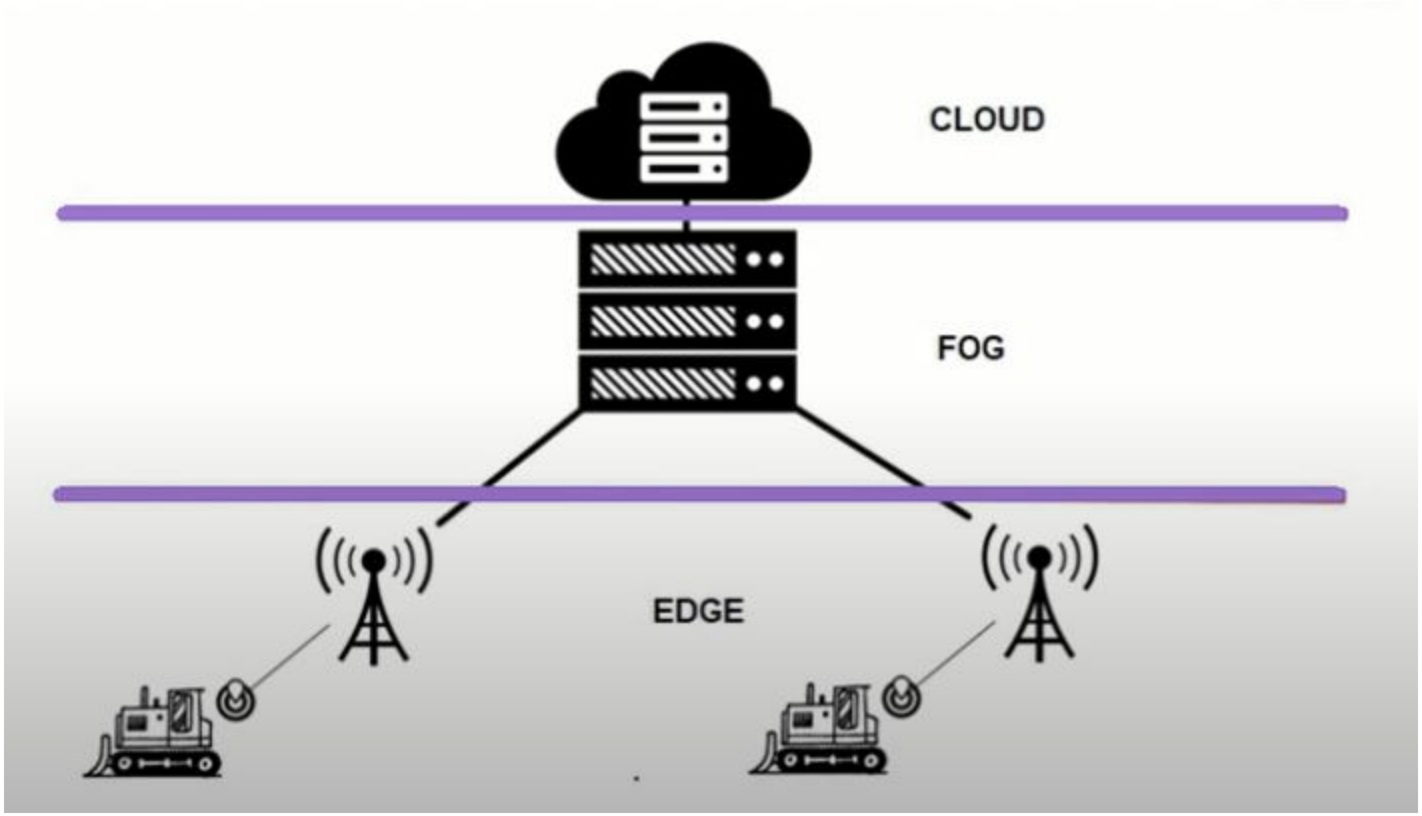
Layers of Computing

The terms “cloud,” “edge,” and “fog” represent three layers of computing:

- **Cloud Layer**: Industrial big data, business logic and analytics databases and data “warehousing”
- **Fog Layer**: Local network assets, micro-data centers
- **Edge Layer**: Real-time data processing on industrial PCs, process-specific applications and autonomous equipment

✔ Edge computing allows processing to be performed locally at multiple decision points for the purpose of reducing network traffic.

Contd…



Cloud Computing

- Cloud Computing ≈ Grid Computing + Utility Computing
- Outsource utilities (storage, computation etc.) to a third party, called **Cloud Service Provider**
- Managed by the service provider
- Illusion of unlimited resources
- Pay-as-you-go model
- Accessible through a network

Evolution of Applications

Stand Alone

- Resides on local system
- Local resources
- Self Sustaining
- Not shareable
- Prohibitive costs
- Frequent updates

