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CODECO

Cognitive Decentralised Edge Cloud Orchestration

CODECO: USE CASES

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CODECO USE CASES

CODECO benefits will be demonstrated across four European competitiveness domains:
Smart Cities & Buildings, **Mobility**, **Energy**, and **Manufacturing**

P1: Smart Monitoring of the Public Infrastructure

Lead: Univ Göttingen/City of Göttingen, DE
Goal: Improved QoE
Domain: Smart Cities

P2: Vehicular Digital Twin for safe urban mobility

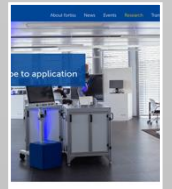
Lead: I2CAT, SP
Goal: Increasing road safety
Domain: Mobility

P3: Decentralized Edge MDS

Lead: Telefonica, SP
Goal: Cross-layer resource optimization for MDS
Domain: Smart Cities

P4: Decentralized Grids Collective Demand Side Management

Lead: Univ Politecnica de Madrid, SP
Goal: Smart monitoring of the energy generation, consumption & availability
Domain: Energy



P5: Decentralised, wireless AGV Control for Flexible Factories

Lead: fortiss, DE
Goal: Increased AGV autonomy and scalability via decentralized control
Domain: Manufacturing

P6: Smart Buildings

Lead: Almende, NL
Goal: Far Edge management of Crownstone meshes & their appliances
Domain: Smart Buildings

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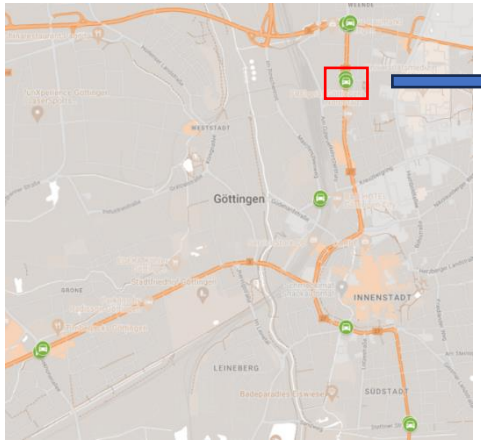
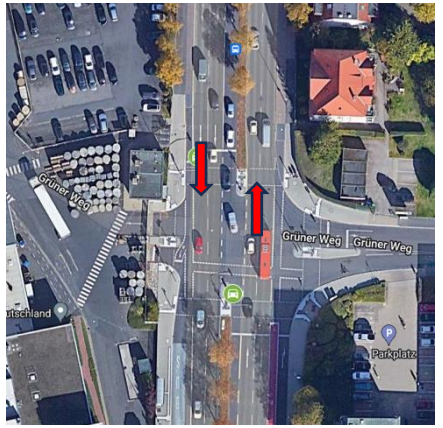
P1: SMART MONITORING OF THE PUBLIC INFRASTRUCTURE 1/2

Lead: University of Göttingen (UGOE), Germany
Domain: Smart Cities

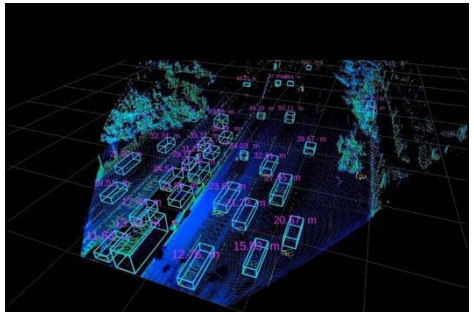
Actors:

- **GOV & Municipalities**
  - Monitor traffic and get analytics on patterns (e.g., traffic, volumes of cars, bikes, etc.).
- **Network Infrastructure Providers**
  - Offers network connection.
- **Cloud/Edge Infrastructure Providers**
  - Offers computation and storing resources for analytics.
- **Users (developers, subscribers, citizens)**
  - Gets information about traffic.





Each location includes 2 – 3 nodes to form a cluster.



Traffic point cloud data.

Why CODECO?

Migrate part of the processing task to another worker node within a cluster, when one area encounters a heavy traffic.

