Sustainability and Edge Cloud Computing

Smart-Edu4.0

Erasmus+ project

Sustainability and Edge Cloud Computing

Sustainability and edge cloud computing are two areas that are increasingly interconnected.

Edge cloud computing is a model where data processing and storage occur closer to the end-users or devices generating the data, rather than in a centralized data center.

From a sustainability perspective, edge cloud computing can have several benefits:

- lower energy consumption
- cost savings
- reduced carbon emissions
- less resources
- reducing the latency of the service
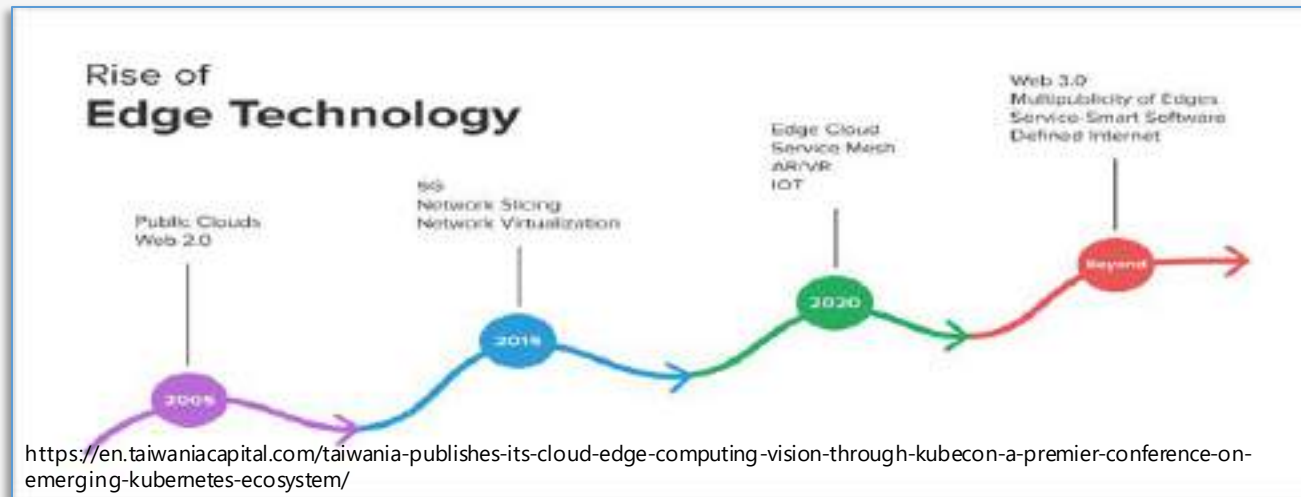- improving the accuracy and
- security of data collection

https://sustainability-success.com/how-can-edge-computing-be-used-to-improve-sustainability/?utm_content=cmp-true
https://venturebeat.com/business/state-of-the-edge-report-projects-edge-computing-will-reach-800b-by-2028/

What is Edge to Cloud?   -   What is Data Sustainability?

Edge to cloud refers to the fact that data is no longer confined to the data center; It is being generated at the edge in ever-growing amounts, processed and stored in the cloud, and used by an increasingly distributed global workforce.

Data from IoT devices, smart sensors, and devices on the edge of networks, must be collected, stored, and processed.

https://en.taiwaniacapital.com/taiwania-publishes-its-cloud-edge-computing-vision-through-kubecon-a-premier-conference-on-emerging-kubernetes-ecosystem/

Data Sustainability

While processing, centralized data centers emit high carbon emissions and consume a lot of energy.

Shifting to edge computing →Cutting unnecessary traffic, computational power, and storage

https://www.tutorialspoint.com/iot-edge-computing-and-data-sustainability
https://www.hpe.com/us/en/what-is/edge-to-cloud.html
https://www.slingshotsimulations.com/sustainability/7-ways-to-make-data-more-sustainable/

Sustainability and Edge Cloud Computing topics

Edge cloud computing: the practice of using distributed computing resources located close to the devices and users

→faster processing times, improved latency, and reduced bandwidth requirements.

Sustainability and edge cloud computing:

1. Energy Efficiency
2. Renewable Energy
3. Reduced Latency
4. Smart Grids
5. Reduced E-Waste

https://hbr.org/2020/09/how-green-is-your-software/

Definition of Edge Computing

EDGE COMPUTING IS THE PLACEMENT OF

DATA CENTER-GRADE **NETWORK, COMPUTE & STORAGE**

Closer to

ENDPOINT DEVICES

TO IMPROVE **SERVICE CAPABILITIES**

Optimize **TCO**

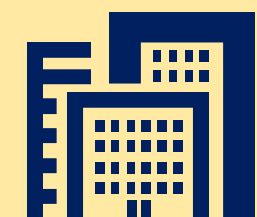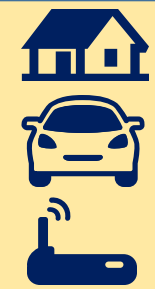Comply with Data **Locality**

And reduce application **Latency**

The Edge Is the

Outmost layers of

Processing or Network

BEFORE TRANSITION TO THE ENDPOINT **OR** Another Network

Edge computing is simply optimizing data processing

Data collected at the edge is categorized:

- Immediate attention is needed
- Should be retained for later analysis
- Can be ignored

HOW EDGE COMPUTING WORKS

Edge computing allows data from Internet of Things devices to be analyzed at the edge of the network before being sent to a data center or the cloud.

INTERNET OF THINGS

CLOUD

EDGE LOCAL PROCESSING

CORPORATE DATA CENTER

Edge computing :