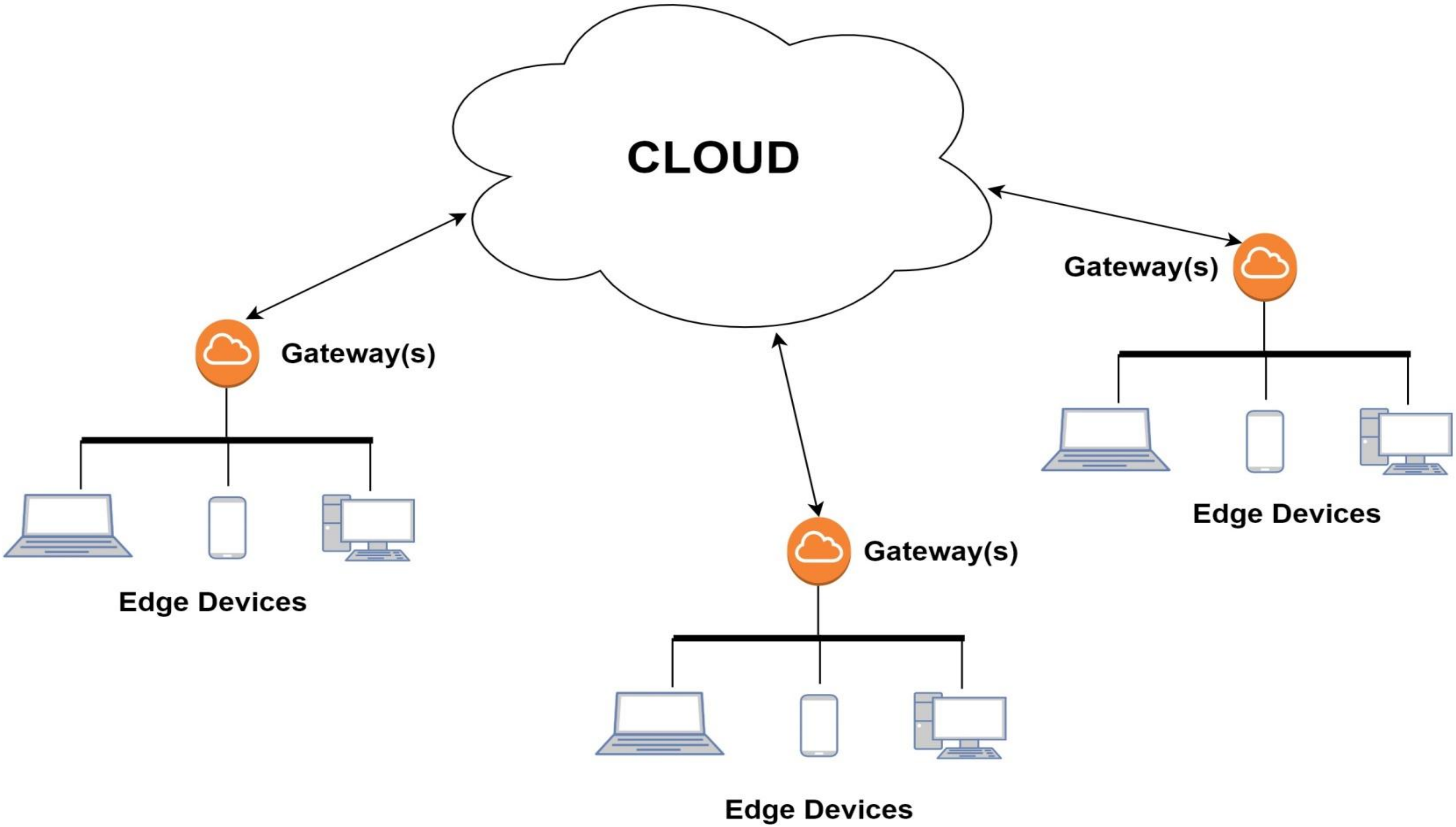
Web Apps

- Resides on remote system
- Client - Server Model
- Network Dependent
- QoS depends on number of users
- Inflexible usage model

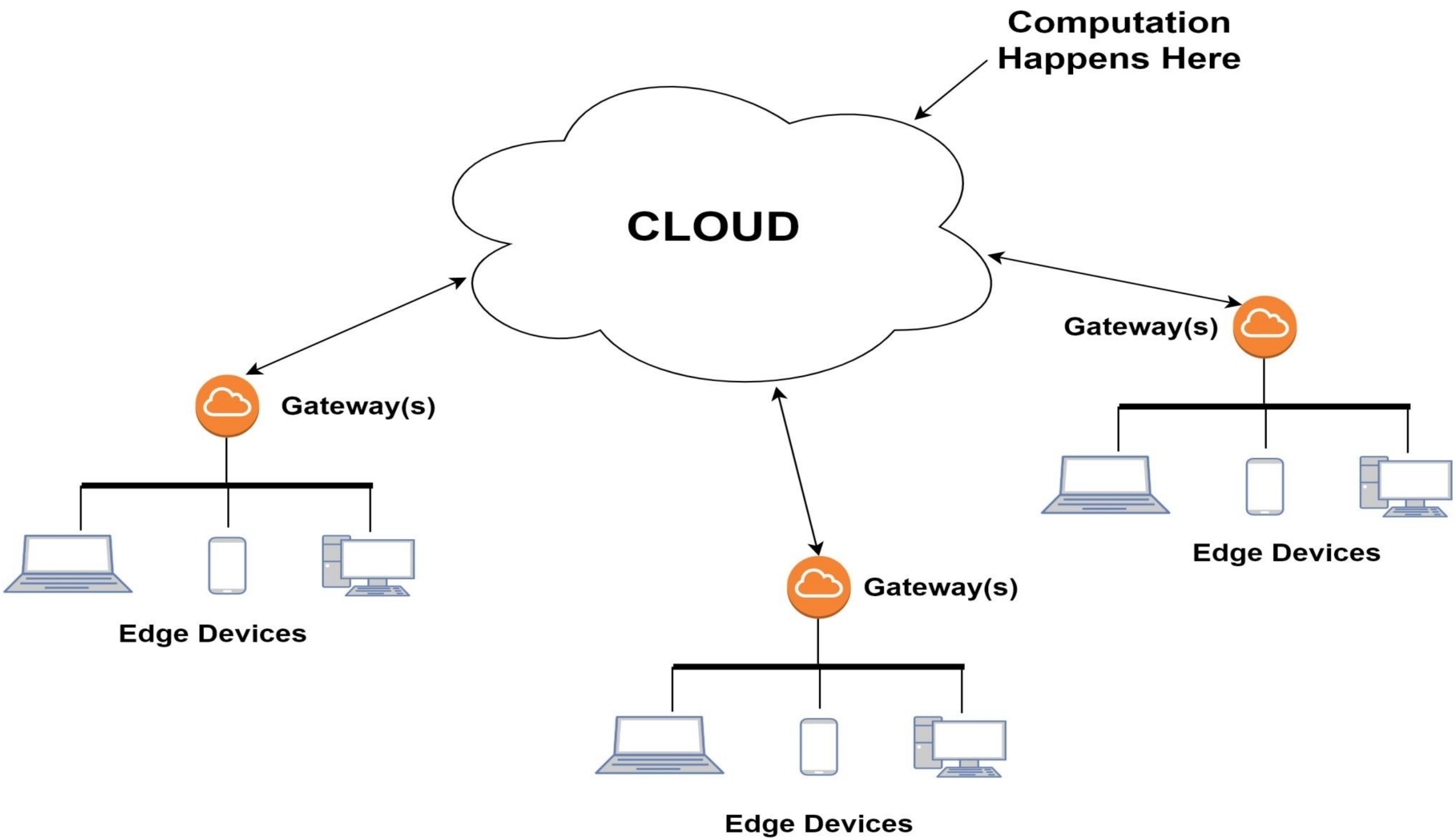
Cloud Apps

- Multi-tenancy
- Elasticity
- Heterogeneity
- Measured use
- On-demand
- Network dependent

