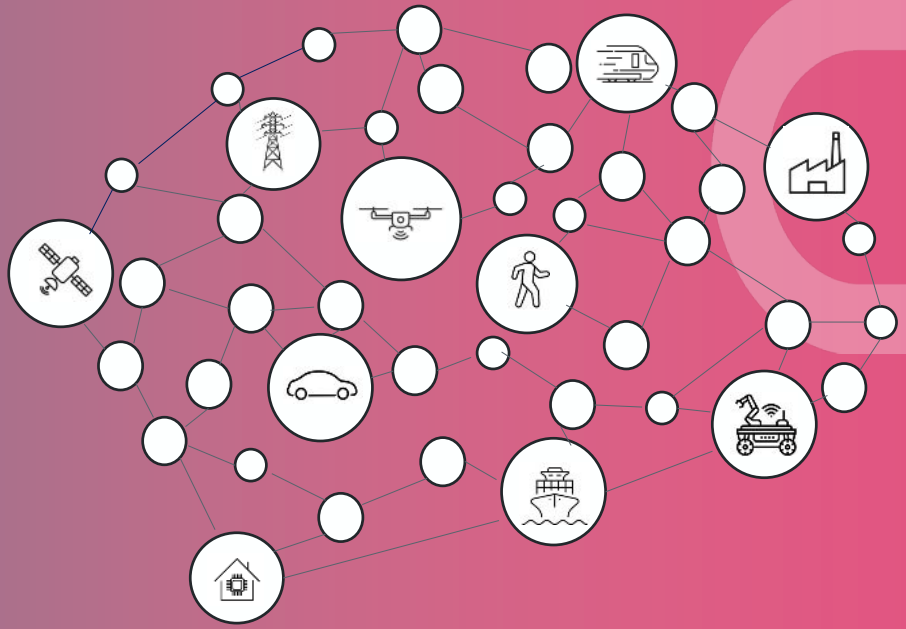
EUCloudEdgeIoT.eu



SWARM COMPUTING
KEY SOLUTIONS AND USE CASES

July 2024

EUCloudEdgeIoT.eu

Disclaimer

The information provided in this booklet is intended for informational purposes only and may not necessarily be complete or up-to-date. While we have made every effort to ensure the accuracy of the information presented, we encourage readers to visit each project's website for the latest information and to verify any information presented in this booklet. We assume no responsibility or liability for any errors or omissions in the iformation provided, or for any actions taken in reliance on the information contained in this booklet.

Table of Contents

THE EUROPEAN CLOUD, EDGE AND IOT CONTINUUM

The **European Cloud, Edge & IOT Continuum (EUCloudEdgeIOT.eu)** aims to realise a pathway for the understaning and development of the Cloud-Edge-IoT (CEU) Contrinumm by promoting cooperation between a wide range of research projects, developers and suppliers, business users and potential adopters of this new technological paradigm.

To achieve these goals, the EUCloudEdgeIoT intiative coordinates a diveres portfolio of projects clusters with different specialisations.

These are:

Cloud Computing	Next Generation Internet of Things	Meta Operating Systems	Cognitive Cloud	Swarm Computing	Sopen Source	Software Technologies

This bookl;et focuses specifically on the **Swarm Computing portfolio** providing insights on televant use cases under devleopment. For more information on the wider initiative, or on other portfolios, please see our Research Community Booklet.

The OpenSwarm project triggers the next revolution in data-driven systems by developing true collaborative and distributed smart nodes in three technological pillars:
•efficient smart nodes
•energy-aware Artificial Intelligence (AI)
•energy-aware swarm programming.

The SmartEdge project aims to achieve dynamic integration of decentralized edge intelligence while prioritizing reliability, security, privacy, and scalability. This will be realized through a semantic-based interplay of edge devices in a cross-layer toolchain, allowing seamless and real-time distribution of autonomous intelligence swarms.

