

# Data Engineering for Smart City Applications

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## CONCEPT AND MOTIVATION

In today's increasingly connected world, the volume and diversity of data generated by IoT devices is transforming how we design and manage smart systems. This explosion of information necessitates innovative data management strategies that move beyond traditional centralized systems, which often struggle with latency and scalability.

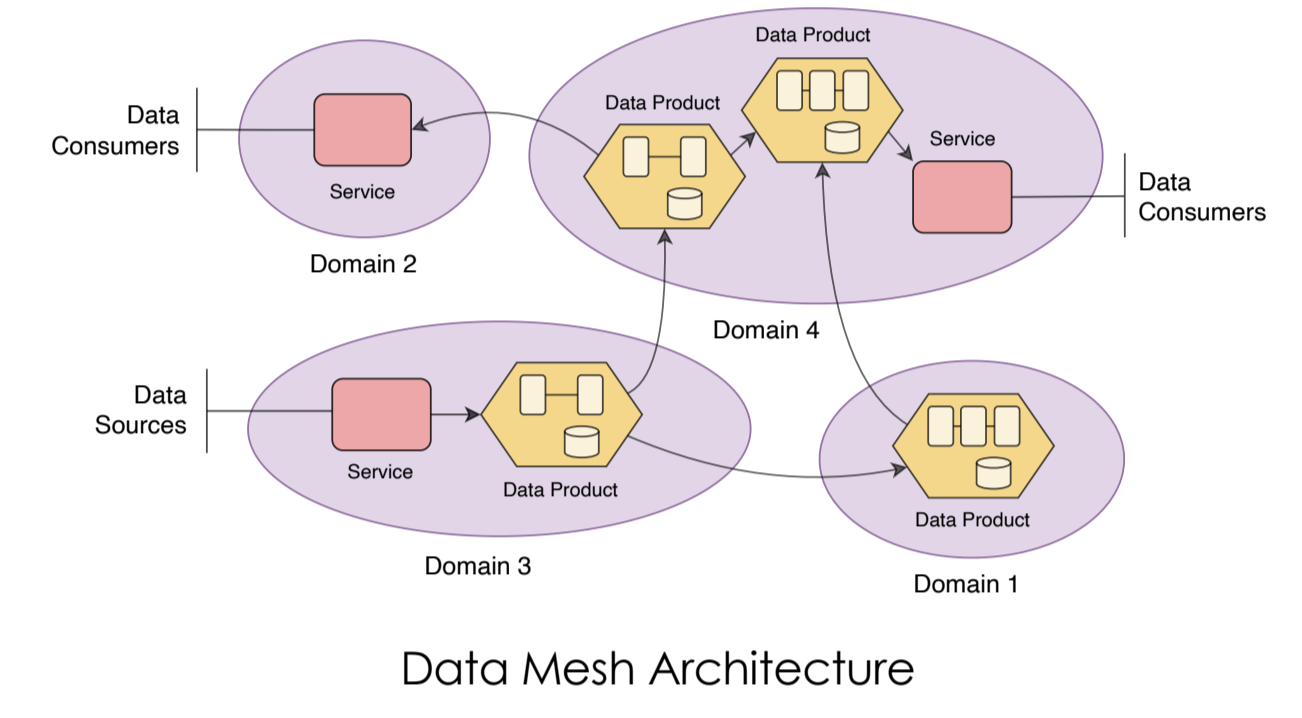
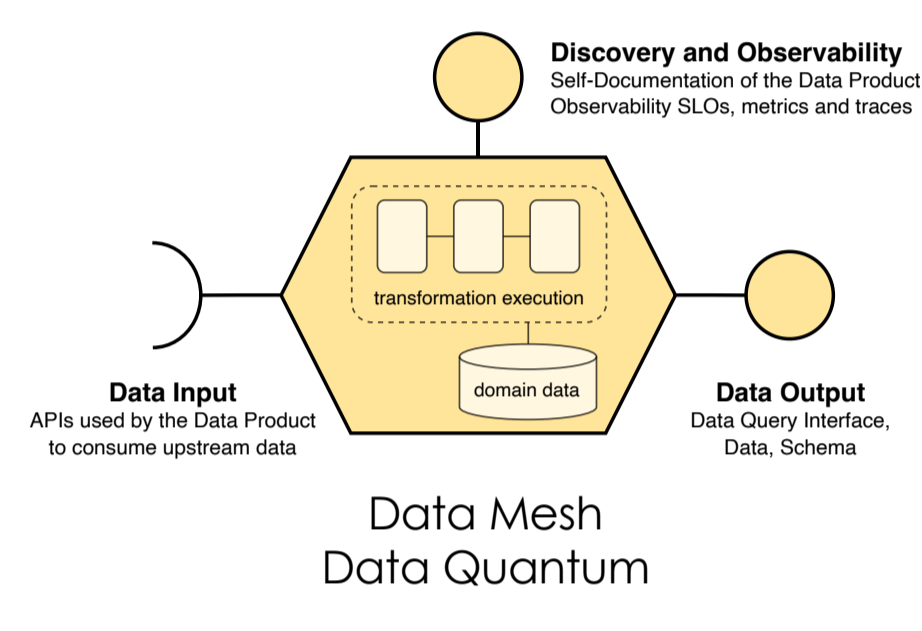
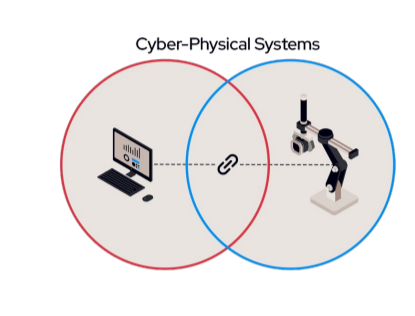
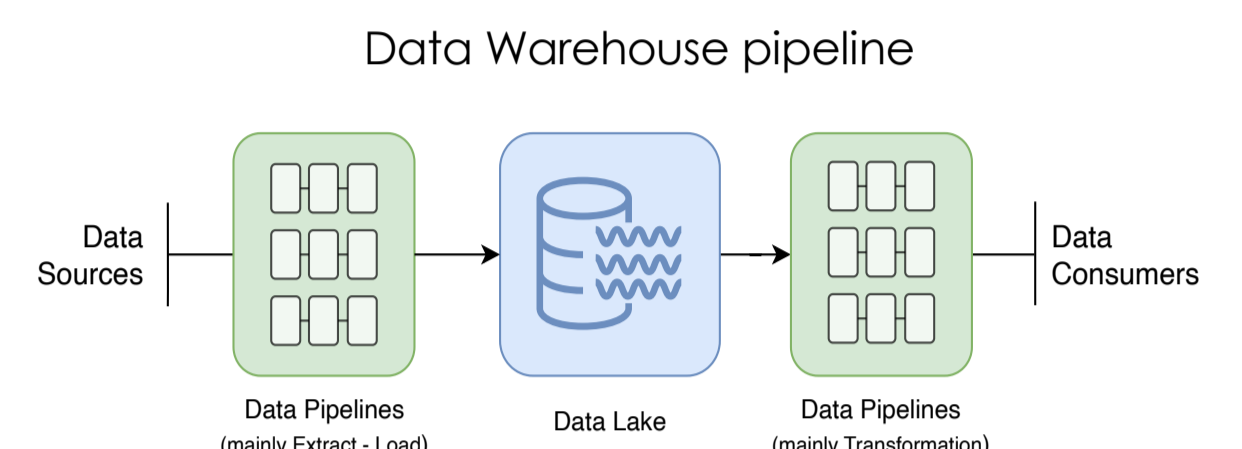
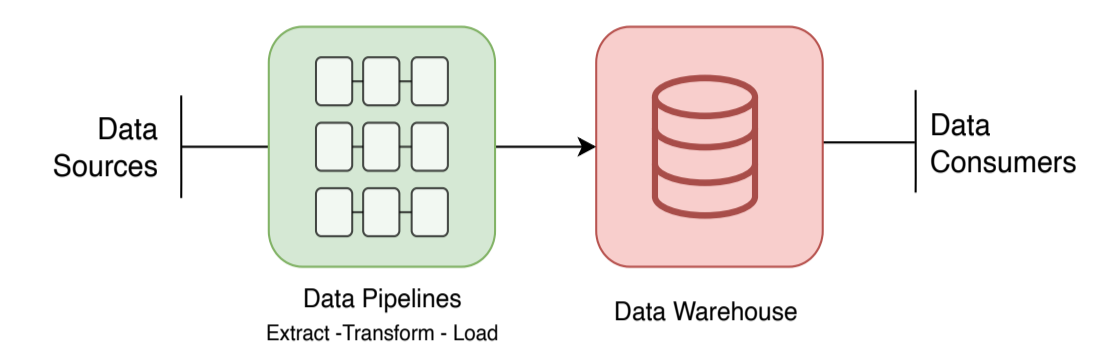
**Cyber-physical systems** underscore the need for real-time interactions, where devices and sensors continuously process data to adapt to dynamic conditions.