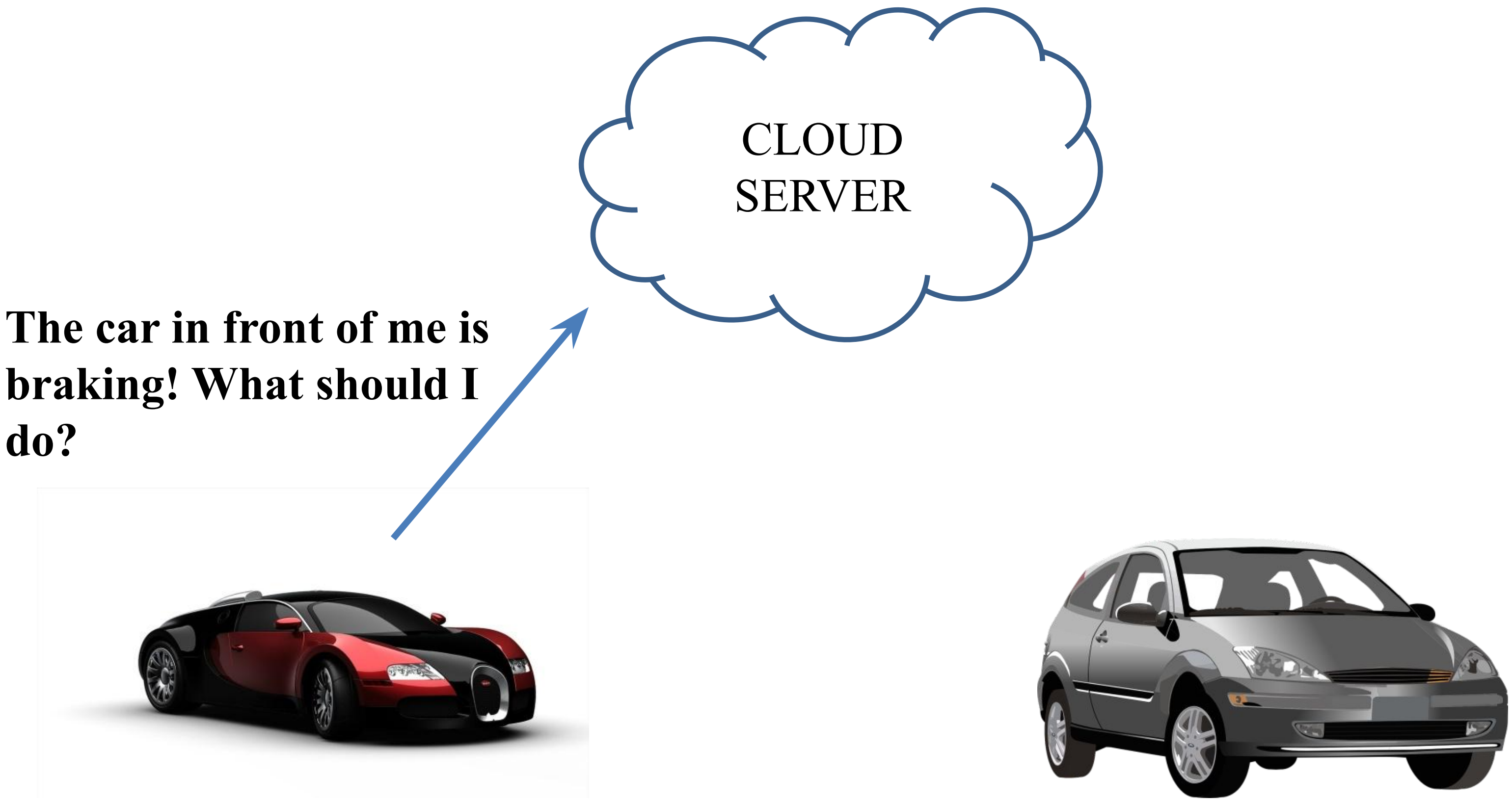
A Simple Architecture



Cloud Computing



Is Cloud Computing the Best Choice Always?

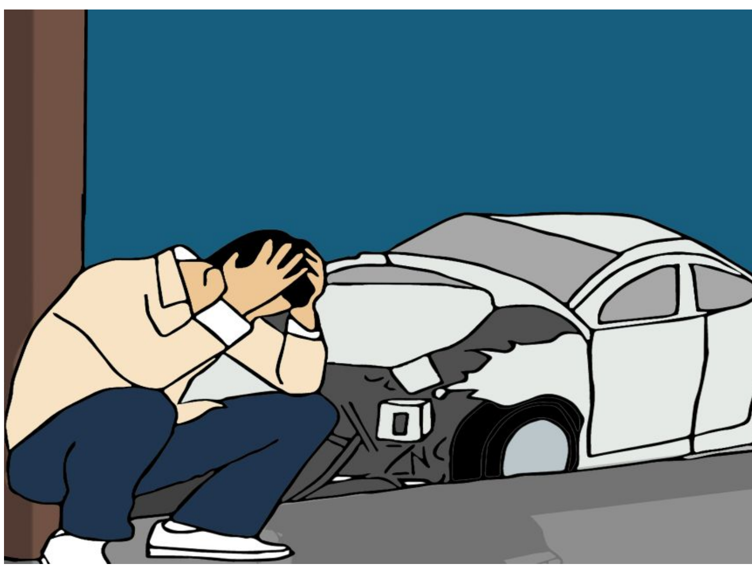


Consider the scenario of driverless cars

Is Cloud Computing the Best Choice Always?