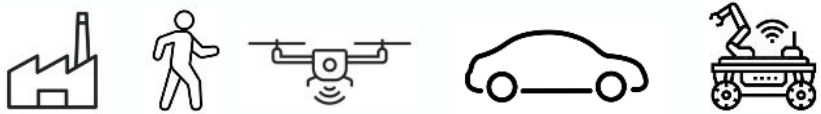
TaRDIS's primary goal is to significantly ease the complexity and reduce the effort of building correct and efficient heterogeneous swarms.
TaRDIS focuses on supporting the correct and efficient development of applications for swarms and decentralised distributed systems, by combining a novel programming paradigm with a toolbox for supporting the development and executing of applications.

The OASEES project will deliver a European, fully open-source, decentralized, and secure Swarm programmability framework for edge devices and leveraging various AI/ML accelerators (FPGAs, SNNs, Quantum) while supporting a privacy-preserving Object ID federation process.

The INCODE project will deliver a wide-open, secure and trusted IoT-to-edge- to-cloud compute continuum that will realize the true potentials of edge intelligence. The project will design and develop an open platform for the deployment and dynamic management of end-user applications, over distributed, heterogeneous and trusted IoT-Edge node infrastructures, with enhanced programmability features and tools.

OpenSwarm

smartedge

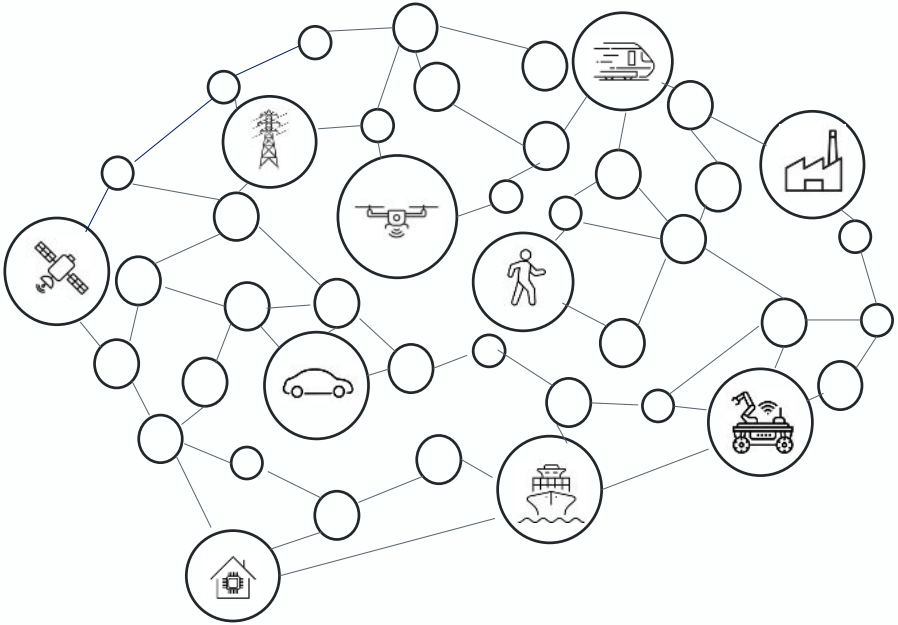


ToRDIS

OASEES

INCODE

EUCloudEdgeIoT.eu



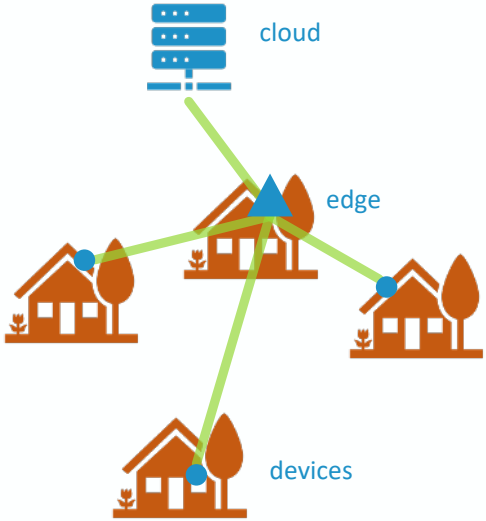
Overview of Use Cases per project

OpenSwarm Use Cases

Use case of Renewable Energy Community

Concept

We enable the implementation of renewable energy communities (RECs) to achieve climate neutrality and decarbonize the energy system. OpenSwarm develops a system of smart sensors (the **devices**) that orchestrate and interact in a collaborative manner with the customer gateway (the **edge**) using distributed swarm intelligence and low-latency communication. The devices monitor raw data (e.g. instantaneous energy consumption), forward that to the edge device which generates a summary of the data (e.g. using a Exponential Moving Average) to the OpenSwarm **cloud**. The cloud, which runs remotely, dynamically orchestrates the