- Enabling real-time data processing
- Caching, buffering, and optimizing the data
- Transforming the data into a format for analysis.
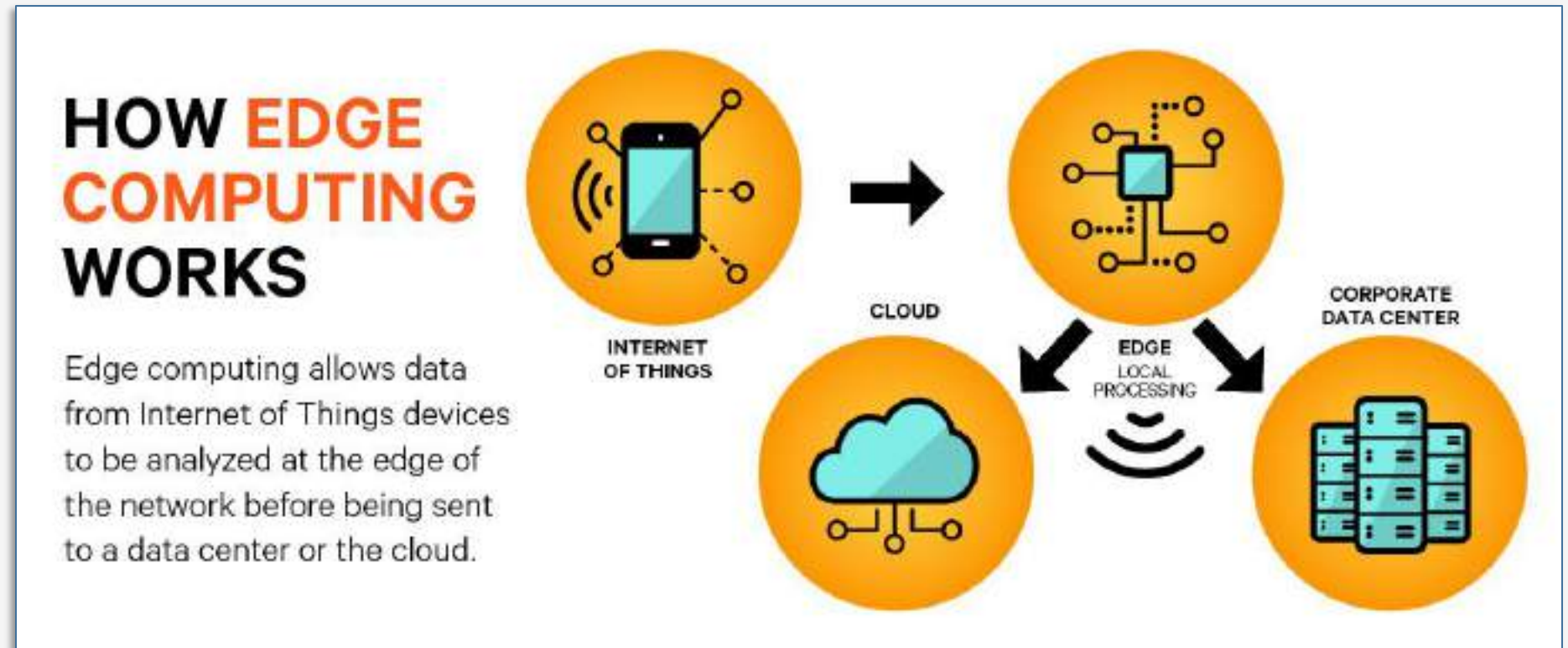
Cloud versus Edge: an Example

In a typical cloud setup, data is gathered on edge devices and forwarded to the cloud for computation and storage.

Edge devices are dumb devices that are dependent upon a working internet connection and a working cloud server. In a smart home cloud example, data would be sent from devices in the home, e.g. a thermostat, the door, the TV etc. to the cloud, where it is saved and used.

If the user would want to make changes via a cloud-based mobile app when in the house, the changes would be send to the cloud, changed there and then from there be sent to the devices. When the Internet connection is down or the server is not working, the application will not work.

https://objectbox.io/why-do-we-need-edge-computing-for-a-sustainable-future/
https://thenewstack.io/emerging-edge-cloud-and-computing-infrastructure/
https://www.spiceworks.com/tech/edge-computing/articles/best-edge-computing-platforms

Cloud versus Edge: an Example

With Edge Computing, data stays where it is produced, used and where it belongs – without traversing the network unnecessarily. This way, cloud infrastructure needs are reduced in three ways: less network traffic, less central storage, less computational power.

E.g. in a smart home, all the data could stay within the house and be used on site. Only the small part of the data truly needed accessible from anywhere would be synchronized to the cloud.


Edge Computing enables the smart home to work fast, efficiently, and autonomous from a working internet connection. In addition, the smart home owner can keep the private data to him/herself and is less vulnerable to hacker attacks.

https://objectbox.io/why-do-we-need-edge-computing-for-a-sustainable-future/

Energy Efficiency

Edge cloud computing can contribute to sustainability by reducing the energy consumption required for data processing and storage.

processing data closer to the source →reduces the energy required to transmit data
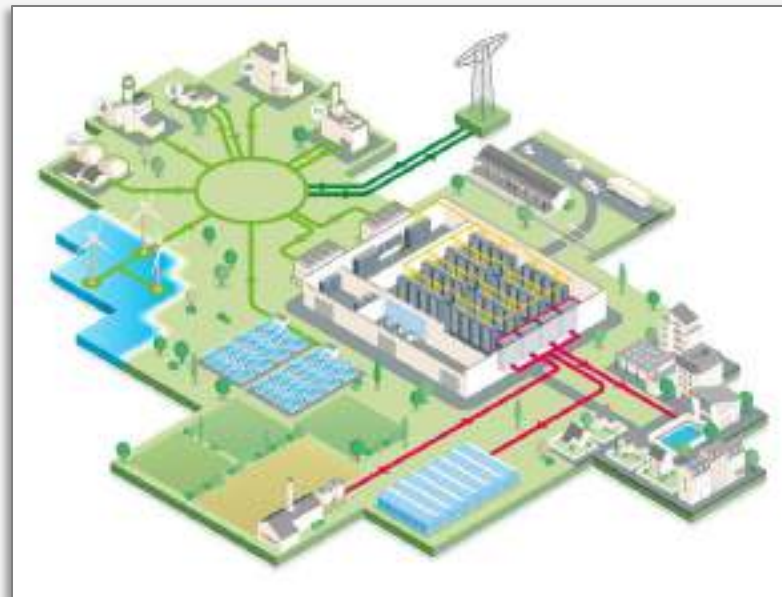
Reducing energy consumption is good for the environment and benefits the data center operator financially.

https://thenewstack.io/emerging-edge-cloud-and-computing-infrastructure/
https://www.datacenterdynamics.com/en/opinions/future-data-centers-green/
https://www.engie.com/en/campaign/green-data-centers

Energy Efficiency - Cost Savings

Data centers already consume over 3% of world's total electricity.   2020: around 200TWh of electricity

lower energy consumption ➔ cost savings

- Cloud data centers often run 24/7 even when they are not being used.

- Energy is required for the power and cooling of data centers.

- An edge data center require less energy for cooling, relative to its output and size.

https://stlpartners.com/articles/edge-computing/edge-computing-changing-the-balance-of-energy-in-networks/
https://www.racksolutions.com/news/blog/edge-data-center/

Renewable Energy

Edge cloud computing can support the use of renewable energy sources by processing data closer to renewable energy sources.

For example, edge cloud computing can be used to process data generated by wind turbines or solar panels, reducing the need to transmit the data to centralized data centers powered by non-renewable energy sources.

https://aiforgood.itu.int/embracing-digitalization-the-accelerating-force-behind-decarbonization-and-energy-transition/

Source: https://stlpartners.com/articles/edge-computing/edge-computing-changing-the-balance-of-energy-in-networks/
https://www.racksolutions.com/news/blog/edge-data-center/