The **IoT-Edge-Cloud Continuum (IECC)** addresses these challenges by:

- Processing data on the Edge (closer to the source) for reduced latency;
- Leveraging Cloud resources for enhanced scalability.

Traditional **centralized data architectures**, suffer from:

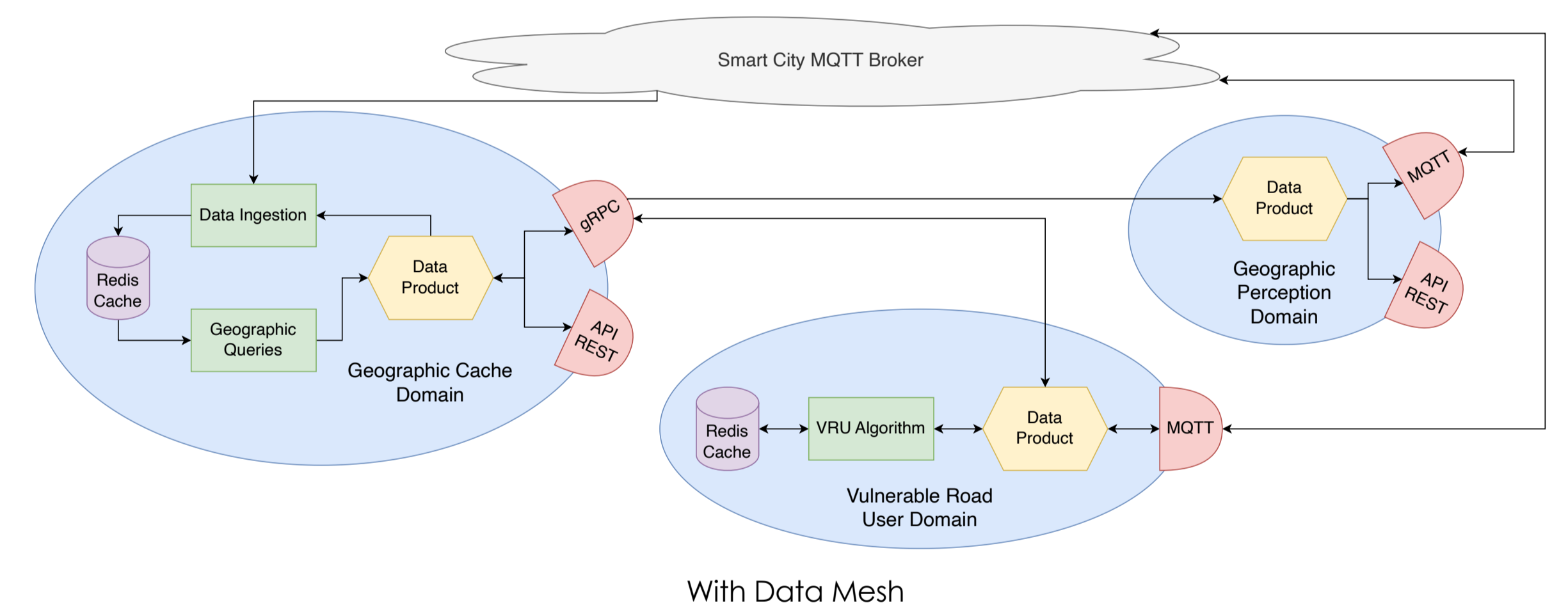
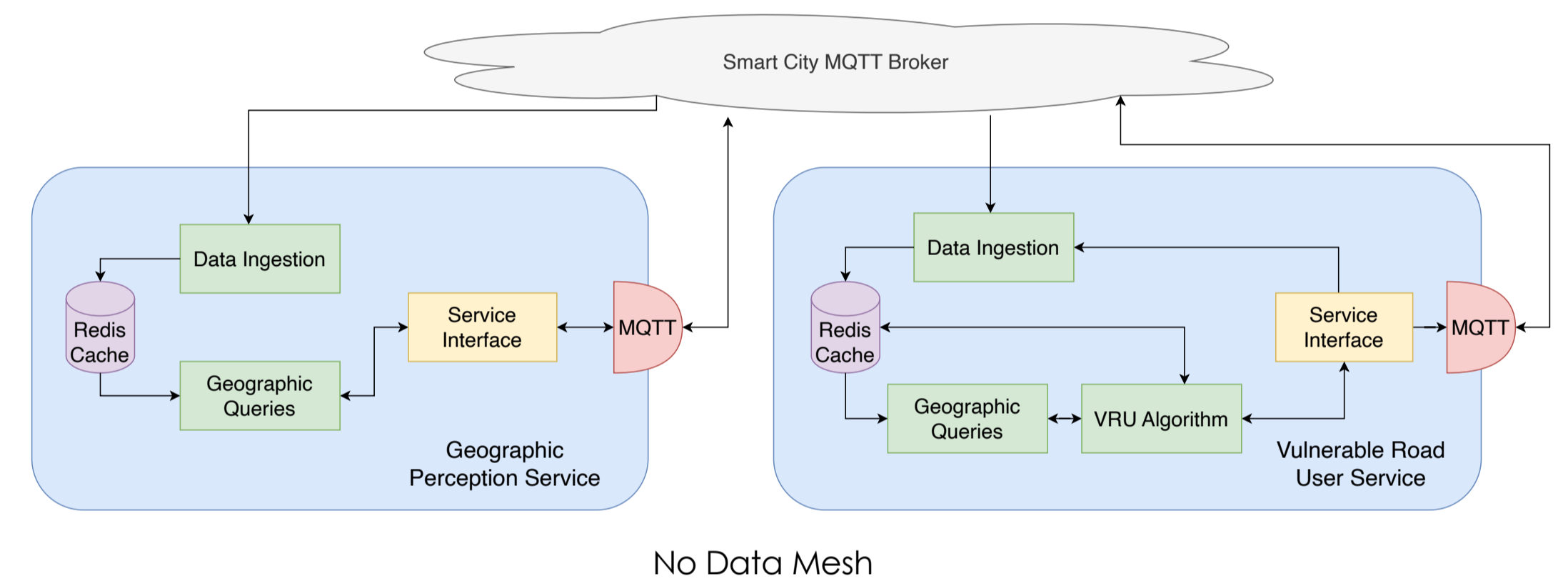
- Isolated data ownership and limited accessibility;
- Data silos that hinder data relocation and efficient processing;
- Customized, unmaintainable ETL processes for each silo.



