Edge Computing Benefits in Low-Latency IoT Applications

Michael Amista'

Prof. Claudio Enrico Palazzi

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DIPARTIMENTO MATEMATICA

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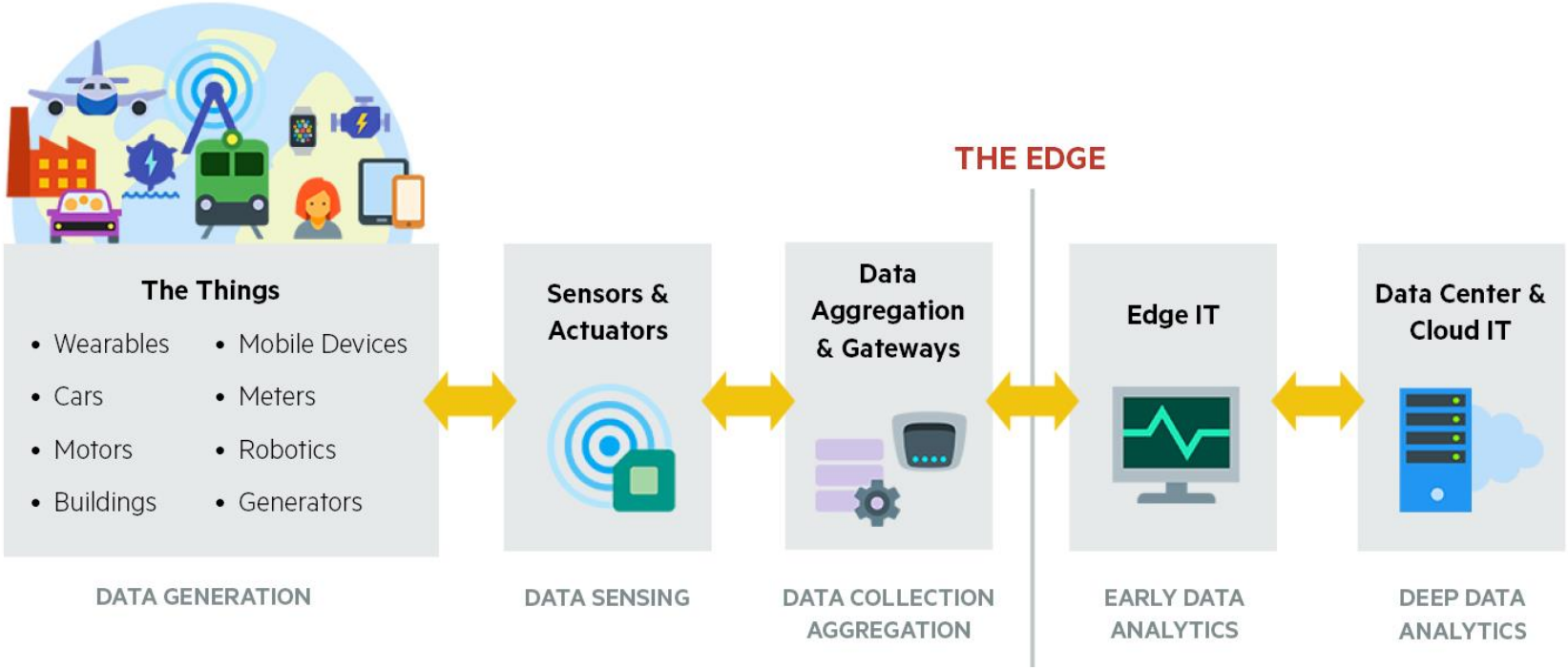
IoT data flow



