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

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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

Architecture Overview

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

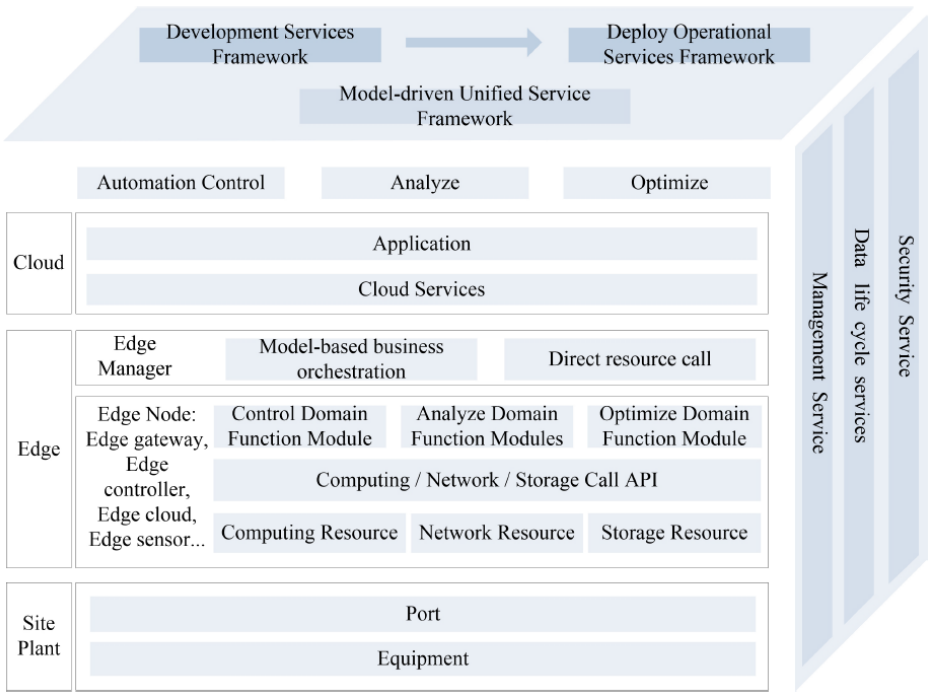

Figure 1: Edge computing reference architecture

Use Case: Internet of Things (IoT)