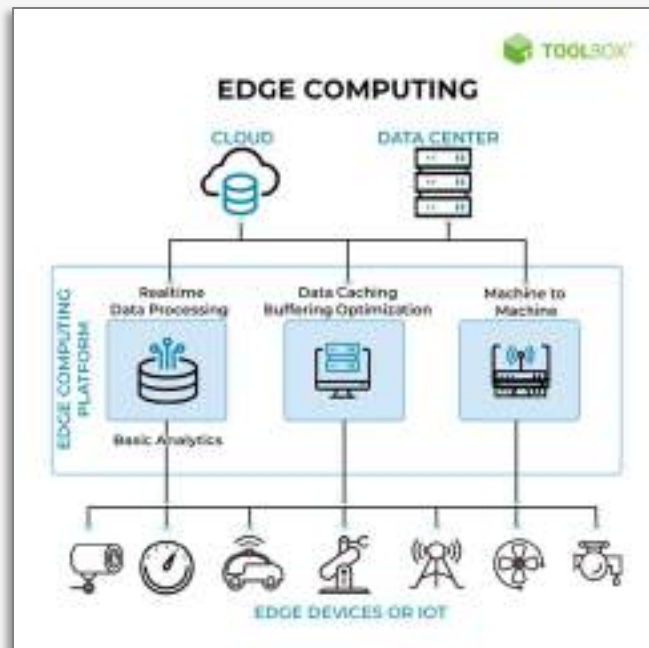# Reduced Latency

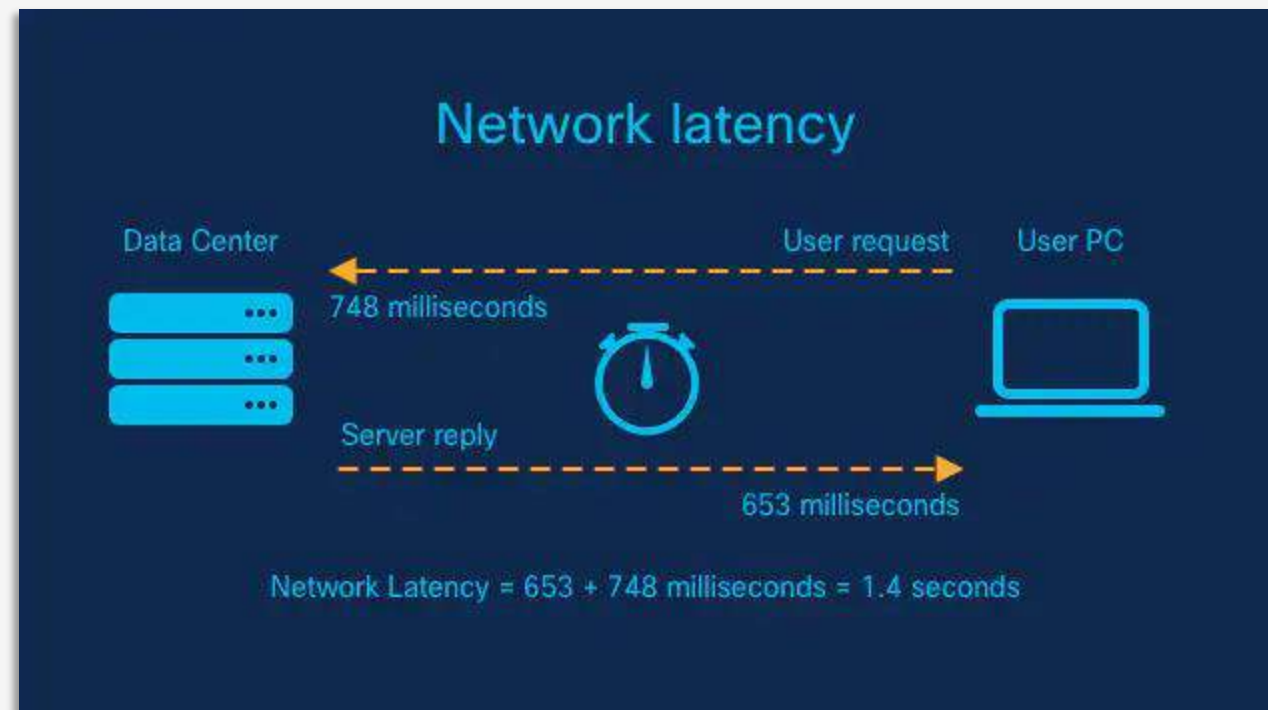Edge cloud computing reducing the latency required for data processing and storage.

- data closer to the source →reduces the time required to transmit data to centralized data centers for processing

- reduced latency → reduce the overall energy required for data processing and storage

Latency: travel time of data
reduced latency → improved speed

Reduced Latency - Improved speed : Examples

For example, autonomous vehicles, industrial and manufacturing IoT deployments and medical use cases all require machines to analyze data and return instructions nearly instantaneously in order to function safely.

https://threatpost.com/patched-flaw-in-bosch-diagnostic-dongle-allowed-researchers-to-shut-off-engine/125061/

https://www.softeq.com/blog/5g-and-edge-computing-in-iot-deployments-where-does-the-value-come-from

Smart Grids

Edge cloud computing can support the development of smart grids. Smart grids are intelligent power distribution networks that can balance the supply and demand of energy, reducing waste and increasing efficiency. Edge cloud computing can be used to process the large amounts of data generated by smart grids.
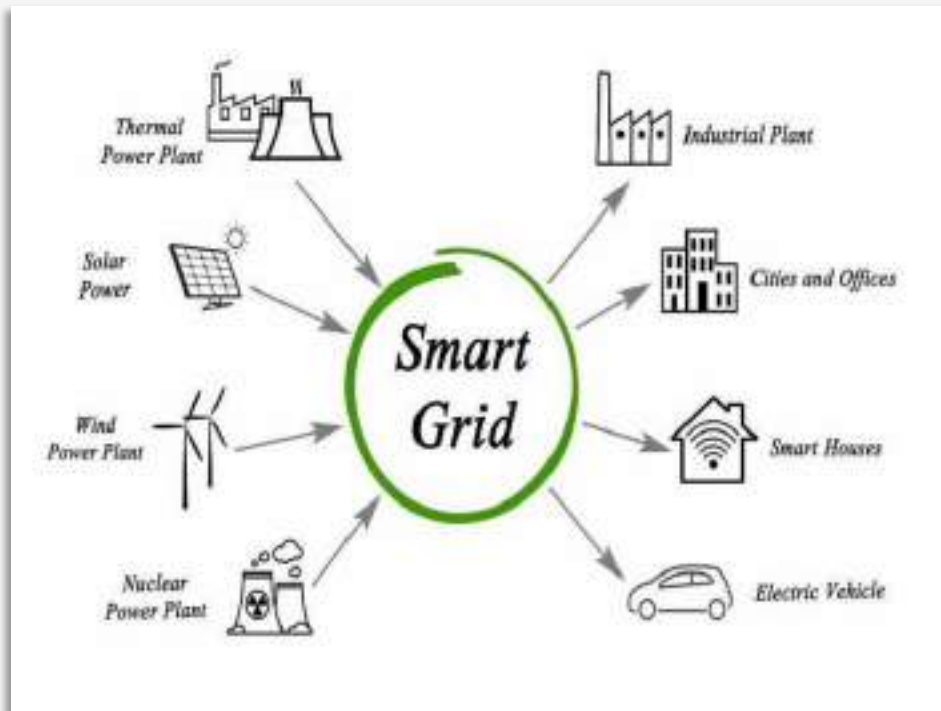
Smart Grids and Smart Cities

Edge cloud computing enables smarter grids and allows enterprises to better manage their energy consumption.

