Edge Computing: A Decentralized Evolution of the Cloud

Galiléa LE MOULLEC (Mun ID: 202415993) Félicien MOQUET (Mun ID: 202415994)

Memorial University of Newfoundland, St. John's, Canada

March 2025

Edge Computing: A Decentralized Evolution of the Cloud

Galiléa LE MOULLEC (Mun ID: 202415993) Félicien MOQUET (Mun ID: 202415994)

Memorial University of Newfoundland, St. John's, Canada

March 2025

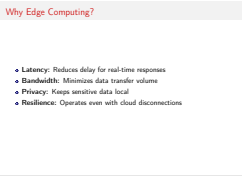
Definition

Edge computing is a distributed computing paradigm that integrates networking, computing, stor- age, and application resources **near data sources** to provide intelligent services with minimal delay. By processing and storing data closer to its origin, edge computing **minimizes latency**, **optimizes bandwidth usage**, and **enhances system responsiveness**

Introduction
Definition
Edge computing is a distributed computing paradigm that integrates networking, computing, stor- age, and application resources **near data sources** to provide intelligent services with minimal delay. By processing and storing data closer to its origin, edge computing **minimizes latency**, **optimizes bandwidth usage**, and **enhances system responsiveness**

Why Edge Computing?

- **Latency:** Reduces delay for real-time responses
- **Bandwidth:** Minimizes data transfer volume
- **Privacy:** Keeps sensitive data local
- **Resilience:** Operates even with cloud disconnections



In this video, we'll explore Edge Computing and its importance. Consider a startup that initially relies on cloud computing to manage financial data. As the company grows, real-time decisions are needed, making cloud computing inefficient. Instead, they hire an in-house accountant to process data locally, improving speed and decision-making.

Edge Computing works similarly, by processing data closer to the source rather than relying on the cloud. Key benefits include:

- **Latency:** Processing data locally reduces delays, which is vital for applications like smart cars or real-time sensors. - **Privacy:** Keeping sensitive data local minimizes the risk of exposure, especially in industries like healthcare. - **Bandwidth:** Instead of transmitting all data to the cloud, only relevant information is sent, reducing the need for high bandwidth. - **Resilience:** Edge devices continue to function even without cloud connectivity, ensuring uninterrupted service in critical situations.

These benefits make Edge Computing essential for fast, private, and reliable applications, even when cloud services are unavailable.

Architecture Overview

- **Edge devices:** Sensors, wearables, cameras
- **Edge nodes:** Gateways, micro-servers, local processors
- **Cloud layer:** For large-scale analytics and storage

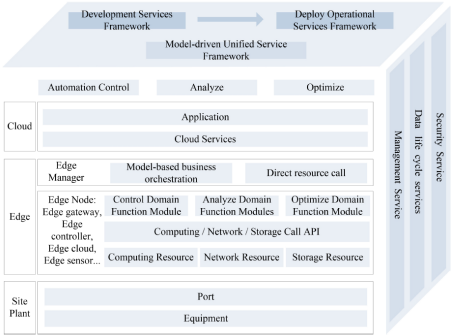


Figure 1: Edge computing reference architecture

Architecture Overview
- **Edge devices:** Sensors, wearables, cameras
- **Edge nodes:** Gateways, micro-servers, local processors
- **Cloud layer:** For large-scale analytics and storage

Figure 1: Edge computing reference architecture

Use Case: Internet of Things (IoT)

- Smart homes: temperature, lighting, security
- Environmental monitoring: air quality, agriculture
- Local processing improves responsiveness and privacy

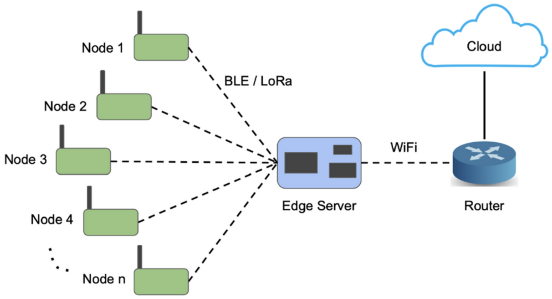
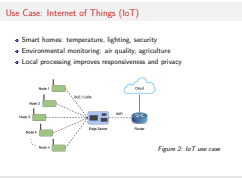


Figure 2: IoT use case



IoT applications benefit from edge computing through fast reactions and privacy. In smart homes, sensors react immediately. In agriculture, edge devices adapt irrigation in real time.