CLOUD
SERVER

BRAKE!!!
Sorry for the delay ☹

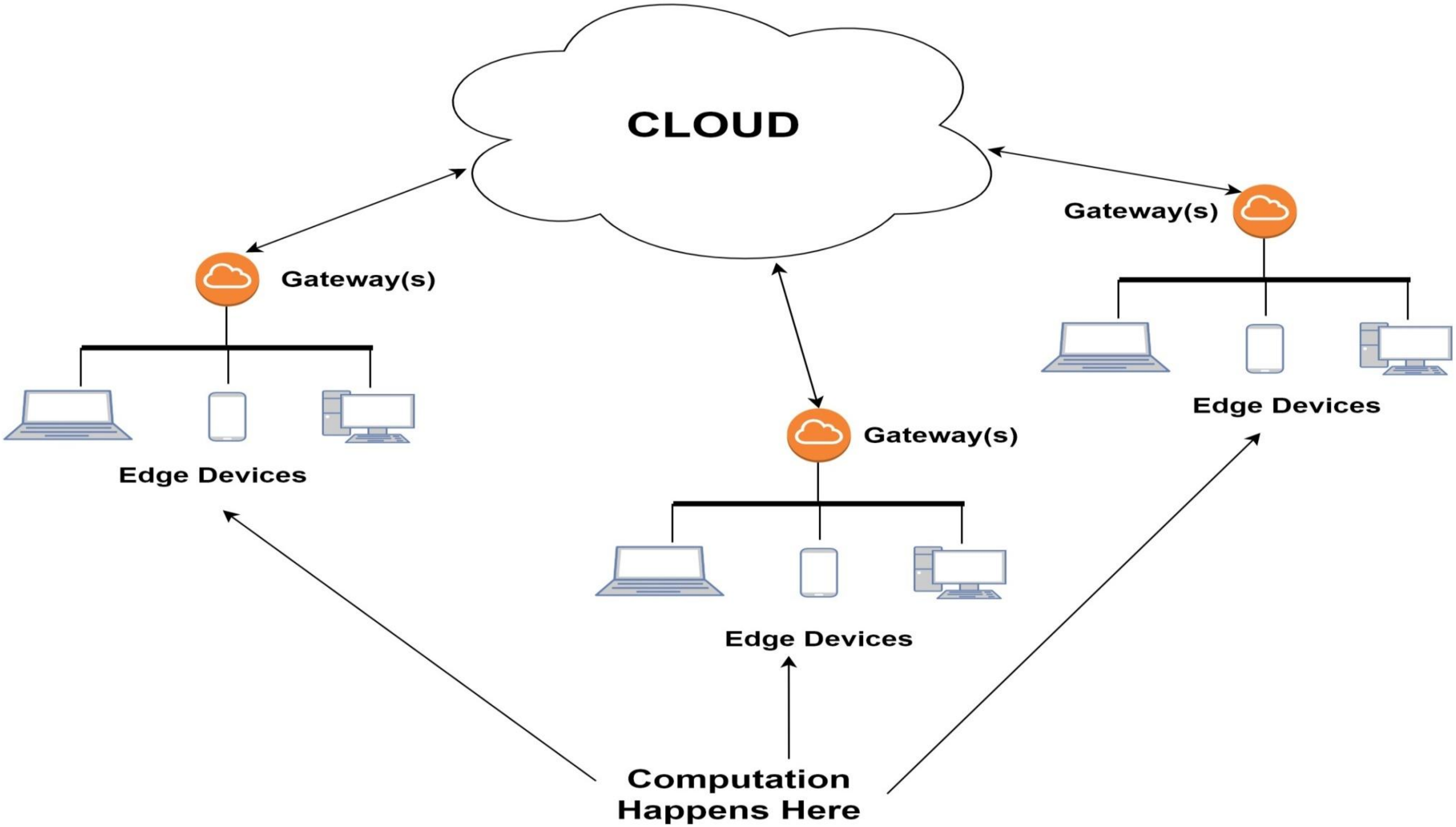


Consider the scenario of driverless cars

Problem: Self Driving Cars

- In real time systems, would there be enough time for data to be processed by a cloud server?
- In such cases, wouldn't it be better if data was processed closer to the source?

Edge Computing



Features of Edge Computing

- **Advantages**
  - Low Latency
  - Faster Decisions
  - Privacy
  - Edge computing also improves security by encrypting data closer to the network core
- **Disadvantages**
  - Edge devices will have lower computational power
  - Lack of a global (or network level) view

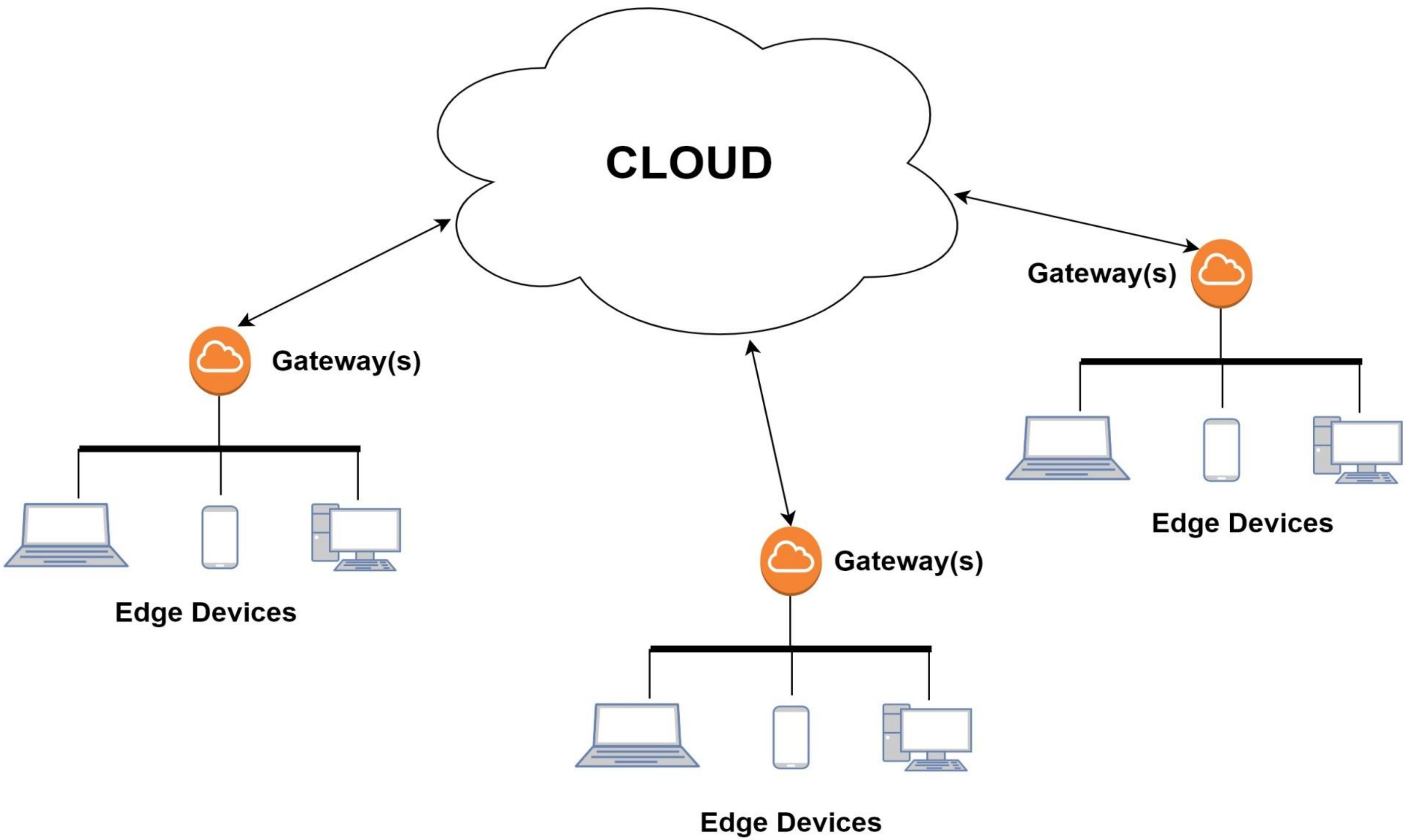
Automated Museum Tour Guides

More and more museums are now relying on automated robots to replace museum tour guides. For example, the Smithsonian Museum launched a robot named “Pepper” in 2018