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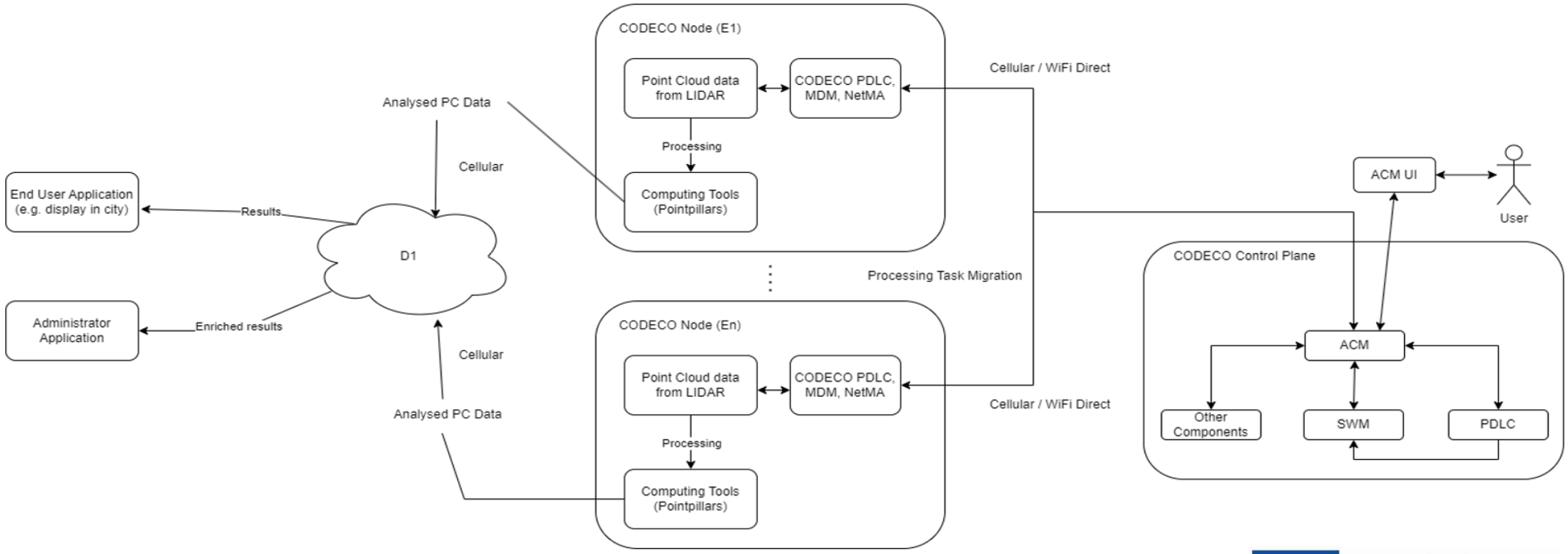
P1: SMART MONITORING OF THE PUBLIC INFRASTRUCTURE 2/2

KPIs:

- Number of installed CODECO Toolkits:
  - **Toolkits >= 10**
- Analytics Accuracy: **>= 75%**
- Data Processing Time:
  - **AVG of # processing frames / second / node to increase at least 5%**
- Minimize Bandwidth costs: **< 10G / month . LiDAR**



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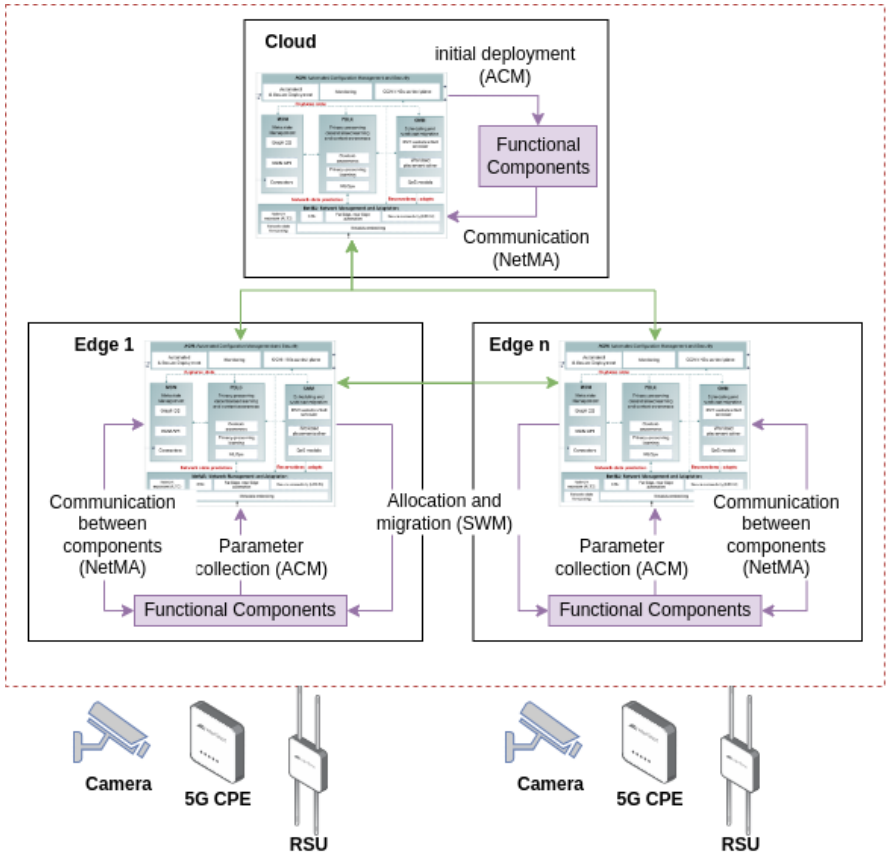
P2: VEHICULAR DIGITAL TWIN FOR SAFE URBAN MOBILITY 1/2

Lead: I2CAT, Spain
Domain: Mobility

Actors:

- **VRUs**
  - Vehicles or transport users who lack physical protection while navigating roadways.
- **Pedestrians**
  - Equipped with a smartphone and/or tracked by a camera.
- **Light Mobility Vehicles**
  - Equipped with an On-Board Unit (OBU) or smartphone and tracked by cameras.
- **Cars**
  - Equipped with an OBU.