Sensors and IoT devices connected to an edge platform in factories, plants and offices are being used to monitor energy use and analyze the energy levels in real-time → manage energy consumption
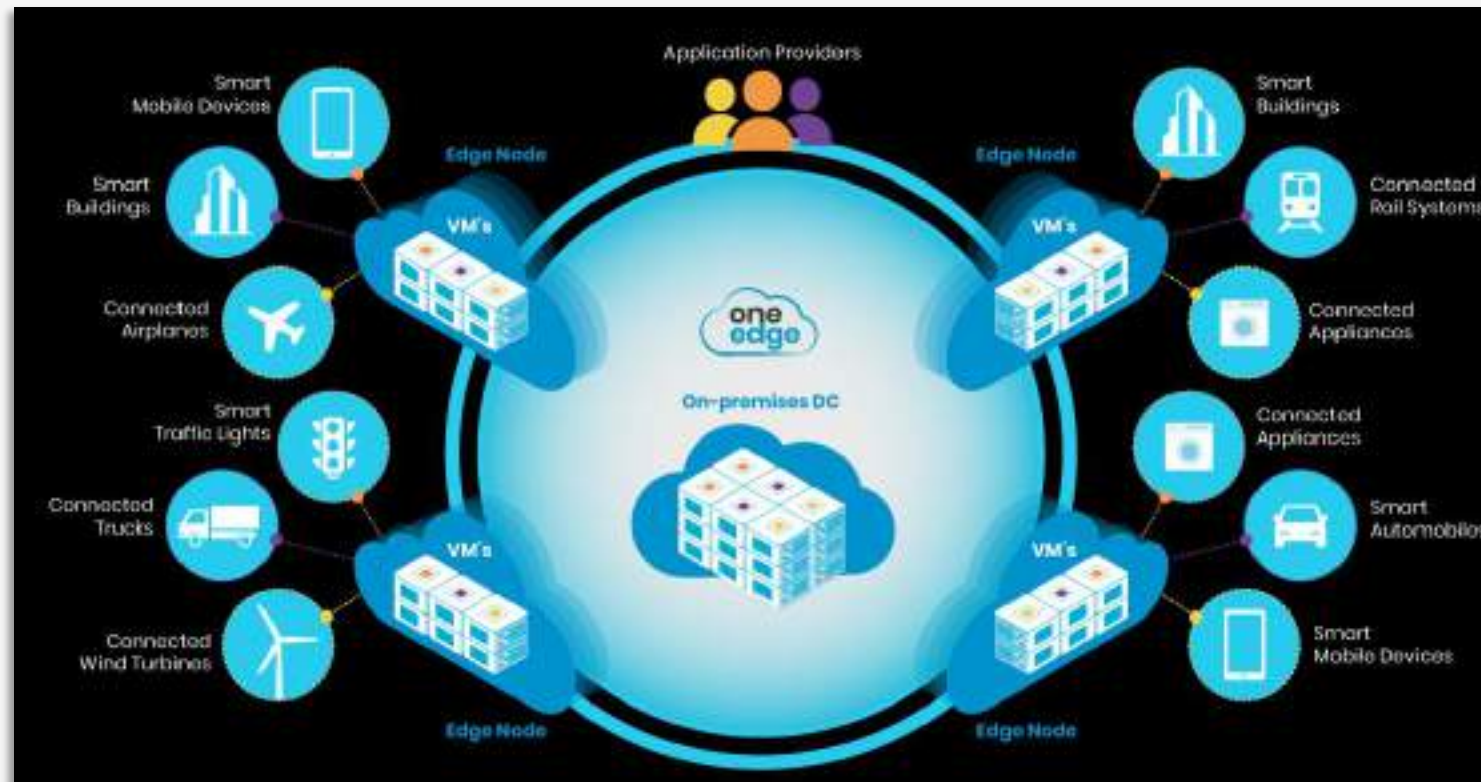
Smart Grids and Smart Cities

When Category 4 Hurricane Ike knocked out Houston's entire power grid in 2008, CenterPoint Energy, a provider of electrical power to 2.4 million customers in the Houston area, saw the event as a wake-up call. It was spurred into action to transform its service into an internet of things network steered by intelligent meters and IoT sensors around the power grid.

The new smart grid system that resulted allows for automatic insight into power delivery patterns, service, disruption, infrastructure damage, security breaches, and other information.
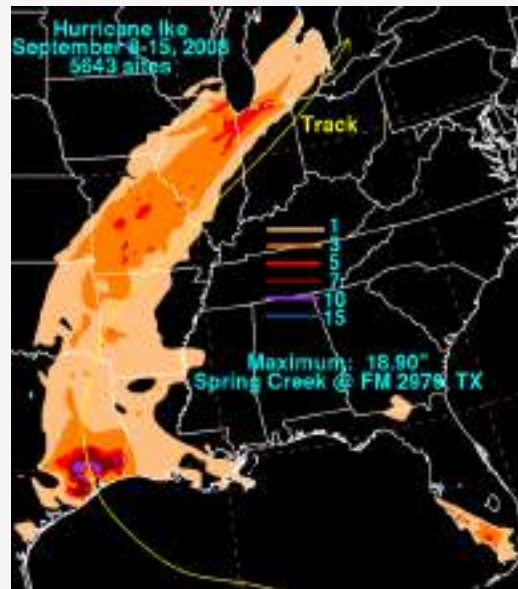
https://upload.wikimedia.org/wikipedia/commons/thumb/9/9d/Ike_2008_rainfall.gif/220px-Ike_2008_rainfall.gif

https://eu.patriotledger.com/story/news/2008/09/13/crews-fan-out-in-texas/40154083007/

https://www.hpe.com/us/en/insights/articles/how-edge-to-cloud-computing-powers-smart-grids-and-smart-cities-2204.html

https://www.cbsnews.com/news/texas-pounded-by-hurricane-ike/

Edge cloud computing and Smart Cities

Smart city ➔ integrate all data into system that uses edge cloud computing to function optimally and safely

Understanding the ever-shifting availability of energy and location of demand ➔ lot of processing capability (which systems and customers are the priorities etc.).

- Running such systems via the cloud has limitations, particularly when it comes to security and efficiency.
- Certain sectors, such as utilities and government, may not want systems to be in the public cloud.
- Edge cloud computing is an alternative brings the data and the processing location closer together to ensure rapid processing at reasonable cost while eliminating key security risks to maintain a safe energy supply.
- The same principle applies to traffic monitoring, waste handling, public transit management.

https://www.axiomtek.com/Default.aspx?MenuId=Solutions&FunctionId=SolutionView&ItemId=2168&Title=Smart+City+Infrastructure

https://www.hpe.com/us/en/insights/articles/how-edge-to-cloud-computing-powers-smart-grids-and-smart-cities-2204.html
https://www.axiomtek.com/Default.aspx?MenuId=Solutions&FunctionId=SolutionView&ItemId=2168&Title=Smart+City+Infrastructure

Reduced E-Waste

Edge cloud computing can contribute to sustainability by reducing e-waste. By processing data closer to the source, edge cloud computing can reduce the need for end-users to upgrade their devices to handle the increasing amounts of data generated by new applications. This reduced need for device upgrades can reduce the overall amount of e-waste generated.

Optimizing Resource Usage

Edge cloud computing allows real-time monitoring and analysis of data, enabling optimization of resource usage such as energy, water, and raw materials.