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

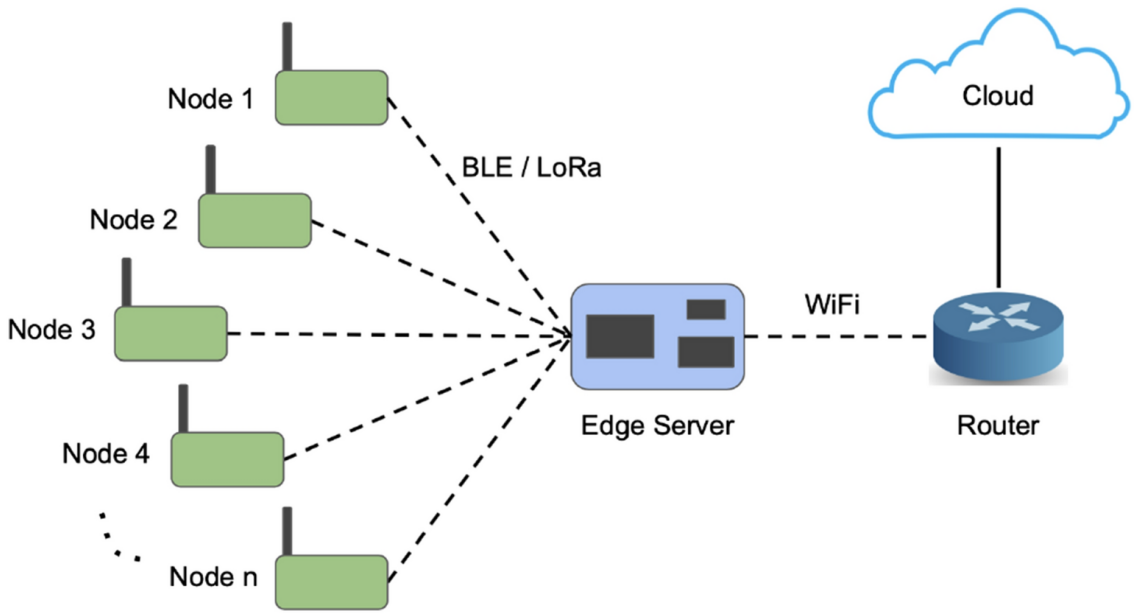

Figure 2: IoT use case

Use Case: Autonomous Vehicles

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

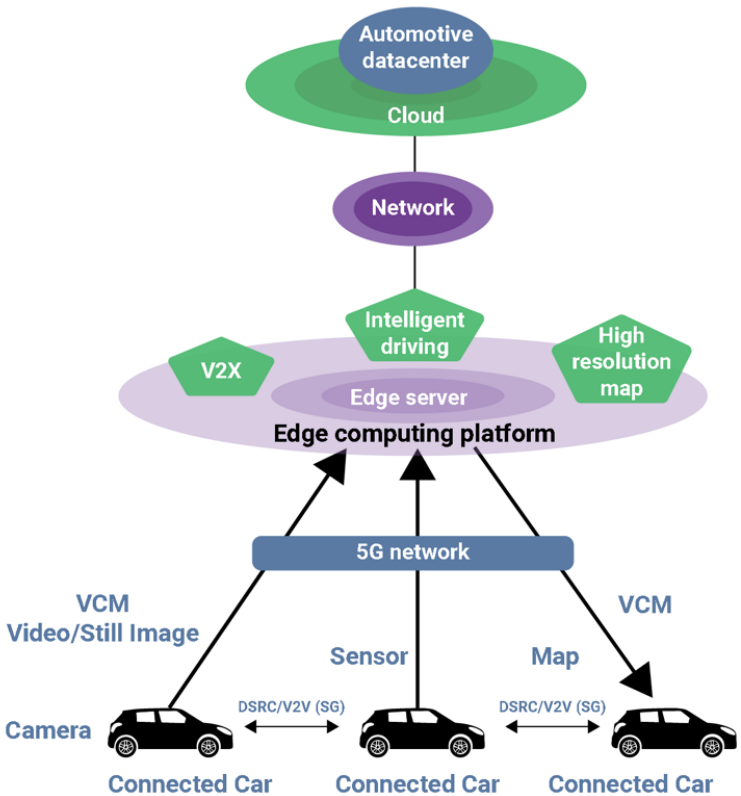

Figure 3: Autonomous vehicles use case

Use Case: Smart Cities

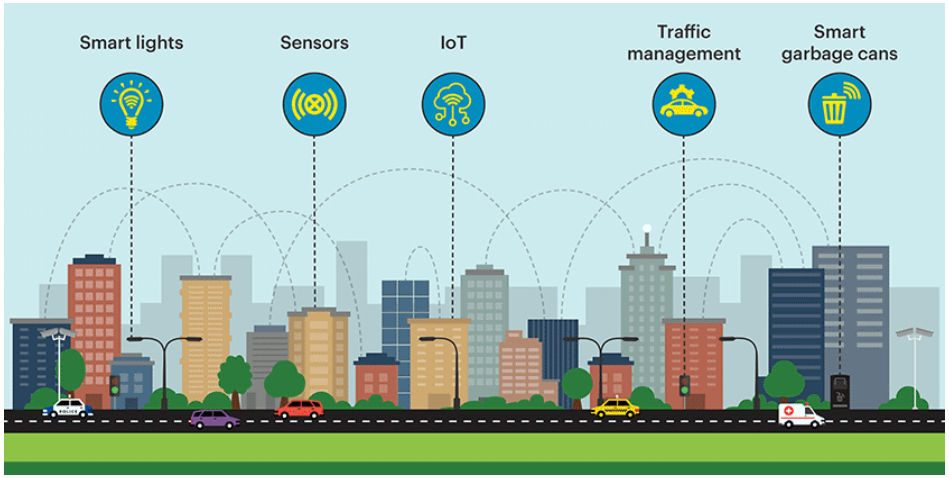

Figure 4: Smart cities use case

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

Use Case: Healthcare and Telemedicine

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

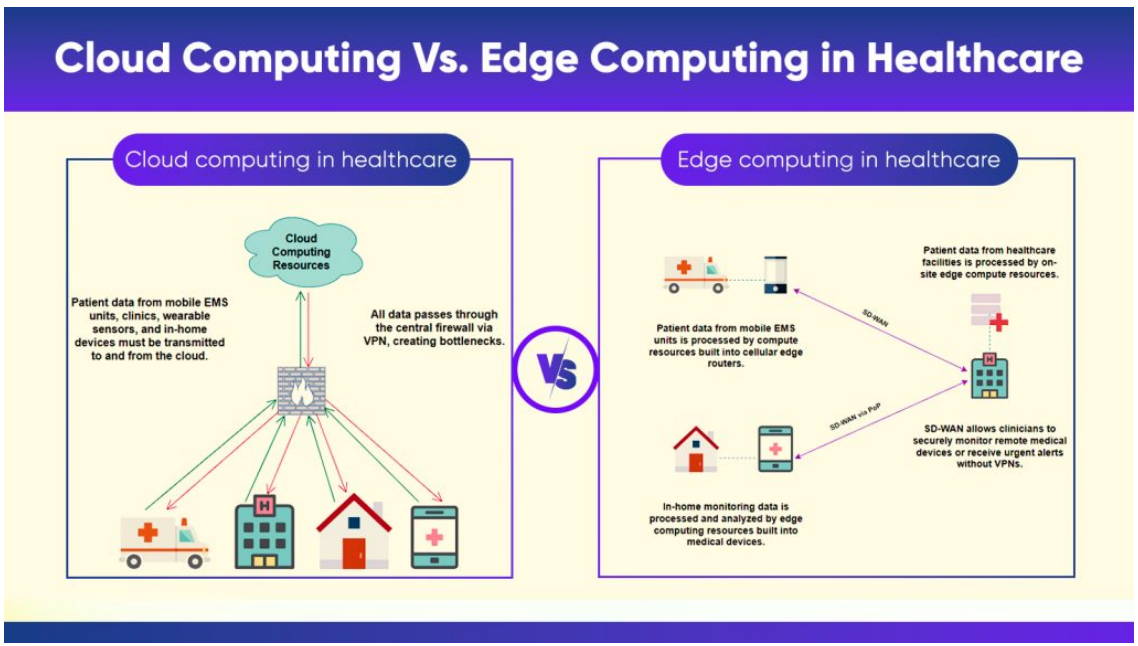

Figure 5: Healthcare use case

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

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

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

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- *Figure 2*: Nature, "The rise of IoT: Edge computing applications," Sci. Rep. 11, 2021. Available: `https://www.nature.com/articles/s41598-021-01431-y`
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- *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/`