Why CODECO?

VRU protection demands **real-time coordination** across vehicles, roadside units, and edge/cloud resources. CODECO enables **adaptive**, **decentralized orchestration**, ensuring **low-latency** and **fresh** Digital Twin updates despite mobility and network dynamics.

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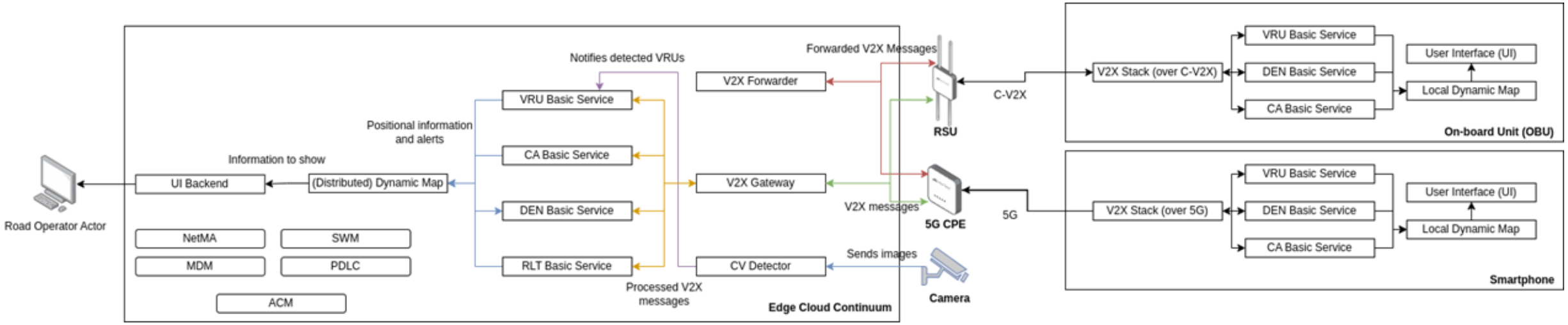
P2: VEHICULAR DIGITAL TWIN FOR SAFE URBAN MOBILITY 2/2



KPIs:

- Latency (OBU – cloud & cloud – phone): **Average latency < 20 ms**.
- Age of Information (AoI) Statistics:
  - **Average AoI < 70ms**
  - **Average Peak AoI < 200ms**
  - **Average AoI Penalty: < 20**
  - **Average AoI Penalty Peak: < 50**
  - *(AoI Penalty: The penalty function is the L2-Norm between the estimated trajectory and the real one)*
- Processing time: **< 5 ms**
- **Connected** Neighbourhood Awareness Ratio:
  - **100% for distances < 100 meters**
  - **> 80% for distances of 100 – 300 meters**
- **Disconnected** Neighbourhood Awareness Ratio:
  - **> 95% for distances < 100 meters**
  - **> 50% for distances of 100 – 300 meters**
- Usefulness & Convenience Suggestions:
  - **< 5% False Positives**
  - **> 95% True Positives**
- Roadside Units (RSUs) Coverage Area:
  - **> 90%**