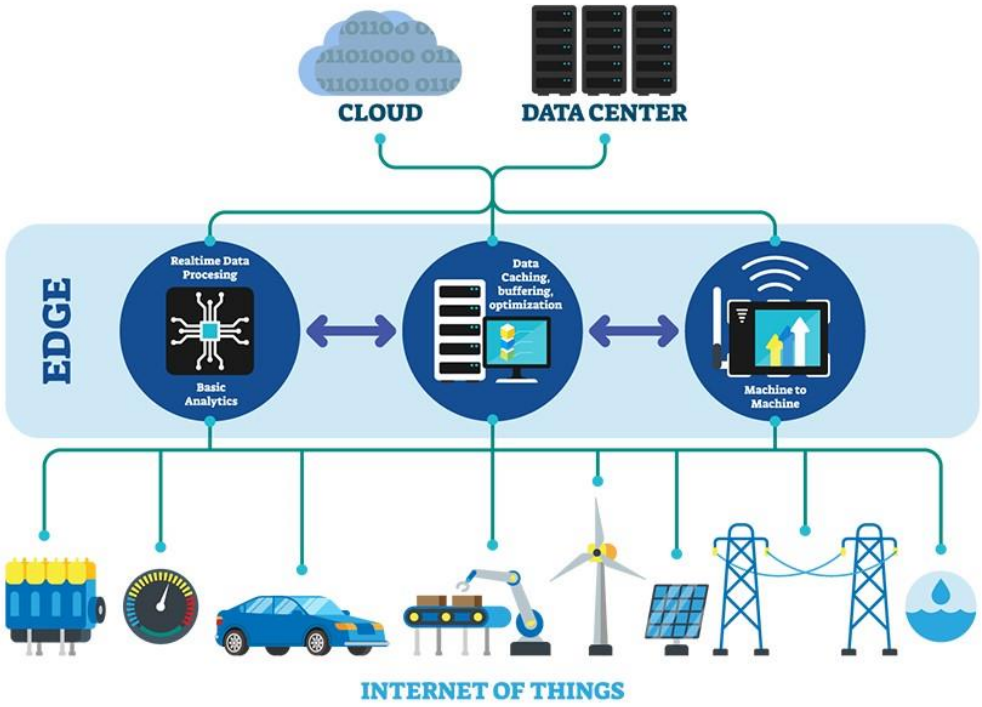
Limitations of traditional Cloud Computing

- **Communication Latency**: The physical distance from the servers introduces substantial processing delays.
- **Network Bandwidth**: Sending large volume of data to centralized cloud servers may lead to network congestion.
- **Resource Inefficiency**: Sending all the collected data to remote servers may be critical for energy-constrained devices.
- **Privacy and Security Concerns**: Continuous data transmissions to external servers may be a potential point of attack.