This can help reduce waste and lower the environmental impact of resource-intensive industries.

https://iotmktg.com/how-edge-computing-is-driving-sustainability/
https://www.nutanix.com/theforecastbynutanix/technology/edge-and-cloud-computing-together
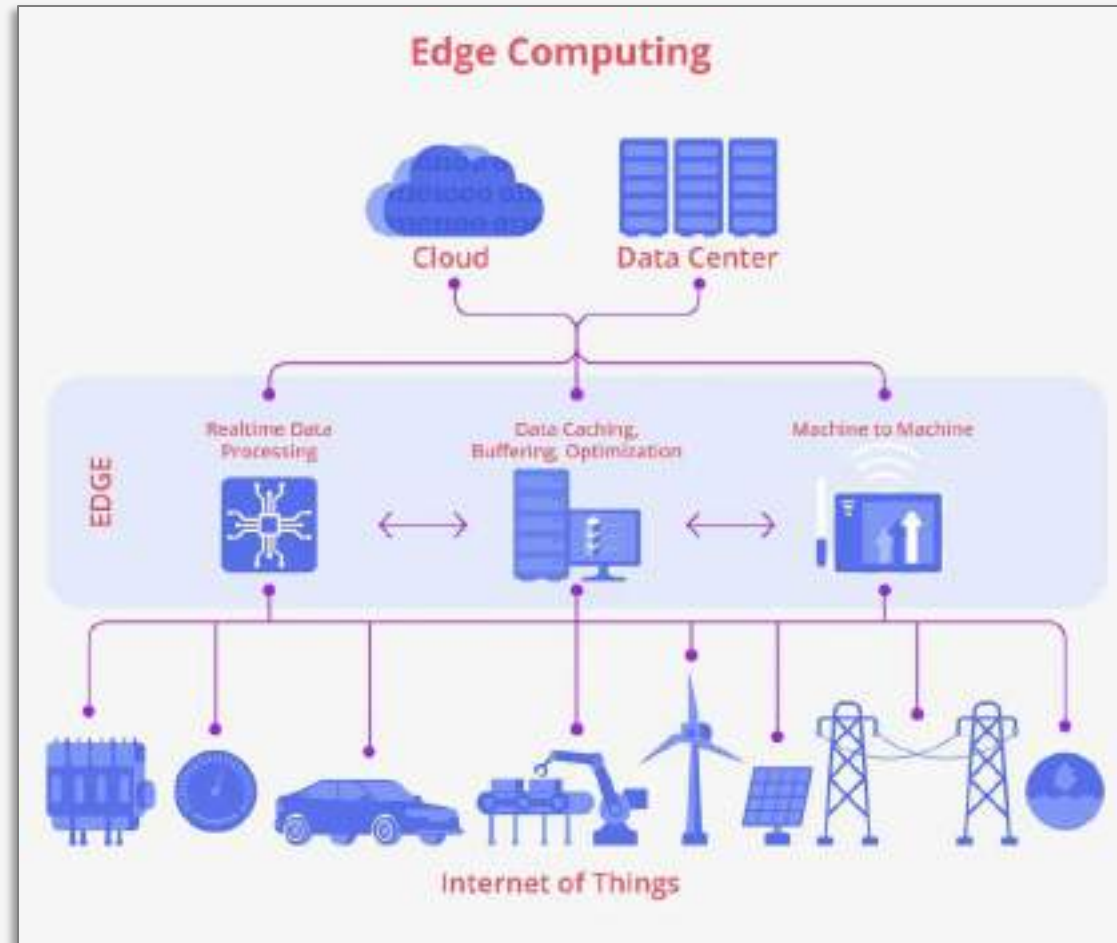
Improving Sustainability in Transportation

By reducing fuel consumption and associated greenhouse gas emissions, edge cloud computing helps to optimize traffic flow and reduce congestion.

It also allows real-time monitoring of vehicle emissions, enabling better management of pollution levels.

Enhancing Sustainability in Buildings

Edge cloud computing aids in improving energy management in buildings by providing real-time data on energy usage and enabling the optimization of energy consumption.

This can help reduce energy waste and improve the sustainability of buildings.

https://iotmktg.com/how-edge-computing-is-driving-sustainability/
https://www.freepik.com/free-photos-vectors/green-building
https://rmjm.com/10-examples-of-sustainable-architecture-around-the-world/

Enabling Sustainable Agriculture

Edge cloud computing can help optimize agricultural production by providing real-time data on soil conditions, crop growth, and weather patterns.

This can help farmers optimize crop yields, reduce waste, and improve the sustainability of agricultural practices.

https://iotmktg.com/how-edge-computing-is-driving-sustainability/
https://www.lanner-america.com/blog/smart-farming-iot-5g-agriculture/

At the Edge Vs. In the Cloud: Artificial Intelligence and Machine Learning

Cloud Computing

Remote Devices

Cloud AI

Remote devices connect to an AI in the cloud, where data processing occurs.

Edge Computing

Edge AI

Cloud AI

With increasing power and smaller size, AI processors perform computation and inference on the device.

https://www.cardinalpeak.com/blog/at-the-edge-vs-in-the-cloud-artificial-intelligence-and-machine-learning

Case study: Autonomous vehicles (AVs)

A self-driving car needs to stop in a split second for a red light, pedestrian crossing or a stray moose on the road. It can't afford to send data to the cloud and wait for instructions.

Further, edge technology also helps the car make instant decisions (and communicate with other AVs) based on weather conditions, traffic, detours and accidents in the area.
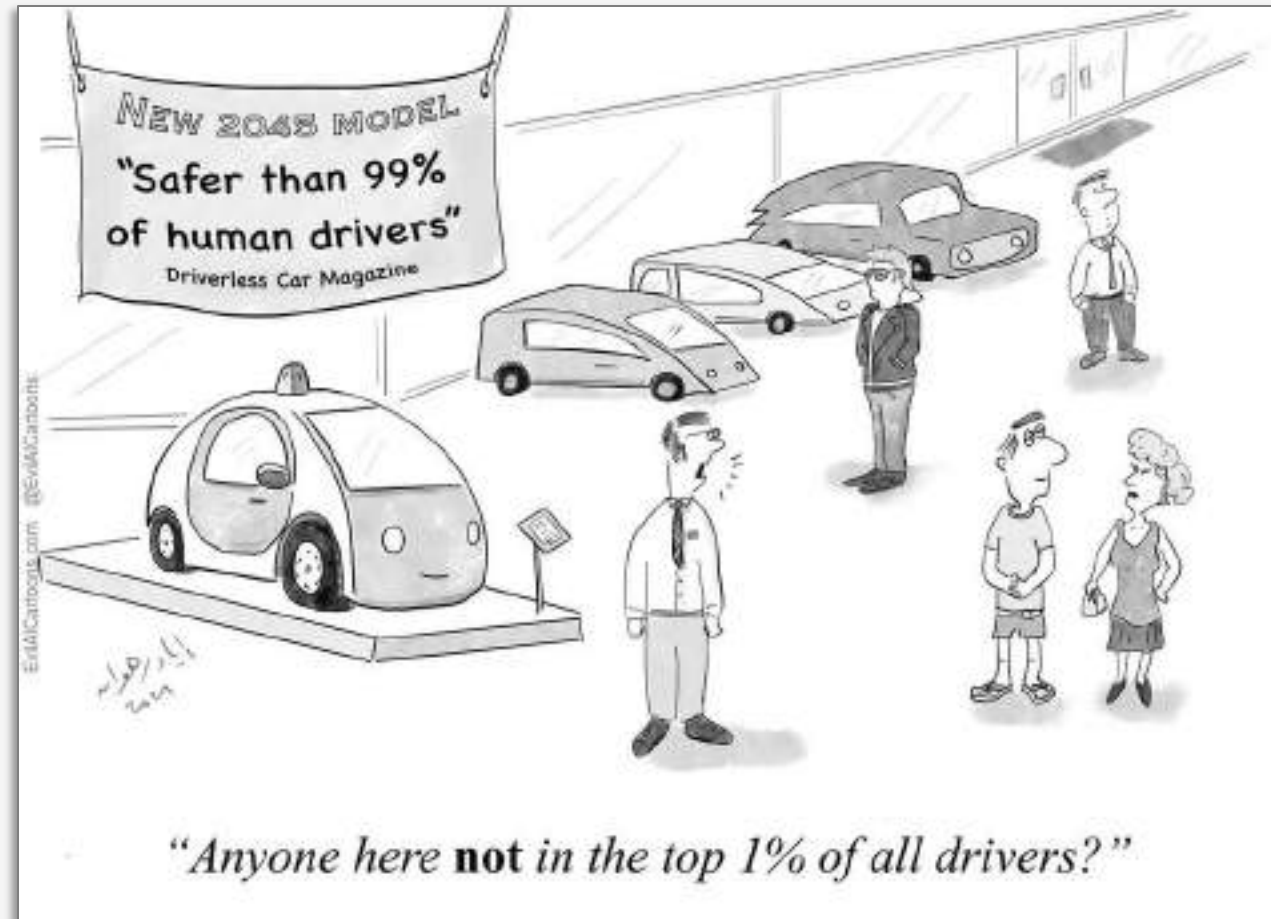
Source: https://www.nutanix.com/theforecastbynutanix/technology/edge-and-cloud-computing-together
https://www.evilaicartoons.com/archive/tame-human-overconfidence
Liu, P., Yang, R. & Xu, Z. How safe is safe enough for self-driving vehicles? Risk Anal. 39, 315–325 (2019).