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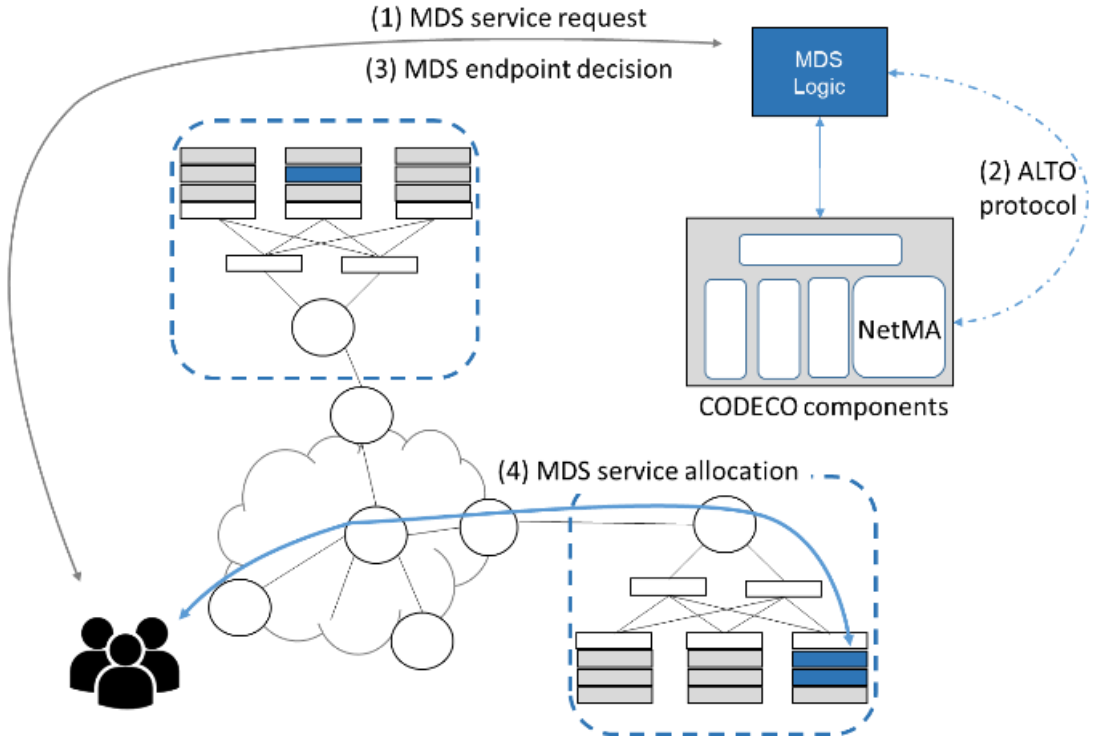
P3: MDS ACROSS DECENTRALISED EDGE 1/2

Lead: Telefonica (TID), Spain
Domain: Smart Cities

Actors:

- **MDS Platform and Content Owners**
  - The owner of the Media Delivery System (A company) and the Media Content Owner (can be the same company or a third party).
- **Network Infrastructure Owners**
  - The owner of a piece of the Network Infrastructure.
- **Cloud/Edge Infrastructure Providers**
  - The owner of a piece of the Cloud/Edge Infrastructure.
- **MDS subscribers**
  - The User of the System
    (e.g., Gamers, Listeners etc.).



Why CODECO?

To dynamically deploy and **interconnect distributed cache** instances across **decentralized edge and cloud resources**, **optimizing media delivery** performance and QoE.

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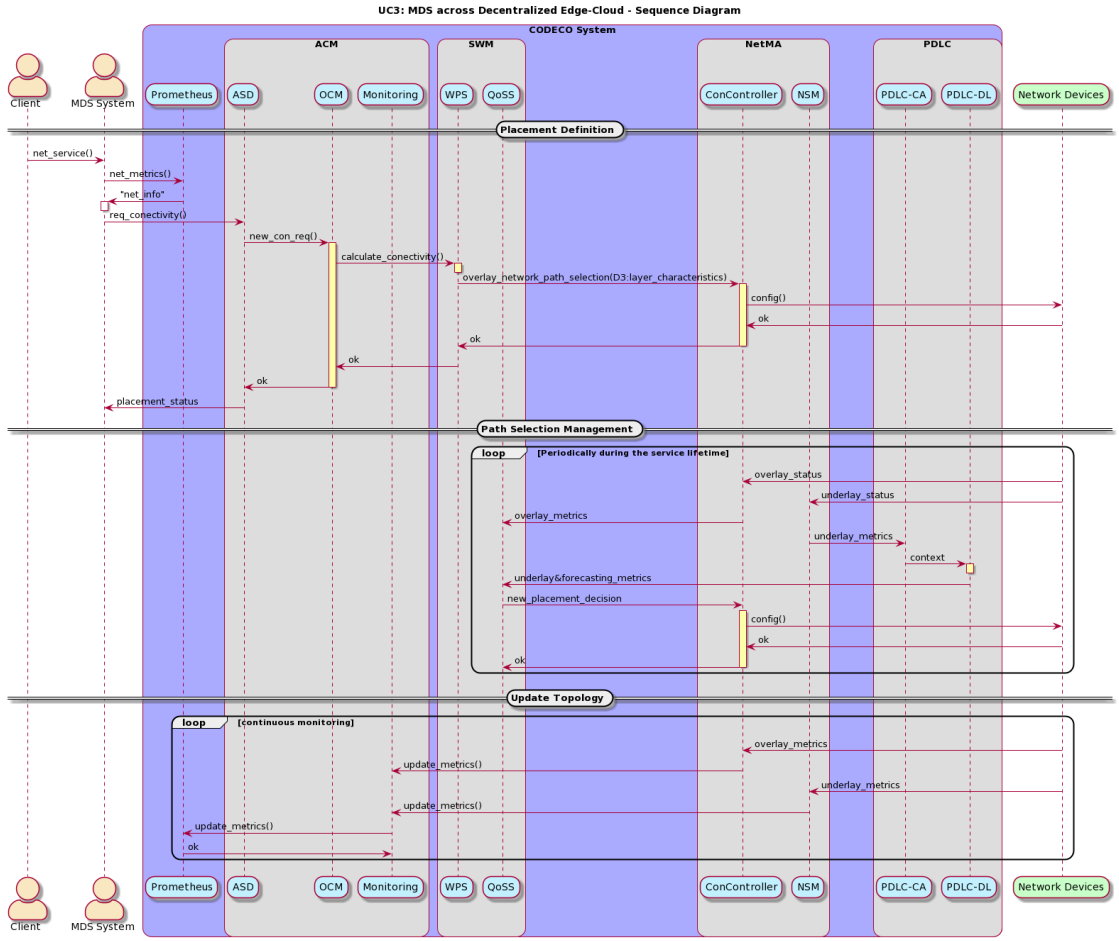
P3: MDS ACROSS DECENTRALISED EDGE 2/2