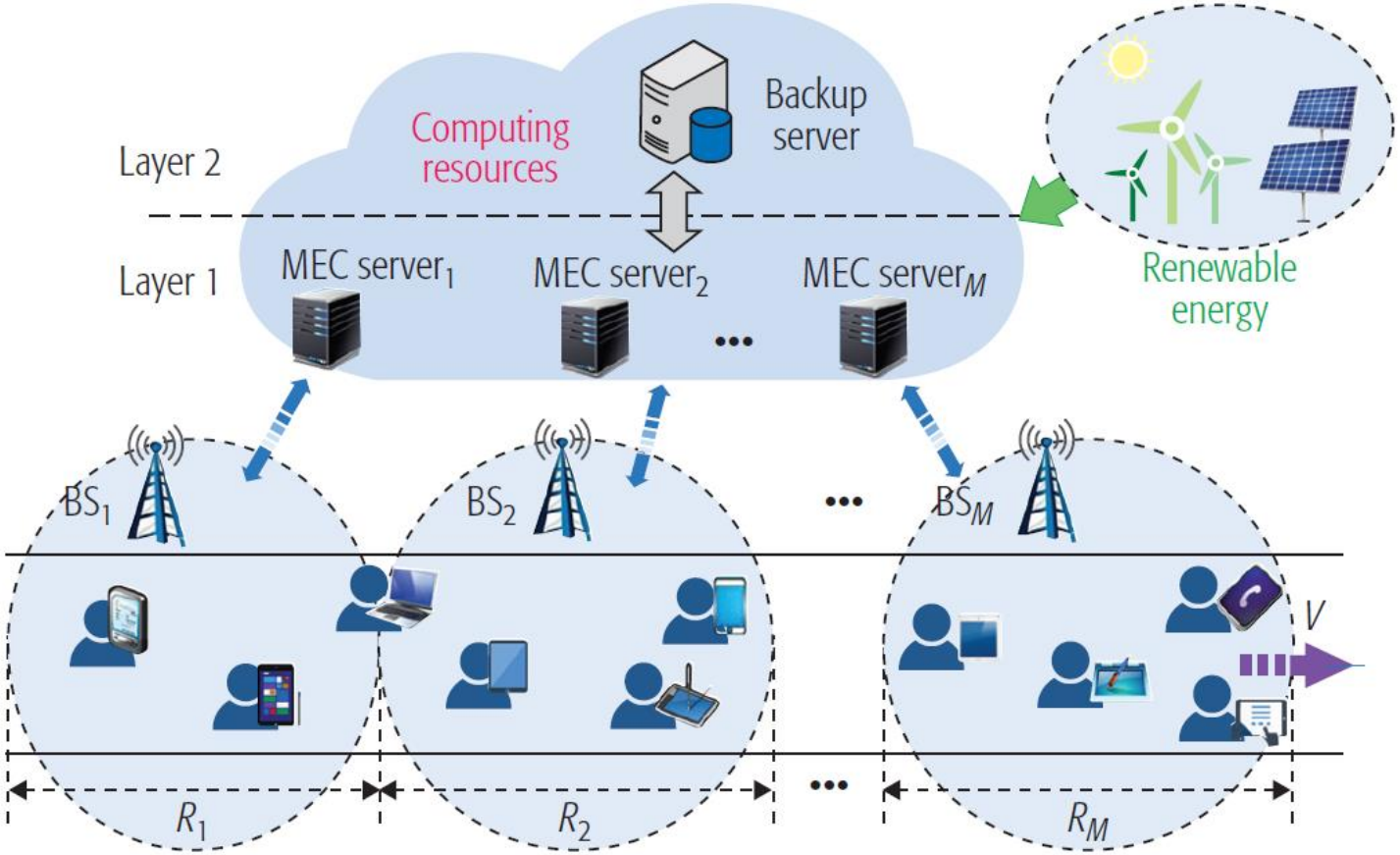
Emergence of Edge Computing

Key features:

- Proximity to data
- Reduced latency
- Real-time processing capabilities
- Enhanced energy efficiency and data security



Applications: healthcare, industrial manufacturing, video surveillance, etc.



Mobility-aware hierarchical MEC framework

A study on Mobile Edge Computing (MEC)

Energy consumption

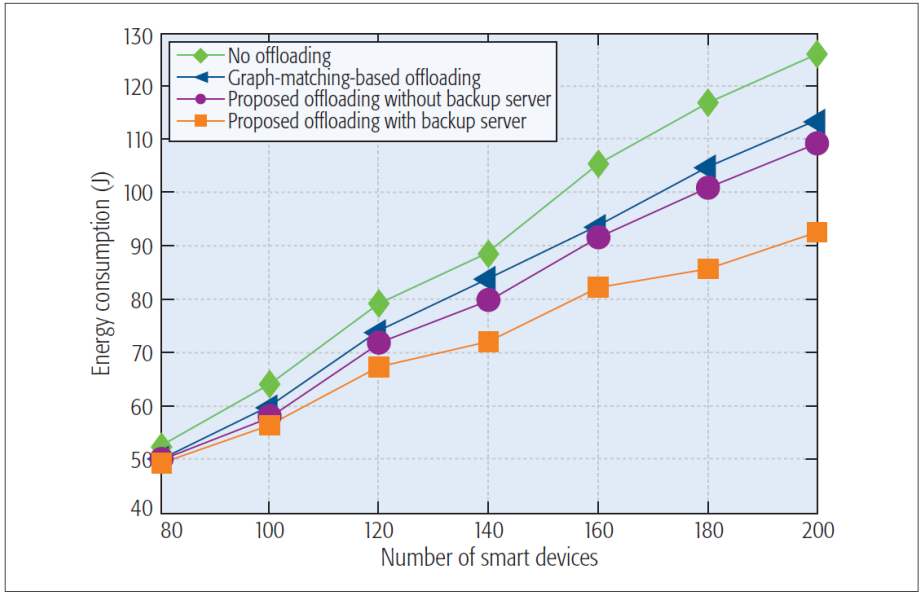


Figure 4. Energy consumption of the task execution with different schemes.