An Issue with Edge Computing

- Consider the case of the automated museum tour guides:
  - All information that the robot needs is localized – need not use the "cloud" realistically
  - Interaction with tourists – need for local processing power
  - What if some exhibits are closed? Or the order changes?
  - There is a need for a broader, museum-level view for efficient functioning

Fog Computing



Fog Computing

- Fog and edge computing are both extensions of cloud networks.
- Move computation to a location between the nodes and the cloud.
- Mobile users have predictable service demands subject to their locations.
- Fog Servers can periodically connect with cloud servers and cache location specific information.
- Information from edge devices can be processed by fog servers to provide an interactive experience.

Features of Fog Computing

- Contextual location awareness + low latency
- Geographical distribution
- Heterogeneity
- Interoperability
- Real-time interactions
- Scalability

How do Fog and Edge Computing Work?

- Fog computing is useful when the Internet connection isn't always stable.
- Fog computing allows to implement data processing at the local networks, especially if it has to be processed in real time.
- On the cloud, data is distributed to dozens of servers, whereas edge computing uses hundreds, possibly thousands of local nodes.
- Each device can act as a server in the edge network. To break into, hackers would need access to thousands of distributed devices, which is practically impossible.

Benefits of Fog Computing

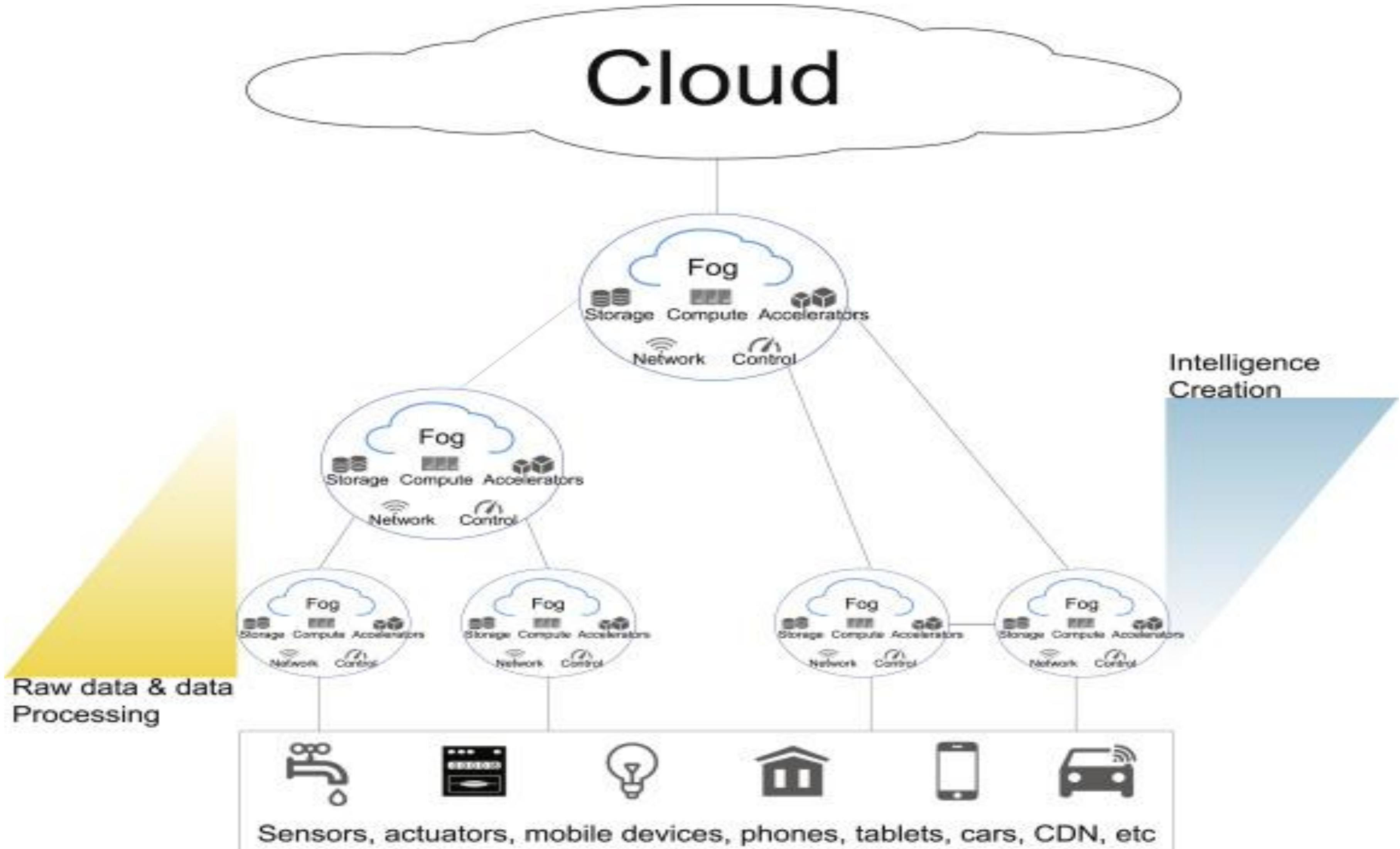
- **Low latency.** The fog network can process large volumes of data with little-to-no delay. Because a lot of data is stored locally, the computing is performed faster.
- **Better data control.** In cloud computing, third-party servers are fully disconnected from local networks, leaving little to no control over data. In fog computing, users can manage a lot of information locally and rely on their security measures.
- **A flexible storage system.** Fog computing doesn't require constant online access. The data can be stored locally or pulled up from local drives — such storage combines online and offline access.
- **Connecting centralized and decentralized storage.** Fog computing builds a bridge between local drives and third-party cloud services, allowing a smooth transition to fully decentralized data storage.