KPIs:

- Proper Service Delivery – Network:
  - The System should be able to detect the path with the **lowest Latency & Hopcount**.
- Proper Service Delivery – Computing:
  - The System should be able to detect which **nodes have enough capacity & Bandwidth** to handle the resource request.
- Guarantee correct updates & exposure of resource information:
  - **Network updates are correctly translated & represented into topology maps**.
- Use QoE as an axis for resource optimization decisioning:
  - The path selected is the one with the **maximum value of QoE**.



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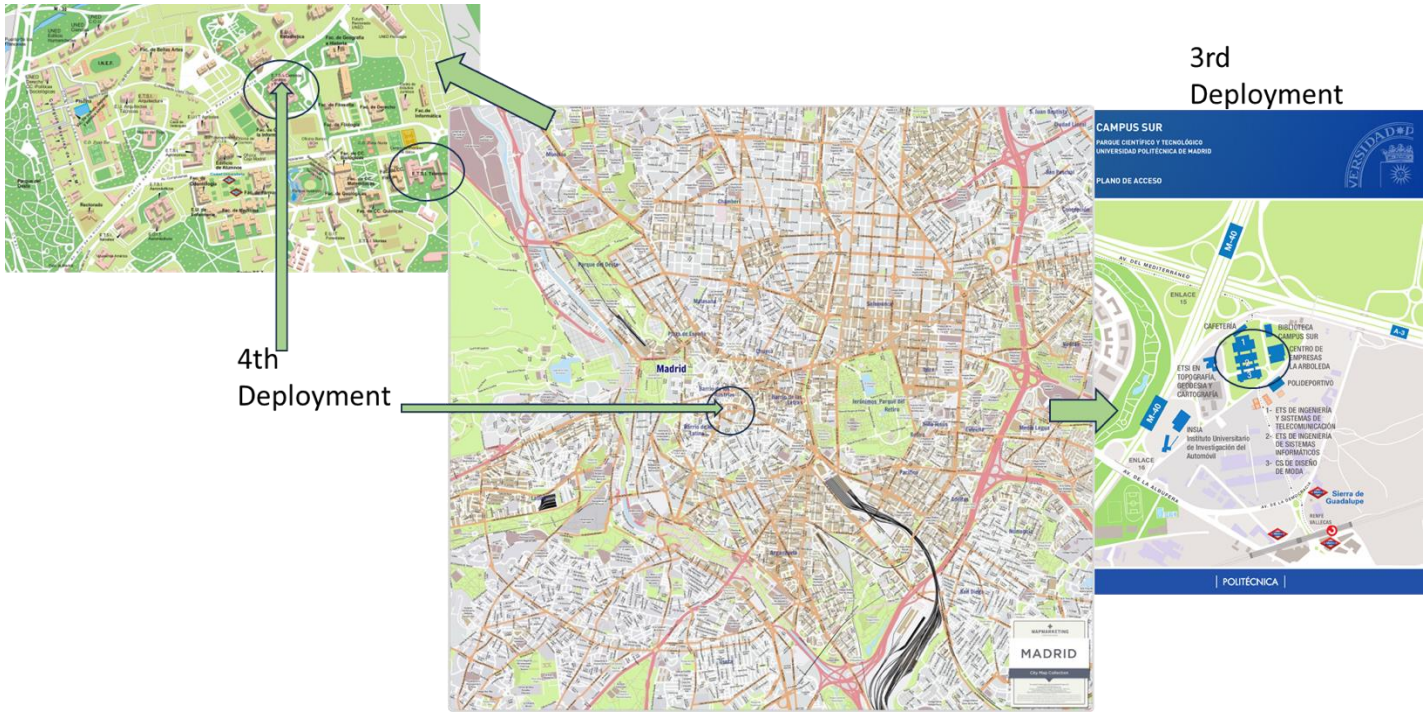
P4: DEMAND-SIDE MANAGEMENT IN DECENTRALIZED GRIDS 1/2

Lead: Universidad Politecnica de Madrid (UPM), Spain
Domain: Energy

Actors:

- **Prosumers**
  - Users that can interact with the electric market.
- **Energy Communities**
  - Users sharing resources and acting as a unity.
- **Energy Resources Aggregators**
  - Managing sets of energy assets within the market.
- **Distribution System Operators (DSOs)**
  - Electric Power Providers
- **Cloud Infrastructure Providers**
  - Offers computation resources for analytics.