Latency reduction

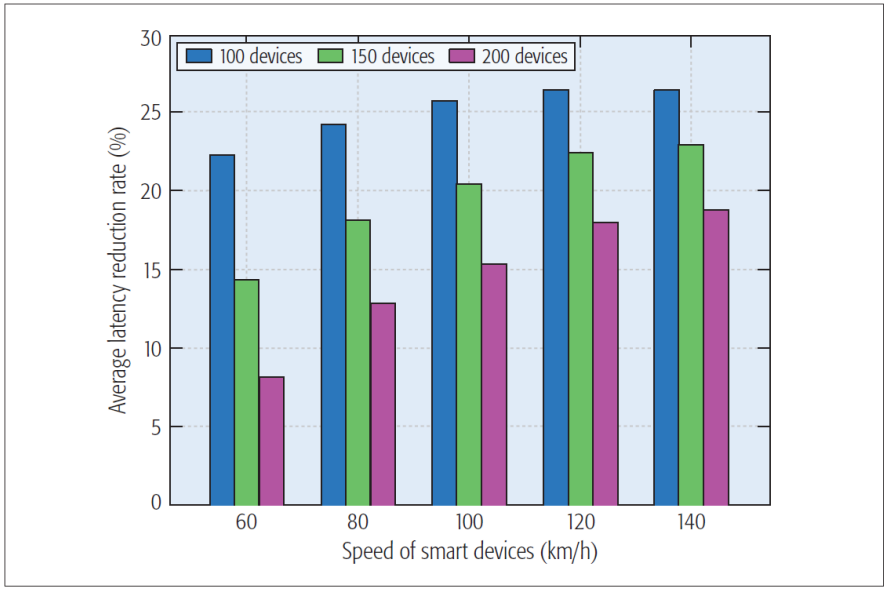
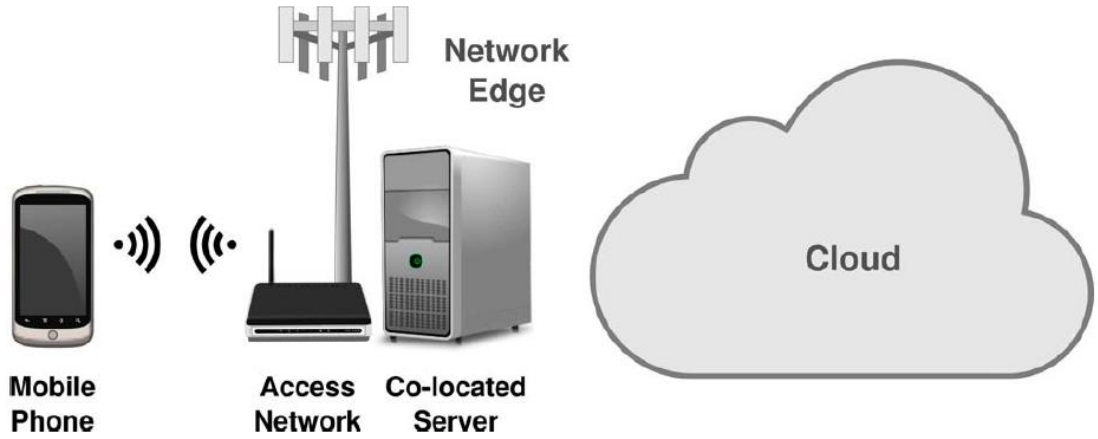


Figure 5. Comparison of average task latency reduction rates with various device speeds.