Case study: Home automation

Home automation is driven by IoT.

Smart home devices such as thermostats, refrigerators, smart speakers, light bulbs and so on can analyze the data they collect and make decisions.

Sending all the data they collect to a cloud would clog up network bandwidth within no time, defeating their purpose.

Source: https://www.nutanix.com/theforecastbynutanix/technology/edge-and-cloud-computing-together
https://www.kdnuggets.com/2018/01/cartoon-ai-at-home.html

Case study: Security and surveillance

Edge technology can help make CCTVs, burglar alarms and the like "smarter" – the device can be programmed to identify unusual activity and potential threats and respond to them instantly by alerting users.

It's critical that the network connection be fully secure →
high-quality encryption, using a technique that avoids storing keys on the edge system

6 edge computing security strategies

1. Use access control and surveillance to enhance the physical security at the edge.

2. Control edge configuration and operation from central IT operations.

3. Establish audit procedures to control data and application hosting changes at the edge.

4. Apply the highest level of network security possible between devices/users and edge facilities.

5. Treat the edge as a part of the public cloud portion of your IT operation.

6. Monitor and log all edge activity, particularly activity relating to operations and configuration.

Case study: Space imagery

The photos taken by satellites, space telescopes and space stations can be instantly analyzed by on-board edge devices that decide which images are worth transferring to the base (an expensive and resource-intensive process).

Case Study: Face Recognition

Face recognition system consists of mainly two phases: face detection and face recognition. In the face detection phase, the potential location of the face is detected within an image. The face recognition phase compares the detected face with the stored face images in the database for recognition.
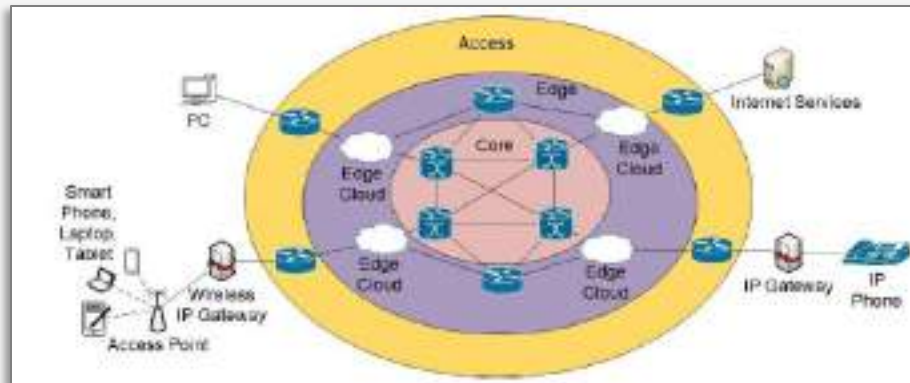
Edge Cloud consists of multiple smaller, generic Clouds situated at the Edge of the network

Source: Islam, S. and Grégoire, J.C., 2010. Network edge intelligence for the emerging next-generation internet. Future Internet, 2(4), pp. 603-623
Muslim N. and Islam Σ., Face recognition in the Edge Cloud, 2017, Conference paper, DOI: 10.1145/3132300.3132310
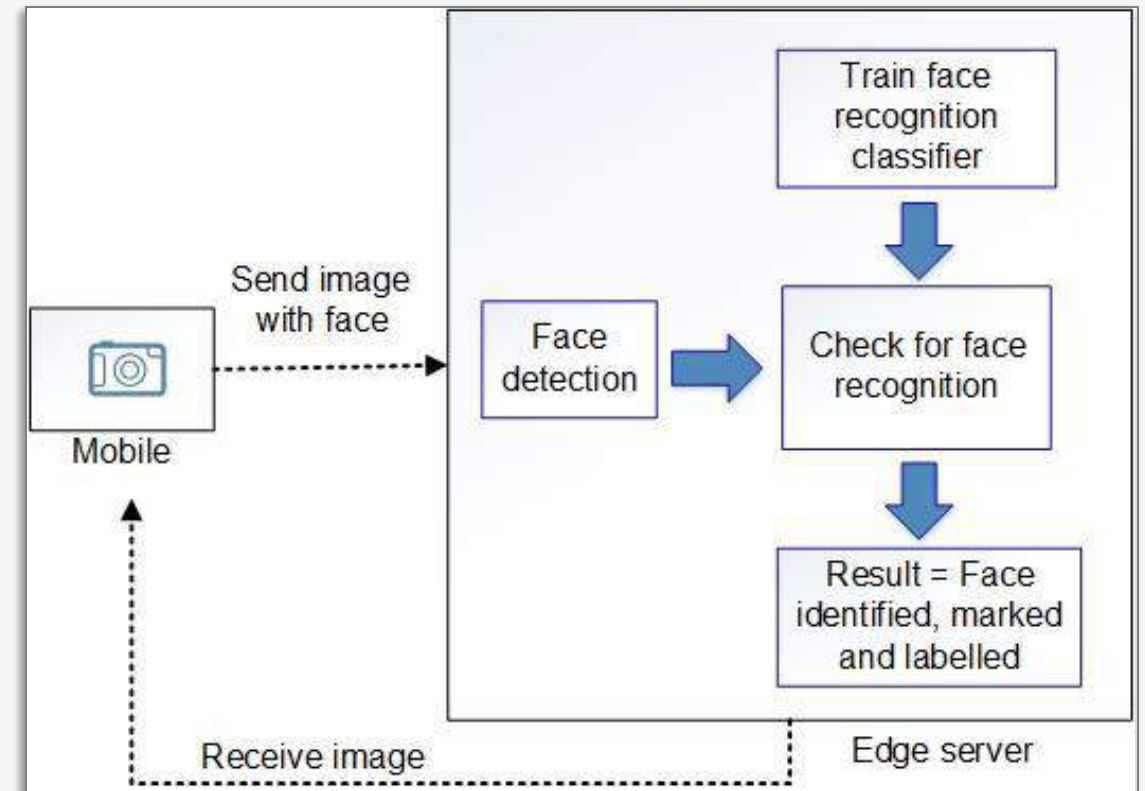
The major computer vision usage types – Applications for edge cloud computing