Why CODECO?

CODECO will be used as a framework to optimally **deploy**, **manage**, and **coordinate** the different components of energy management application in different nodes, **multiple edge devices** and infrastructure (buildings).

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P4: DEMAND-SIDE MANAGEMENT IN DECENTRALIZED GRIDS 2/2

KPIs:

- Number of energy clusters created and modified per day:
  - **clusters = 20**
- Number of buildings involved:
  - **Buildings > 3**
- Energy assets integrated:
  - **assets > 100**
- Amount of kilowatt and kilowatt hours of the energy community:
  - **30% UPM consumption**
- Amount of energy saved (not bought from the grid):
  - **energy saved >= (10 - 20)%**
- CO2 emissions reduction:
  - **reduction > 10%**
- Minimise Latency for Energy function deployment:
  - **less than 1 minute**

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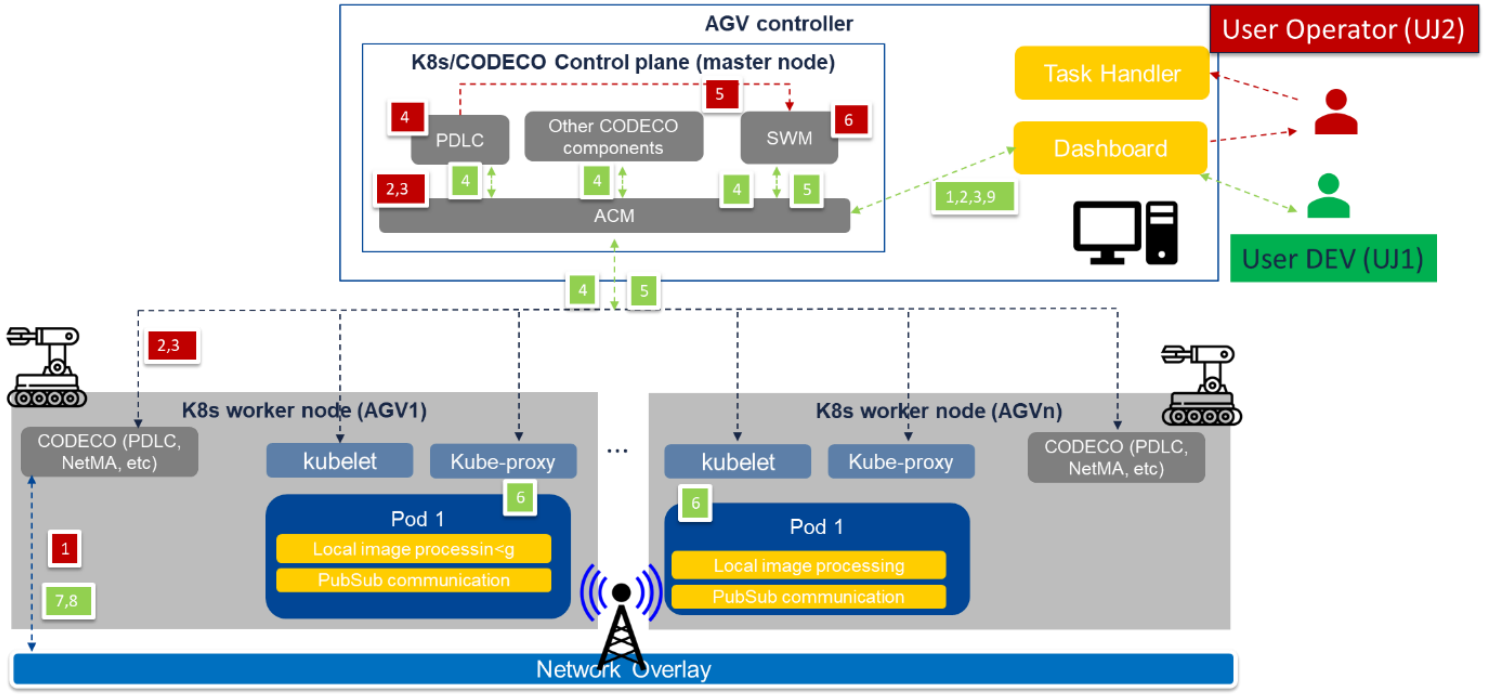
P5: WIRELESS AGV CONTROL IN FLEXIBLE FACTORIES 1/2

Lead: fortiss (FOR), Germany
Domain: Manufacturing

Actors:

- **AGVs (far Edge Nodes)**
  - Mobile robots with different sensors (e.g., cameras, environmental sensors).
- **AGV Fleet Controller**
  - Controller station is usually the centralized point of control in an AGV fleet. It provides AGVs with specific tasks to be carried out.
- **Users**
  - A developer willing to deploy the CODECO AGV App.
  - Operators and respective terminals, remotely assisting AGVs.