local electricity demand (the consumption of the homes) with the supply (the production of their solar panels). This use case verifies the OpenSwarm network's ability to operate renewable energy communities with a hierarchical network organization, as well as to analyze the current consumption pattern using distributed AI.



Benefits

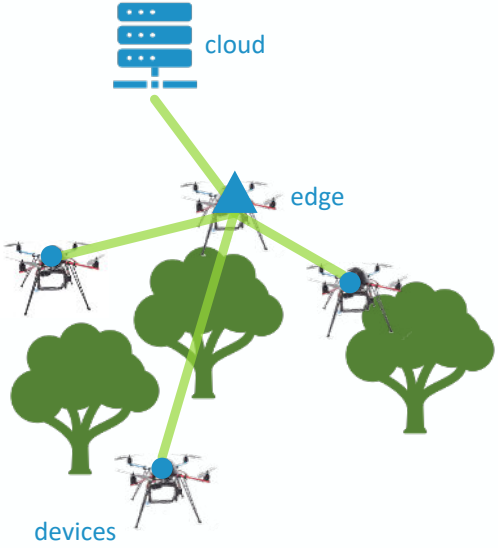
The use case enables the flexible and adaptable interaction of energy consumers and producers, offering business opportunities for new and existing players in the energy domain. It potentially allows for lower energy prices for the end-user, as electricity can be shared between neighbors directly and independently in an energy island. The employment of renewables and its orchestration in the grid leads to a higher share of energy consumption with zero carbon footprint.

OpenSwarm Uses Cases

Use case of Supporting Human Workers in Harvesting Wild Food

Concept

We use drones to map where there are a lot of wild berries or mushrooms, allowing pickers to pick fruit faster. Each drone (the **device**) is equipped with a camera, a wireless radio, and enough processing power to run motion control and image recognition routines on-board. Each drone runs the OpenSwarm networking technology, allowing it to communication with a leader drone (the **edge**). Each drone takes pictures of the trees it flies over and identifies where fruits are. It does so for example by using a model previously trained on a dataset of pictures. The drone forwards that information to the edge, that serves as the expedition leader and coordinates with the **cloud**. The cloud builds a map of the locations of the wild berries or mushrooms, and navigates the drones.



Benefits

Swarm intelligence uses forest-related data for better monitoring and estimating the fruits' life, location and yield. Swarm intelligence coordinates the work between farmers and robots, thereby making the harvesting work more efficient (faster picking).