## DATA MESH ARCHITECTURE

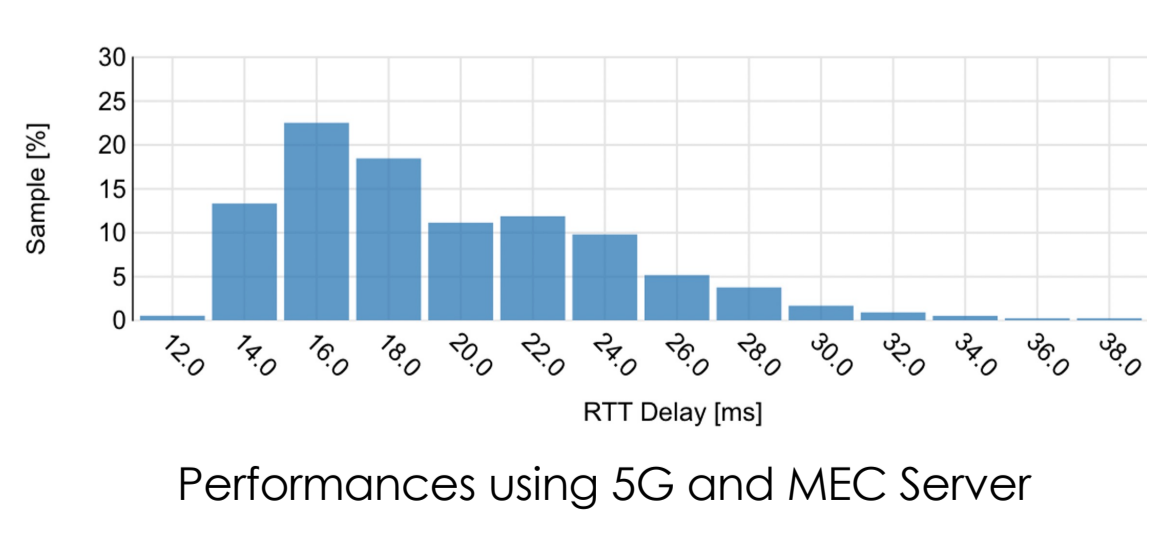
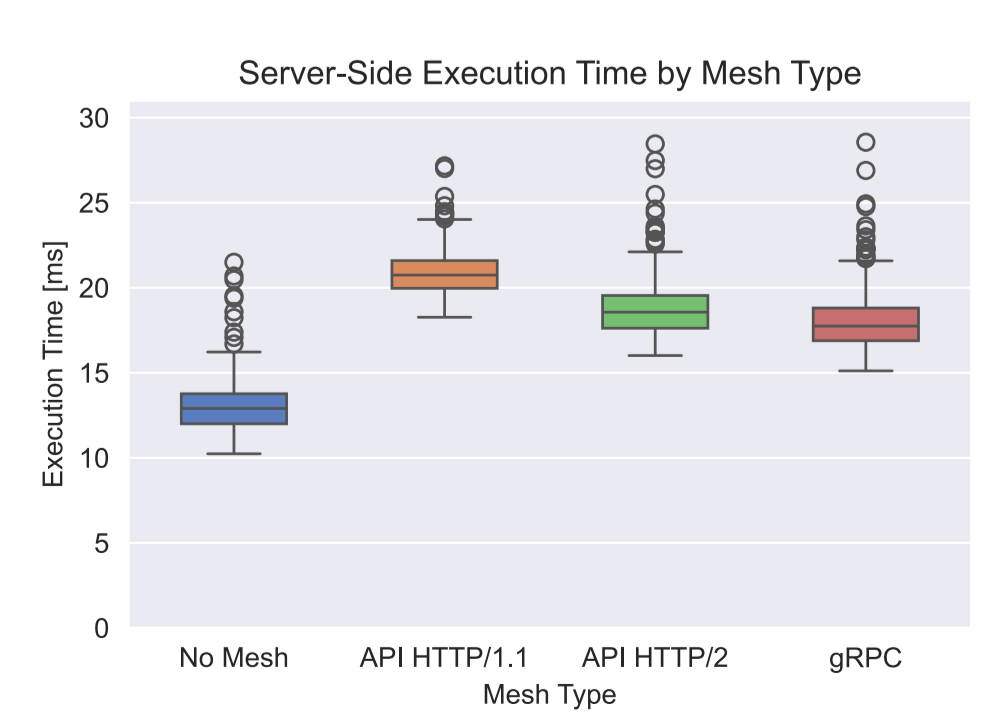
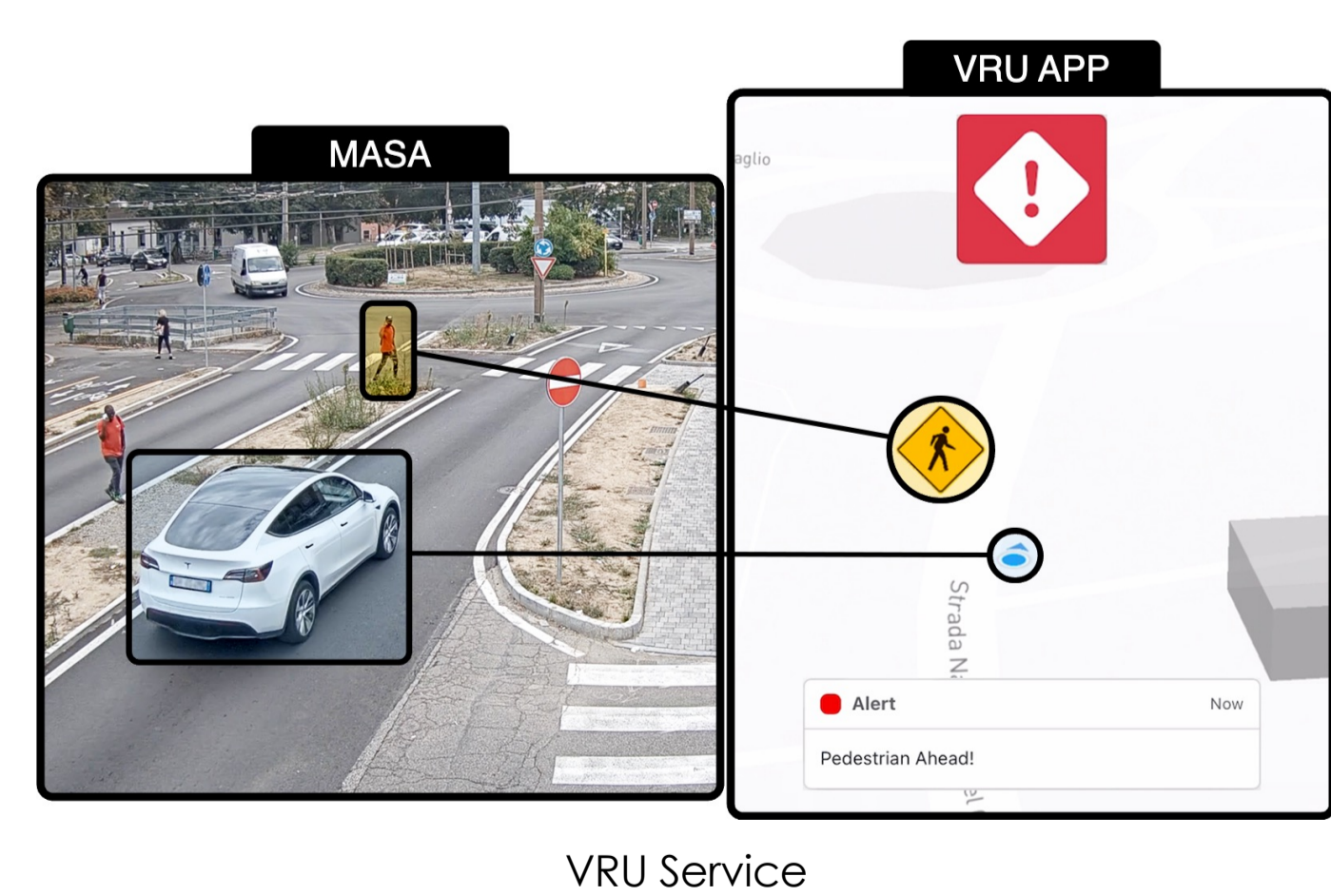
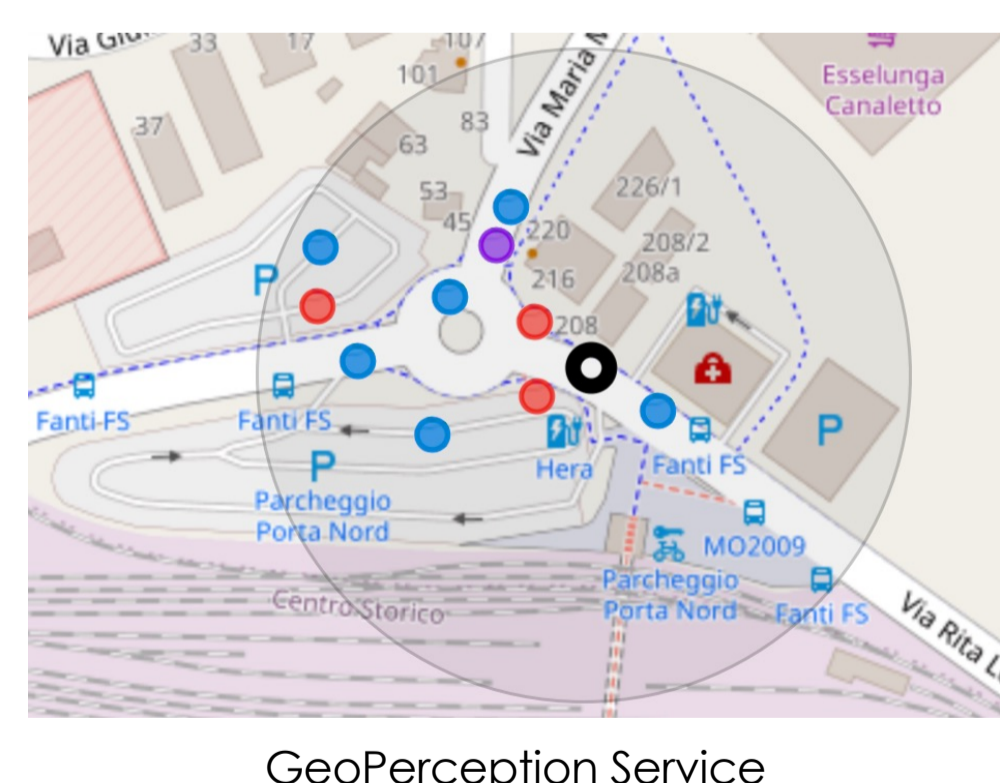
**Data Mesh** offers a game-changing solution, especially for smart cities and interconnected environments:

- It decentralizes data ownership, shifting responsibility from a central team to individual business domains;
- Each domain creates and manages its own data products following standard contracts for accessibility, interoperability, and security;
- Helps tackle issues such as protocol heterogeneity, latency, and isolated data silos;
- It facilitates domain collaboration, agile MLOps, and privacy-preserving Federated Learning.



## OUR APPLICATION

**Modena Automotive Smart Area (MASA)** use case is a key part of our look at smart city innovations. Located in Modena, Italy, MASA is a testing ground for connected vehicles and autonomous driving, thanks to its state-of-the-art infrastructure, making it a hub for next-generation urban mobility.



**One of our Applications** enhances road safety for Vulnerable Road Users (VRUs) through:

- Real-time monitoring: tracking VRUs and vehicles via GPS-enabled devices, municipality cameras, and road-side units (RSUs).
- Collision prediction: processing data to foresee potential crashes and promptly alerting users.
- Minimal Latency: processing data near its source in the Multi-Access Edge Computing (MEC).

In this ecosystem, the **Data Mesh architecture** further supports:

- Seamless collaboration and knowledge transfer;
- Agile development and deployment of innovative solutions.

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