Why CODECO?

CODECO enables **low-latency**, **scalable**, and **energy-efficient orchestration** of AGV fleets across mobile edge nodes, improving **safety** and **performance** compared to static approaches.

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P5: WIRELESS AGV CONTROL IN FLEXIBLE FACTORIES 2/2

KPIs:

- Scalability Aspects:
  - At least **5 Operational AGVs in a Cluster**.
  - **Latency Reduction of 20%** in comparison to an environment without CODECO (e.g., K8s).
  - **Total setup time reduction of 10%** in comparison to K8s.
- Performance Aspects:
  - **10% of reduction in the number of collisions**.
  - **Network Energy Lifetime increase of 10%.**
  - **10% reduction on Energy consumed** during setup in comparison to K8s.
  - **20% reduction for messaging overheat** in comparison to an environment without CODECO.

- ACM: Multi-cluster approach, higher degree of flexibility
- MDM: provides real-time metadata to support ML-based orchestration
- PDLC: context modelling (based on data from MDM, NetMA) to best select Edges (AGV as an Edge)
- SWM: support scheduling and workload migration with intermittent connectivity
- NetMA: support for mobile nodes direct communication (exposure of network features and requirements)

- ACM
  - Setup of CODECO
  - Co-located with the AGV controller node
- MDM
  - Role not yet clear
- PDLC
  - Context modelling – node cost (selection of “best AGV”)
- SWM
  - Scheduling and re-scheduling (control plane)
- NetMA
  - Highly relevant as we are handling mobile nodes; monitoring on each AGV

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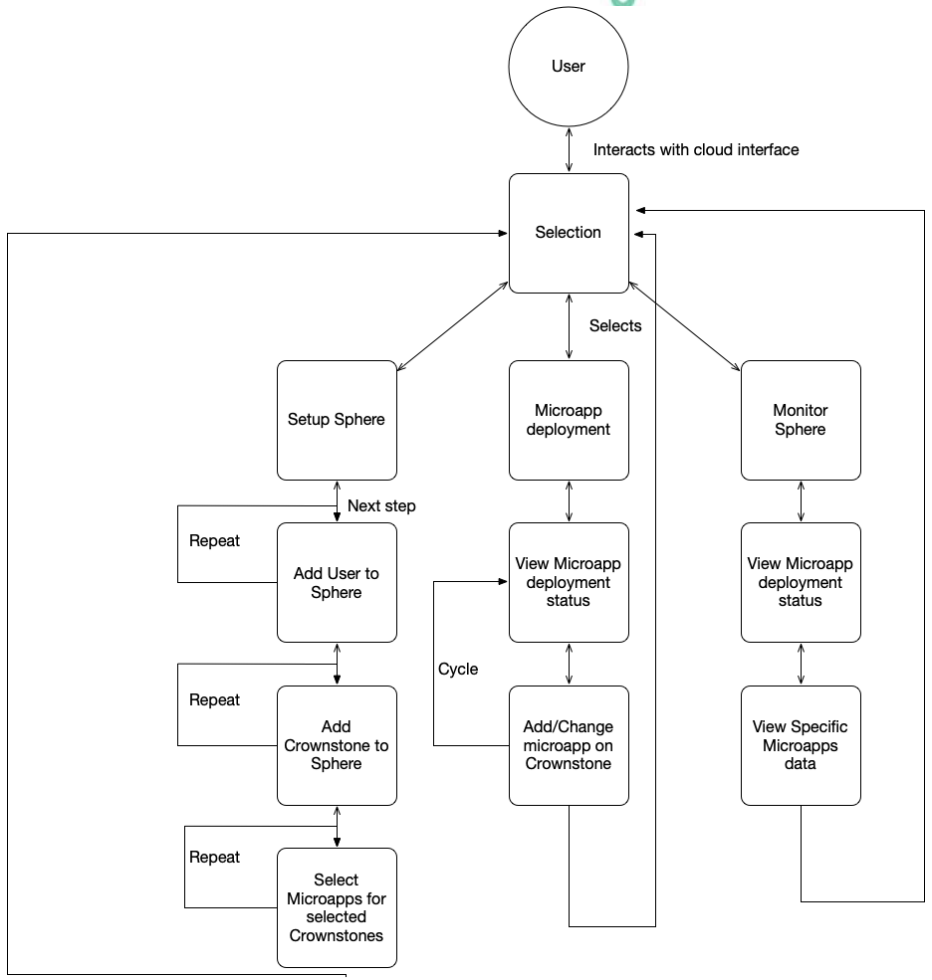
P6: AUTOMATED CROWNSTONE APPLICATION DEPLOYMENT FOR SMART BUILDINGS 1/2

Lead: Almende (ALM), Netherlands
Domain: Smart Buildings



Actors:

- **Crownstone App Devevelopers**
  - Develop and deploy microapps on selected Crownstones across the network, without manual device discovery, Bluetooth proximity, or MAC address handling.
- **Building Managers**
  - Deploy and manage applications using a single configuration file, without needing knowledge of the underlying Crownstone network topology.
- **Crownstone End Users**
  - End-Users of the Infrastructure (e.g., crownstones, hubs, phones).