OpenSwarm Uses Cases

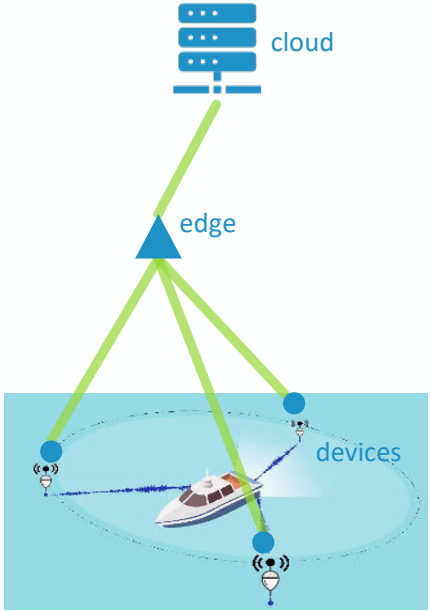
Use case of Ocean Noise Pollution Monitoring

Concept

We develop an automated system that monitors and counts boats in a protected marine area (PMA), and tracks their speed to help manage underwater noise pollution. The proposed system uses smart buoys (the **devices**) equipped with hydrophones. The buoys can communication with one another using OpenSwarm's mesh networking technology. One of the buoys is the gateway (the **edge**), and is connected to the OpenSwarm **cloud**. The buoys listen and detect boats from the sounds recorded by their hydrophones. They send the timestamped sound signature to the edge, which compares them, computes the location and speed of the boats, before forwarding that information to the OpenSwarm **cloud** running on a server on the Internet. The project demonstrates swarm communication, constrained AI framework and energy-aware swarm operation. It takes advantage of the OpenSwarm swarm compiler to allow a user to efficiently program and control the behavior of the devices.

Benefits

The AI model can assess the presence and well-being of wildlife and thus contribute to managing the traffic so that damage to nature is minimized. This system can be applied to all 3,150 European PMAs and to approximately 5,000 marinas in Europe.

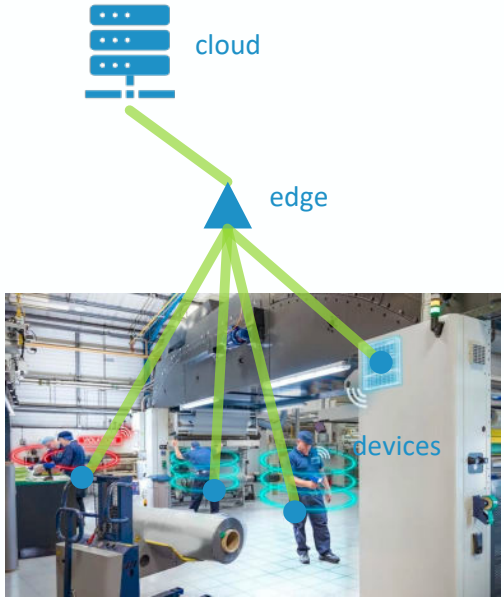


OpenSwarm Uses Cases

Use case of Environment, Health, and Safety in Industry

Concept

This use case focuses on the importance of Environment, Health, and Safety (EHS) measures in industrial sites, which can be potentially dangerous as workers and moving machines are close to one another. We equip workers with smart OpenSwarm wearables, and attach smart tags to static and mobile machines/robots in the factory (the **devices**). These devices form a highly reliable low-power wireless network around a gateway device (the **edge**). The devices monitor the distance between one another and send those measurements to the edge, which summarizes the information (e.g. removing duplicate information) and forwards that to the OpenSwarm **cloud**. This allows the cloud service to closely monitor the distance between workers and machines/robots, and it ready to stop robots to avoid injuries.



Benefits

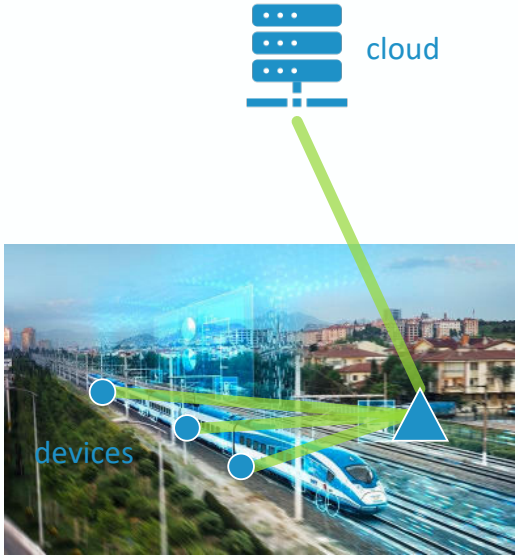
Environment, Health, and Safety measures are legally required in Europe. Their continuous monitoring is expected to result in a significant reduction in accidents (and associated costs) and improved well-being for workers, as well as reduce the duration machines are not operating.