Detection	Recognition	Localization	Motion analysis
Ex: Quality control Default detection Intruser detection Event detection Covid mask detection	Ex: Facial recognition Object recognition	Ex: Person searching Product localization in storage or store	Ex: Person tracking Flow management Crowd management Customer path in retail store

Source: https://motion-x.net/wp-content/uploads/2021/10/Atos-Edge-Computing-offering.pdf

AI-based Video Intelligence – Applications for edge cloud computing

Detection
Violence detection & police support
Real-Time Alert
Person detection
Watchlist Alerting
Automated surveillance
Intrusion detection

Localization
Live investigation
People tracking

Recognition
Non-facial body recognition
Facial recognition
Touchless Access Control
Recognition with Masks

Motion analysis
Crowd management
Internal Zone Control
Track multiple targets simultaneously
Occupancy Counting
Traffic management

Interpret and understand AI models in real time
to detect, recognize, localize and analyze motion.

Take **immediate** actions

Increase security officer's **efficiency** in tracking and searching tasks

Reduce cost of monitoring and lost person search.

Respect people privacy: **No Facial** recognition

Deploy centrally or at the **edge**

Source: https://motion-x.net/wp-content/uploads/2021/10/Atos-Edge-Computing-offering.pdf

Case Study: real time people search and tracking without facial recognition

Search in live feeds on multiple cameras

People Search by Attributes

- Specify a person from unclear witness information: color of clothes (Top, Shoes, Bag, hat, scarf, glasses..)
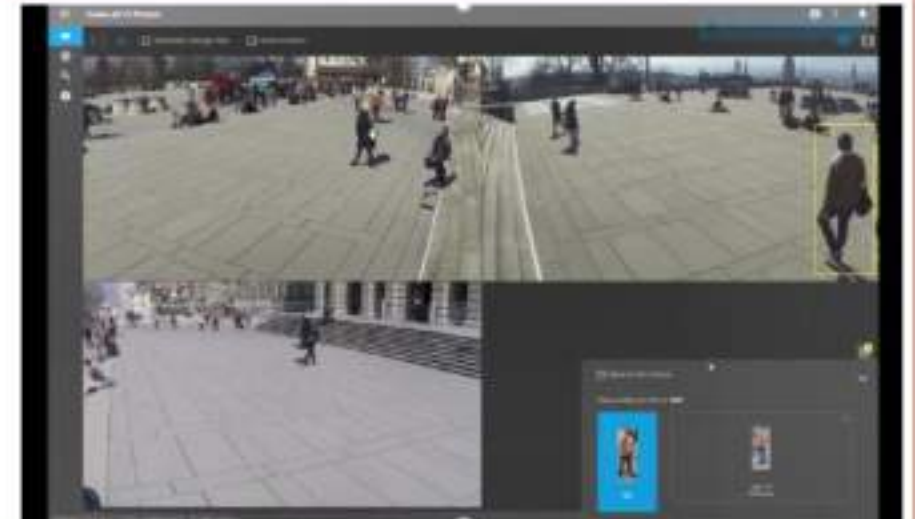
People Search by photo

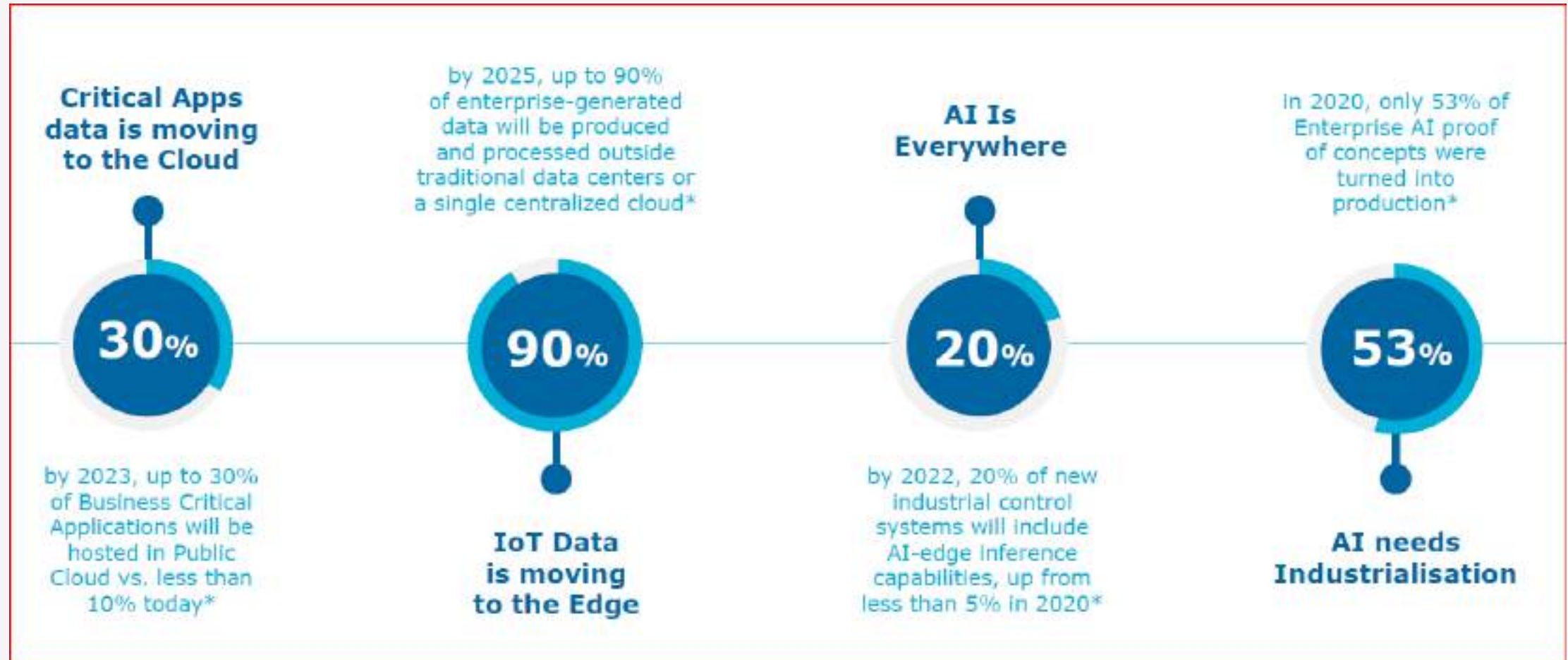- Search from a photo

People tracking

- Start tracking from any people detected on the camera network

- Patented **Body recognition** from different angle of view to reidentify the person