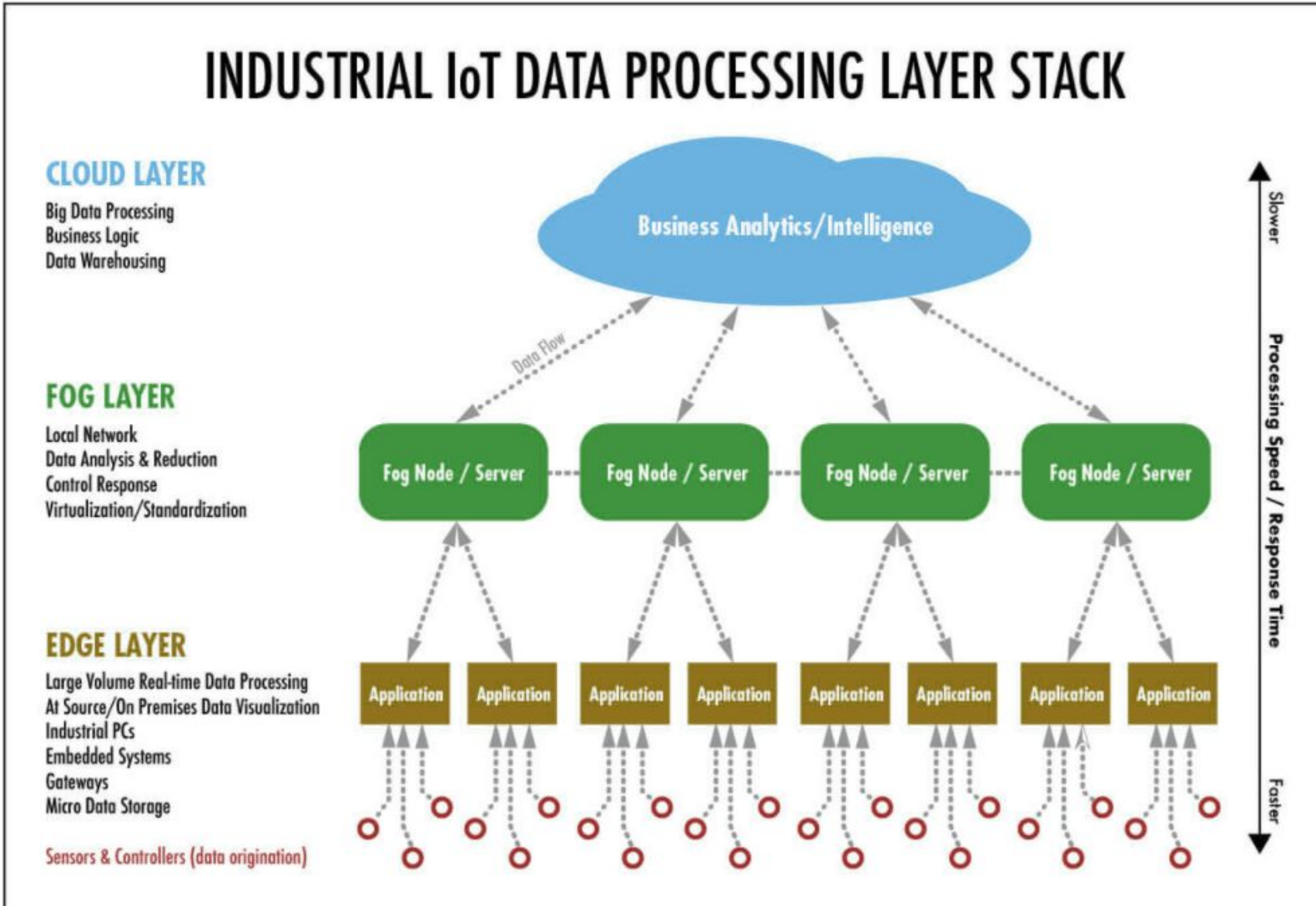
Benefits of Edge Computing

- **No delays in data processing.** The data stays on the "edges" of the IoT network and can be acted on immediately.
- **Real-time data analysis.** Works great when large amounts of data have to be processed and immediately.
- **Low network traffic.** The data is first processed locally, and only then sent to the main storage.
- **Reduced operating costs.** Data management takes less time and computing power because the operation has a single destination, instead of circling from the center to local drives.

IoT edge computing is an optimal solution for small immediate operations that have to be processed with millisecond rates. When many small operations are happening simultaneously, performing them locally is faster and cheaper.

Hierarchy of Edge, Fog and Cloud




INDUSTRIAL IoT DATA PROCESSING LAYER STACK
CLOUD LAYER
Big Data Processing
Business Logic
Data Warehousing
Business Analytics/Intelligence
Data Flow
FOG LAYER
Local Network
Data Analysis & Reduction
Control Response
Virtualization/Standardization
Fog Node / Server
Fog Node / Server
Fog Node / Server
Fog Node / Server
EDGE LAYER
Large Volume Real-time Data Processing
At Source/On Premises Data Visualization
Industrial PCs
Embedded Systems
Gateways
Micro Data Storage
Application
Application
Application
Application
Application
Application
Application
Application
Sensors & Controllers (data origination)
Slower
Processing Speed / Response Time
Faster

Role of IoT and Cloud Computing

- **Increased scalability.** IoT systems **produce and exchange a lot of data and require a lot of storage space** to seamlessly function. IoT services on Cloud platforms like Microsoft Azure IoT Suite, Google Cloud's IoT service, and IBM's IoT platform provide access to powerful cloud services able to handle all this IoT data.
- **Improved safety.** IoT services should rely on safe data storage able to prevent hackers from trying to access and jeopardize the system. Decentralized storage represents one of the ways to secure sensitive resources.
- **Enable IoT.** Decentralized data storage corresponds with the main IoT needs, such as accessibility, safety, mobility, and scalability. Cloud services process massive amounts of data and quickly distribute the information among multiple servers, where it can be later accessed by a connected device anytime.

The future with IoT, Edge, Fog and Cloud Computing?

- IoT sector is rapidly growing, and we are likely heading into a future where every device is connected.
- With smart homes, cars, equipment, and everything else, vast masses of data are generated every second.
- Devices will continue to require increases in computer power, and cloud computing offers decentralized storage solutions for faster and cheaper deployments.
- Developers only have to connect their systems to IoT cloud platform existing infrastructure to benefit from third-party computing power.