A study on mobile gaming

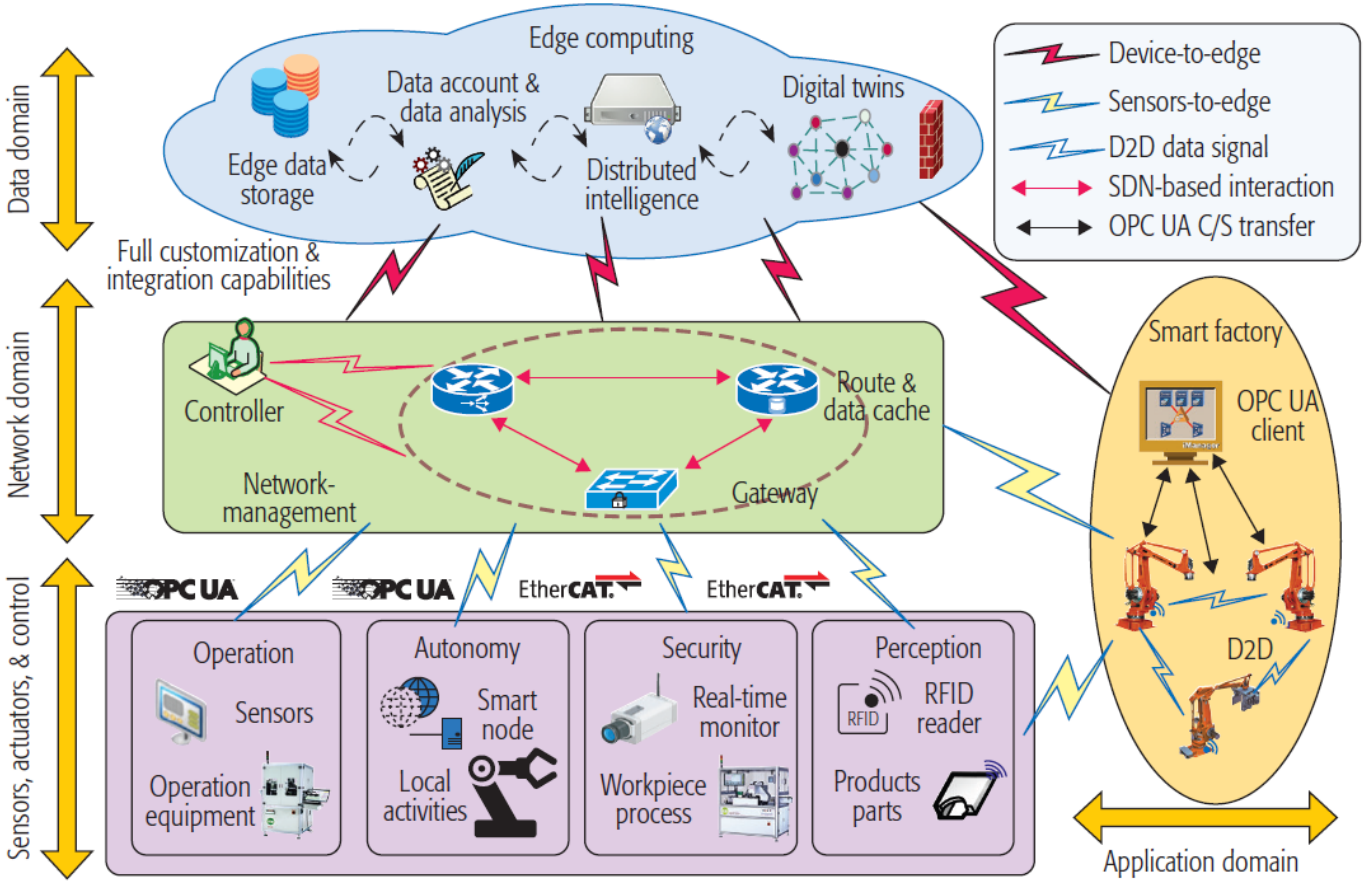
- **Objective**: Evaluate the impact of edge computing on latency in resource-demanding mobile gaming applications.
- **Comparison Scenarios**:
  - Local Edge Deployment: Server located at the network edge.
  - Specialized Cloud Infrastructure: Centralized cloud computing.
- **Key Metrics**: Response delay, comprising processing delay (PD), network delay (ND), and playout delay (OD).



A study on mobile gaming

- **Findings**:
  - **Latency**: Edge setup achieved network delay (ND) of <20ms, outperforming cloud setups which showed >50ms delay.
  - **Virtualization**: Containers delivered near-bare-metal performance, while hypervisor virtualization incurred ~30% higher processing delay.
  - **Resolution**: HD processing times below 70 ms with the edge setup even considering fast-paced interactions.
- **Conclusion**: Proximity of computational resources crucial to enhance the user experience.

A study on industrial manufacturing



Architecture of an edge computing platform in IoT-based manufacturing

A study on industrial manufacturing

- **Objective**: Explores the integration of edge computing in IoT-based manufacturing to address latency, real-time analytics, and resource efficiency.
- **Active Maintenance**:
  - Enhanced responsiveness through localized processing.
  - Case study on candy packaging line showed a 60% reduction in network traffic (from 16-17 Mb/s to 5-6 Mb/s) and an overall improvement on production efficiency.
- **Cloud-Edge Cooperation:**
  - Cloud layers handle long-term data analysis, maintenance planning, and knowledge mining.
  - Edge layers focus on real-time processing, security, and immediate business logic execution.

Open research challenges

- **Heterogeneity**: Need for standardized programming models for diverse devices.
- **Resource Management**: Efficient allocation in dynamic, constrained environments.
- **Security & Privacy**: Safeguarding sensitive data against evolving threats.
- **Data Handling**: Efficient preprocessing of large IoT data volumes.
- **System Reliability**: Ensuring consistent and scalable service delivery.

References

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