Use Case: Autonomous Vehicles

- Onboard sensors generate huge data streams
- Requires instant decision-making (e.g. braking)
- Edge computing enables safety-critical operations

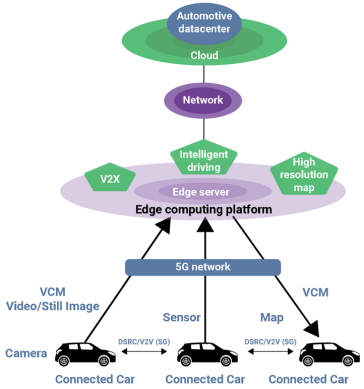
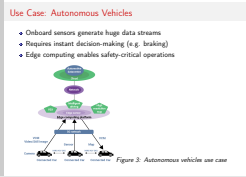


Figure 3: Autonomous vehicles use case



Use Case: Smart Cities

- Real-time traffic management
- Public safety and surveillance
- Energy optimization and environmental monitoring

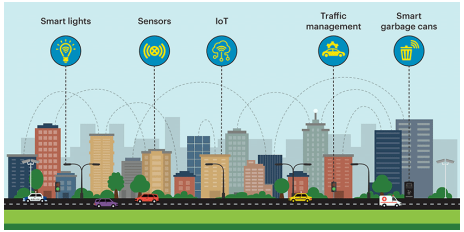


Figure 4: Smart cities use case

Edge computing enables cities to be smarter and more efficient. Local processing in traffic lights and surveillance systems improves responsiveness and reduces network dependency.

Use Case: Healthcare and Telemedicine

- Real-time patient monitoring
- On-site diagnostics in emergencies
- Strong data privacy and compliance (e.g. GDPR)

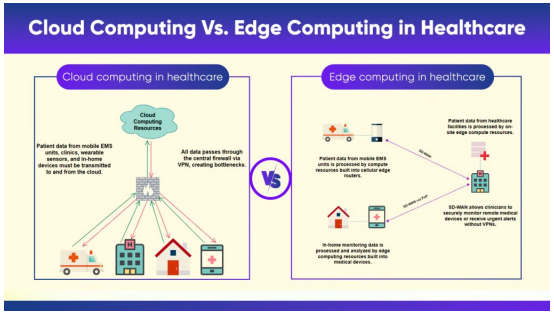
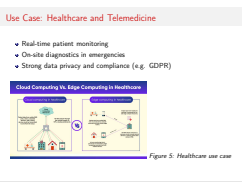


Figure 5: Healthcare use case



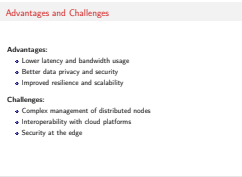
Advantages and Challenges

Advantages:

- Lower latency and bandwidth usage
- Better data privacy and security
- Improved resilience and scalability

Challenges:

- Complex management of distributed nodes
- Interoperability with cloud platforms
- Security at the edge



While edge computing has many strengths, it introduces new challenges. Managing and securing distributed nodes is complex, and integration with existing cloud systems remains tricky.

Trends and Future Perspectives

- Integration with AI and 5G for smarter edge decisions
- Lightweight containers and orchestration (e.g. K3s)
- Research in privacy-preserving analytics, federated learning

Trends and Future Perspectives
- Integration with AI and 5G for smarter edge decisions
- Lightweight containers and orchestration (e.g. K3s)
- Research in privacy-preserving analytics, federated learning

Conclusion

- Edge computing addresses key limitations of centralized cloud
- Use cases show strong benefits in latency, privacy, and efficiency
- Future: a hybrid cloud-edge ecosystem

Conclusion
- Edge computing addresses key limitations of centralized cloud
- Use cases show strong benefits in latency, privacy, and efficiency
- Future: a hybrid cloud-edge ecosystem

In conclusion, edge computing complements the cloud. It improves response times, protects data, and enables smarter systems. The future lies in combining both models for flexibility and power.

Open Discussion

Discussion Point

Edge computing reduces data exchanges by processing locally. But:
With network demands constantly rising, will edge computing be enough?
Or is it just a temporary relief before a new saturation point?

Open Discussion
Discussion Point
Edge computing reduces data exchanges by processing locally. But:
With network demands constantly rising, will edge computing be enough?
Or is it just a temporary relief before a new saturation point?

References

- K. Cao, Y. Liu, G. Meng, et Q. Sun, « An Overview on Edge Computing Research », IEEE Access, vol. 8, p. 85714 85728, 2020, doi: 10.1109/ACCESS.2020.2991734.
- *Figure 1*: K. Cao, Y. Liu, G. Meng, et Q. Sun, «An Overview on Edge Computing Research», IEEE Access, vol. 8, p. 85714-85728, 2020, doi: 10.1109/ACCESS.2020.2991734.
- *Figure 2*: Nature, "The rise of IoT: Edge computing applications," Sci. Rep. 11, 2021. Available: `https://www.nature.com/articles/s41598-021-01431-y`
- *Figure 3*: GSA Global, "Edge AI Computing Advancements Driving Autonomous Vehicle Potential," 2023. Available: `https://www.gsaglobal.org/forums/edge-ai-computing-advancements-driving-autonomous-vehicle-potential/`
- *Figure 4*: StorMagic, "Edge Computing for IoT-Based Energy Management in Smart Cities," 2023. Available: `https://stormagic.com/company/blog/edge-computing-for-iot-based-energy-management-in-smart-cities/`
- *Figure 5*: CIO Influence, "Best Practices for Integrating Edge Computing in Healthcare," 2023. Available: `https://cioinfluence.com/it-and-devops/best-practices-for-integrating-edge-computing-in-healthcare/`