Benefits

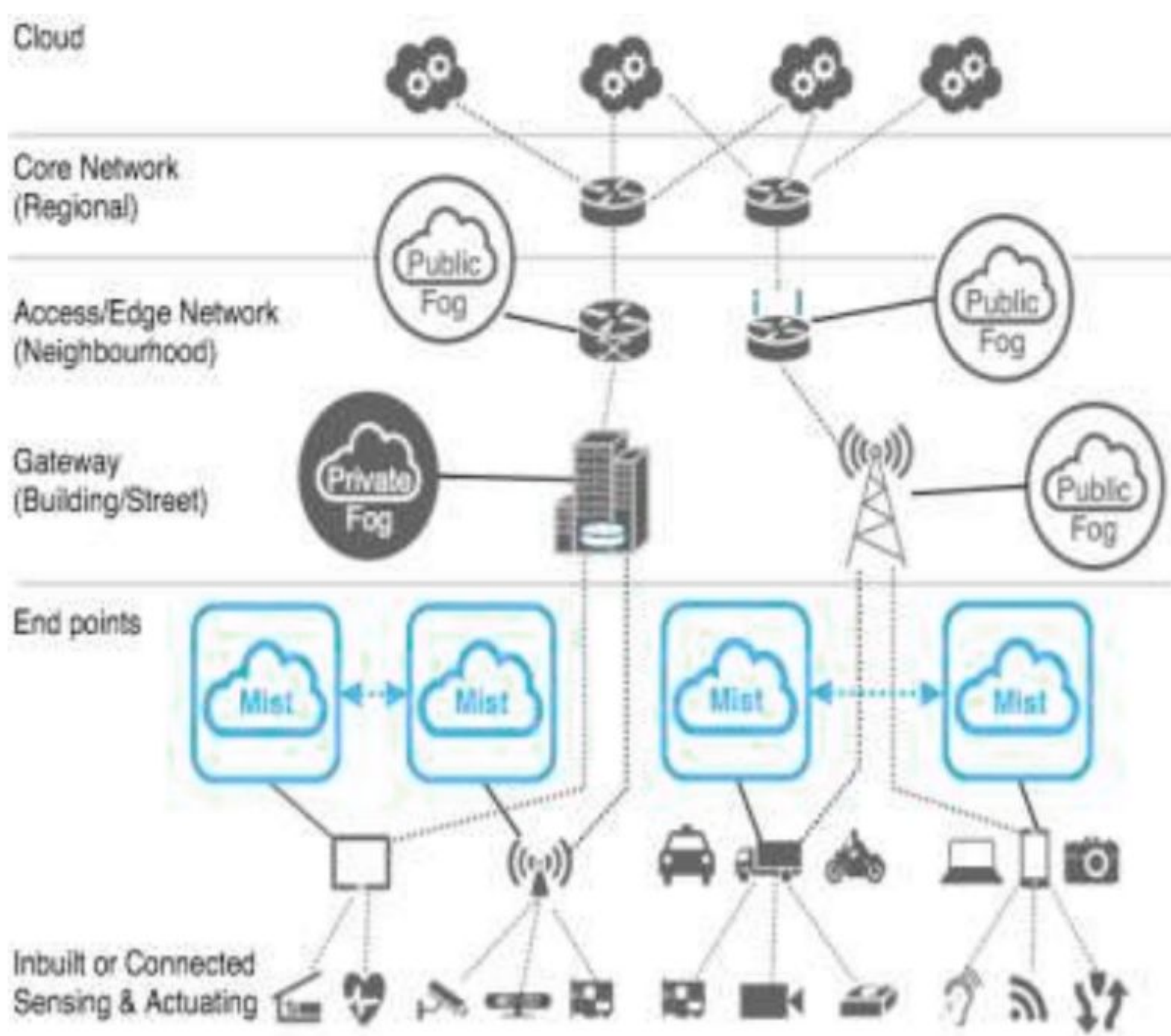
1. **Smart analytics:** Internet of Things systems produce a lot of data. Developers and businesses can use it to know their users better. Cloud services provide a safe environment where this data could be analyzed, managed, and stored.
2. **Better security:** A security breach in IoT networks could mean compromising entire businesses and industries, affecting millions of connected devices and people who use them. Cloud storages are more difficult to target because of their remote position and security practices.
3. **Inter-device interactions:** The cloud improves communication between devices and applications, quickly sending data between data centers and local nodes. Fog and edge computing can be useful for offline communication and micro-operations, reducing operation costs and increasing speed.