- Patented Multi-camera **digital signature** sharing

Big Data Revolution: Analytics and AI Everywhere

Critical Apps data is moving to the Cloud

30%

by 2023, up to 30% of Business Critical Applications will be hosted in Public Cloud vs. less than 10% today*

by 2025, up to 90% of enterprise-generated data will be produced and processed outside traditional data centers or a single centralized cloud*

90%

IoT Data is moving to the Edge

AI Is Everywhere

20%

by 2022, 20% of new industrial control systems will include AI-edge inference capabilities, up from less than 5% in 2020*

In 2020, only 53% of Enterprise AI proof of concepts were turned into production*

53%

AI needs Industrialisation

Source: The major computer vision usage typeshttps://motion-x.net/wp-content/uploads/2021/10/Atos-Edge-Computing-offering.pdf

Edge AI solutions transform IoT data into business insights
Connect securely Any Device Anywhere from Cloud to Edge
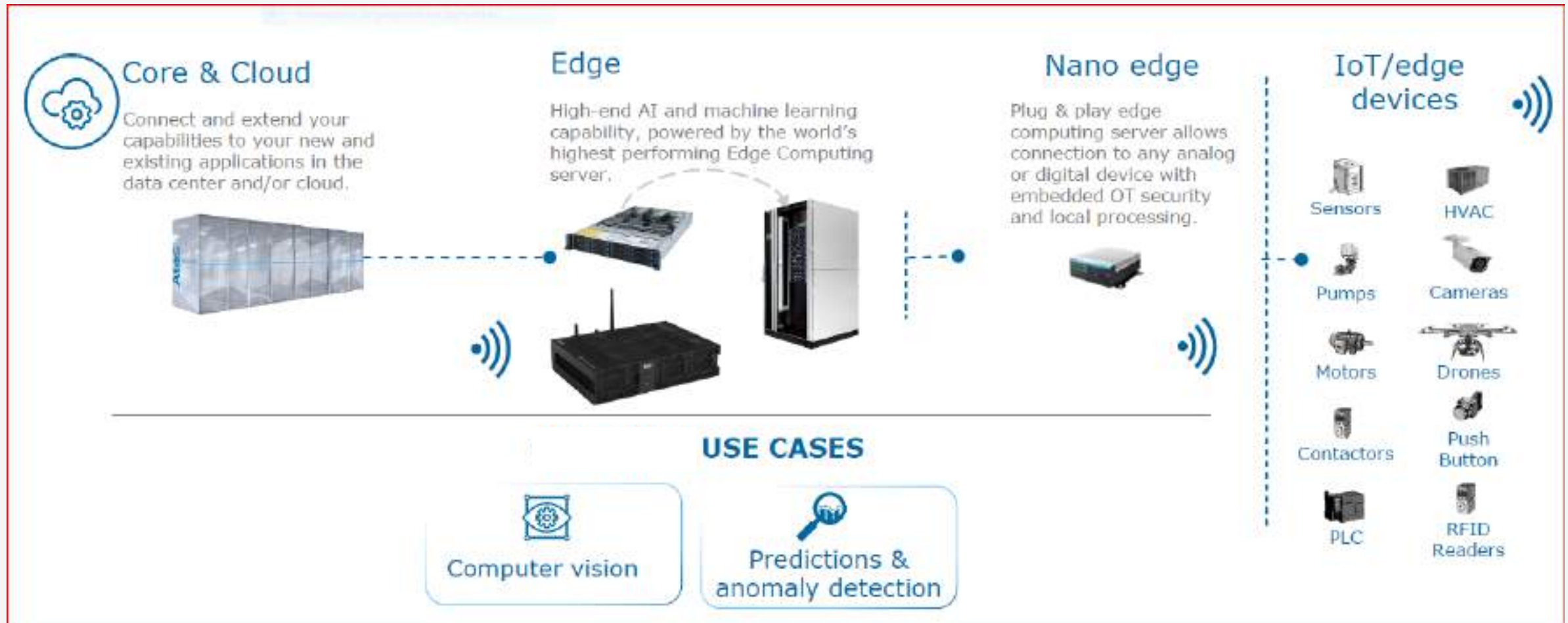
Transformation is shifting to the edge

By 2023

50%

of enterprise data will be generated outside of the core.

Gartner 2021 Strategic Roadmap for Edge Computing November 3, 2020

By 2025

75%

of data will be processed outside the traditional data center or cloud.

How to invest in edge computing, Nasdaq, November 2020

To get more business value from data, organizations need to analyze it near where it's produced and consumed: at the edges of the organization's infrastructure.

Edge computing: The five pillars

Latency	Bandwidth	Security and privacy	Autonomy	Maintained cost
Data is analyzed at its source, which enables the lowest latency possible.	Only pre-processed data is sent to cloud or datacenter for mid- term analysis. It allows to maintain costs whatever the data amount.	Critical data is kept at the data source which reduces vulnerability breaches or hacking.	Edge computing servers works autonomously even without any network and in critical environment.	Whatever the data volume and complexity, the TCO is maintained.

What organizations want to achieve at the edge

	Retailers	want to process payments, run video surveillance, and make customer-specific offers locally in real time
	Manufacturers	need to process industrial IoT data instantly to optimize robotic production lines and maximize quality
	Telcos	want to develop offerings that incorporates edge processing to empower smart cities and autonomous vehicles
	Energy and utilities	need to monitor and manage remote infrastructure like pipelines and sub-stations and respond instantly to anomalies

The challenges of centralized data processing

Computing power sits in the data center, but data is generated and consumed at the edge.
This creates four main challenges:

Connectivity

Bandwidth and latency constraints make processing edge-generated data in the data center too slow for real-time applications

Applications

Utilizing multiple clouds and edge devices makes application management more complex

Security

Industrial IoT and edge devices can be soft targets for cybersecurity attacks

Management

Managing the whole environment from core to cloud to edge can be a burden on resources

Challenges and limitations

Basic challenges of adopting sustainable edge cloud computing practices:

- the complexity of managing large-scale edge computing environments

- the limited availability of renewable energy sources in remote areas.

Sidestep bandwidth and latency issues

Application management
Multi-cloud and edge can increase application complexity

Ensure security as you embrace edge
The proliferation of devices at the edge can increase security risk

Focus your resources on adding value
Moving to the edge can increase your IT operations & management burden

Solutions of the challenges

Put processing power right where it's needed – at the edge

- A unified, end-to-end infrastructure
- Seamless architecture from data center to cloud to edge
- Run video and IoT analysis in real time

Adopt a container-based architecture that supports multi-cloud and edge

- Run legacy and cloud-native apps at the edge
- Run real time analytics workloads at the branch
- Create and deploy one application everywhere

A pre-configured, end-to-end security solution in which all components are fully integrated

- Workloads are encrypted and security policy is enforced from data center to cloud to edge
- Manage patching across the entire ecosystem centrally
- Keep devices, applications and data secure and up to date
- Edge servers are secured physically and logically, and data is protected in motion and at rest

Conclusion

Overall, edge cloud computing can play a vital role in promoting sustainability by reducing energy consumption, supporting the use of renewable energy sources, reducing latency, supporting the development of smart grids, and reducing e-waste.

Source: https://motion-x.net/wp-content/uploads/2021/10/Atos-Edge-Computing-offering.pdf

Any questions?

Thank you ☺