Why CODECO?

CODECO enables **policy-driven deployment** and monitoring of distributed Crownstone microapps, **reducing manual configuration** while ensuring correct execution and observability **across far-edge devices**.

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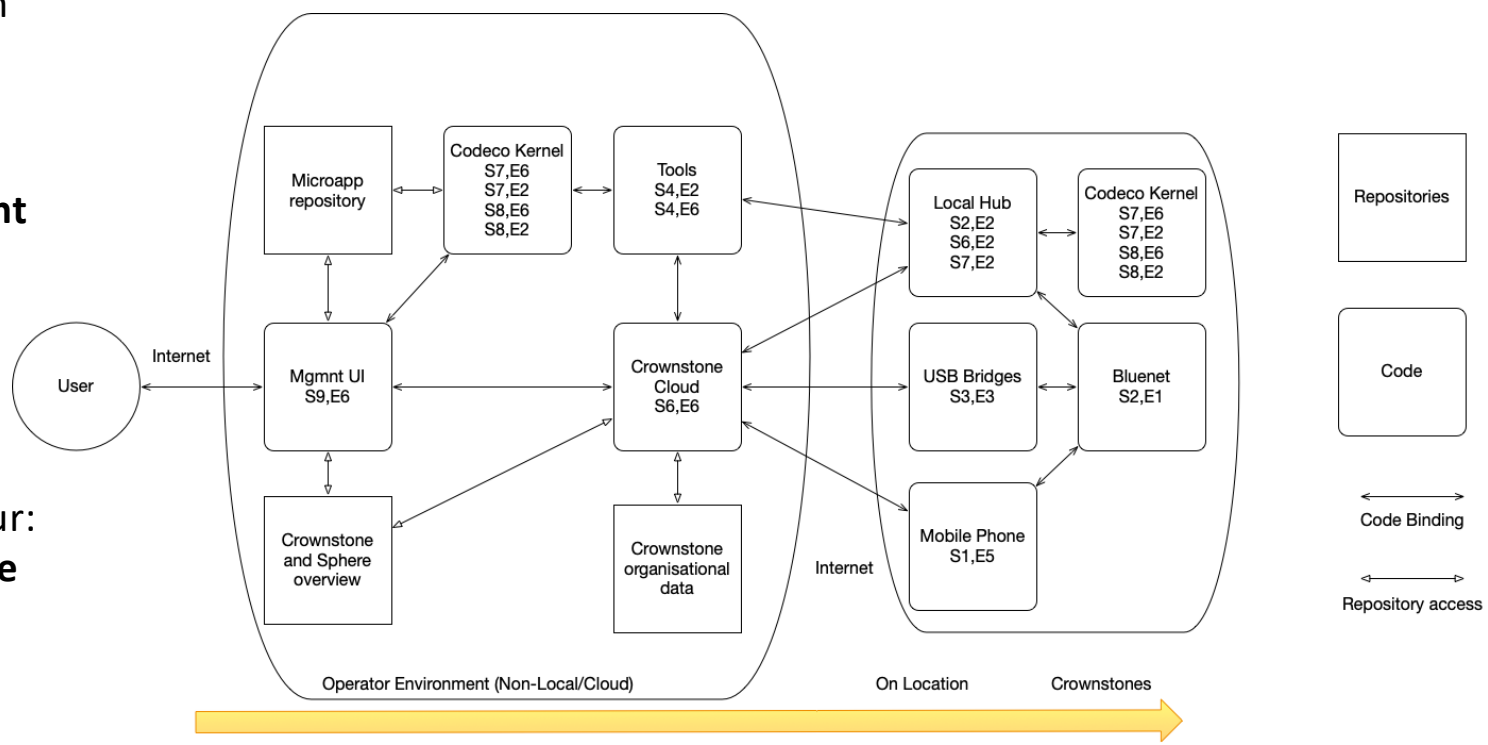
P6: AUTOMATED CROWNSTONE APPLICATION DEPLOYMENT FOR SMART BUILDINGS 2/2

KPIs:

- Deploy & Expand Local Smart Infrastructures:
  - **Sphere is approachable in the dashboard** on the cloud and the app & changes are visible.
- Develop & Deploy Distributed edge-to-cloud AI applications:
  - **The control file/structure for the deployment tooling is generated correctly.**
- Minimise effort on reconfiguring far-edge data processing applications:
  - **Microapps are executing in an expected manner.**
- Monitor & Verify the Crownstone sphere behaviour:
  - **The system should be able to monitor all the Microapps in a sphere using proxy agents**.



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THANK YOU!

Questions?

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