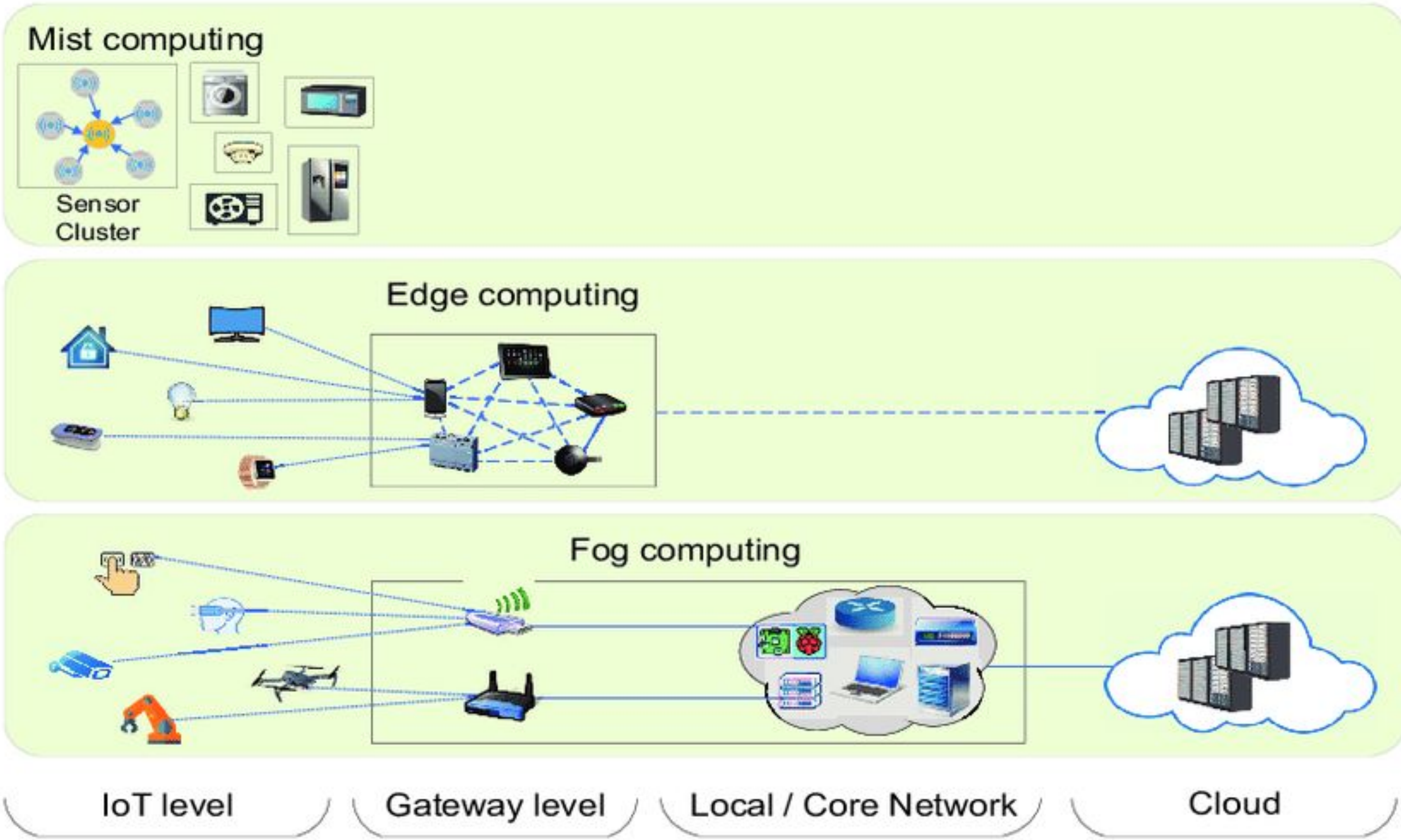
Mist Computing

- **Mist computing** is a lightweight and rudimentary form of fog computing that resides directly within the network fabric at the edge of the network fabric
- Uses microcomputers and microcontrollers to feed into fog computing nodes and cloud computing services.

[Widely varying definitions of fog, mist and edge computing can be seen in literature. The definitions used here are adopted from NIST specifications]

Architecture of Mist Computing

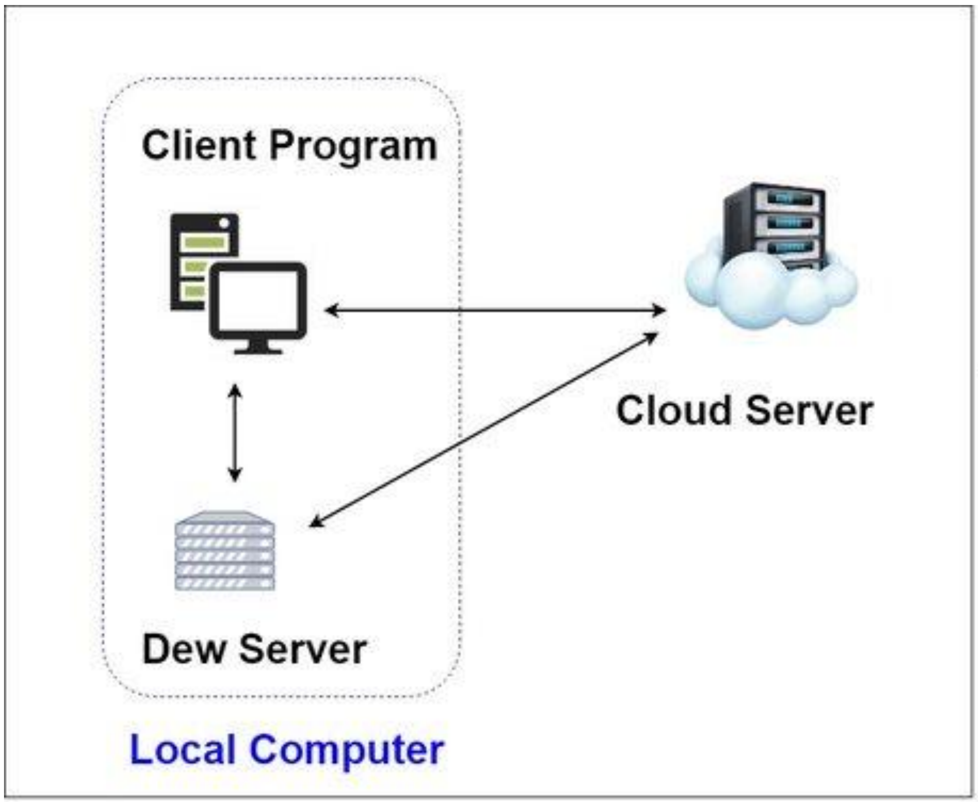


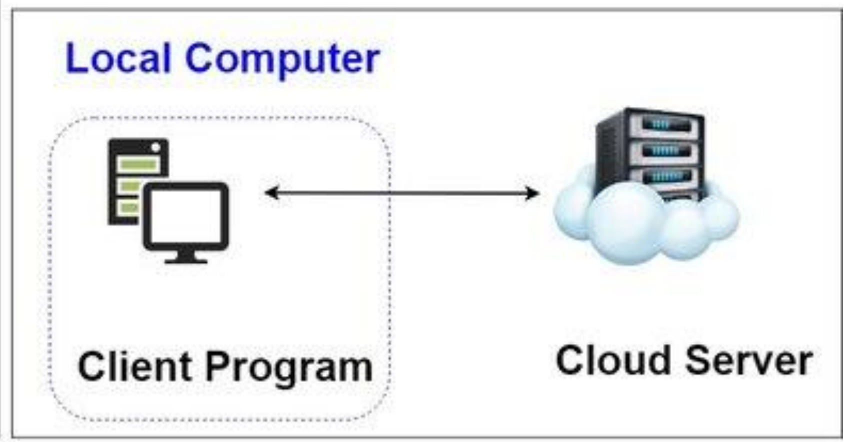

Mist computing
Sensor Cluster
Edge computing
Fog computing
IoT level
Gateway level
Local / Core Network
Cloud

Dew Computing

- What happens to cloud computing when you lose network access?
- Dew Computing is a framework wherein a version of the cloud architecture is replicated on a local system – immune to loss of connectivity
- Applicable to systems with direct human interaction, such as laptops, desktops and mobile devices
- Eg: Dropbox

Dew vs Cloud Computing





Dew Computing Architecture

Cloud Computing Architecture