OpenSwarm Uses Cases

Use case of Moving Network in Trains

Concept

The shift of passengers and goods from air/road to rail significantly reduces CO_2 emissions. Existing sensor systems for monitoring train components typically need to be installed at manufacturing and often don't allow for train cars to be rearranged between trains. OpenSwarm creates a reconfigurable network of wireless sensor nodes (**devices**). We retrofit them on an Intercity Express passenger train. They monitor the state of key elements of the train, for example the vibration of moving elements. They communicate with a gateway on the train (**edge**). The devices monitor the raw data, the edge summarizes the data and sends that to the OpenSwarm **cloud**, which determines whether any element on the train needs maintenance. This use case also validates the "zero-touch" security solution that allows the sensors attached to train cars to reorganize into different trains in a secure manner.



Benefits

A high percentage of train connections do not reach their destination and a significant delay is caused by disruptions and the availability of train cars and traction units. This results in extra costs, and in a decrease in customer satisfaction. OpenSwarm's AI-augmented approach is expected to bring game-changing accuracy, making it strategic for any train manufacturer and operator. This solution can be retrofitted to existing trains, a much cheaper and flexible solution than having to integrate them at manufacturing. The shift of goods from road trucks to train, and passengers from planes to trains reduces carbon footprint.

INCODE Uses Cases

Use case of Smart logistics at terminal stations

Concept:

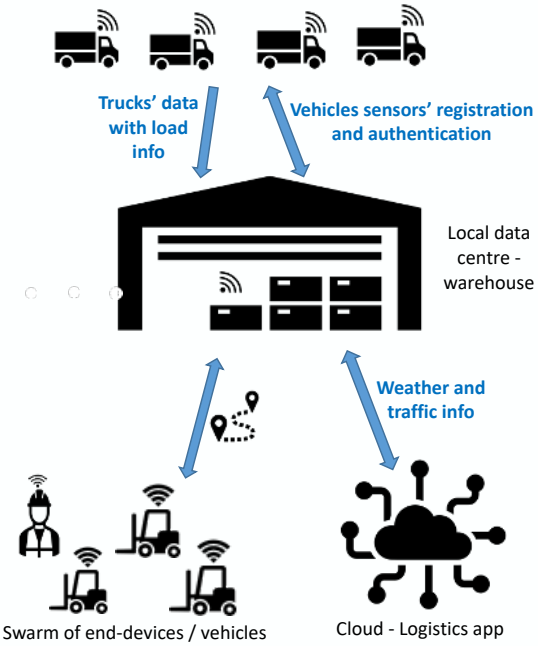
Load information including transport conditions data (perishables like food) flow from mobile IoT sensors of **the truck fleet** in real time (or also periodically (e.g. daily)) to register and authenticate with the local data centre at the **warehouse**. Static IoT sensors in the warehouse provide inventory status info. SOME of the local data is combined with the cloud intelligence (logistics app). Then the local data centre receives commands to manage a **swarm of end-devices / vehicles** for (un)loading of the trucks according to a schedule (or in real time).

Benefits:

Optimised (un)loading scheduling and allocation of respective resources leads to prevention of damage to perishables and to reduced units costs of using trucks and loading vehicles. In turn, this leads to increased profits of the logistics actors.

Logistics app is a trusted framework for all the logistics actors: road carriers, customs, warehouses, distributors or retailers.

Coordinated (un)loading provides for work safety and prevents product mishandling.



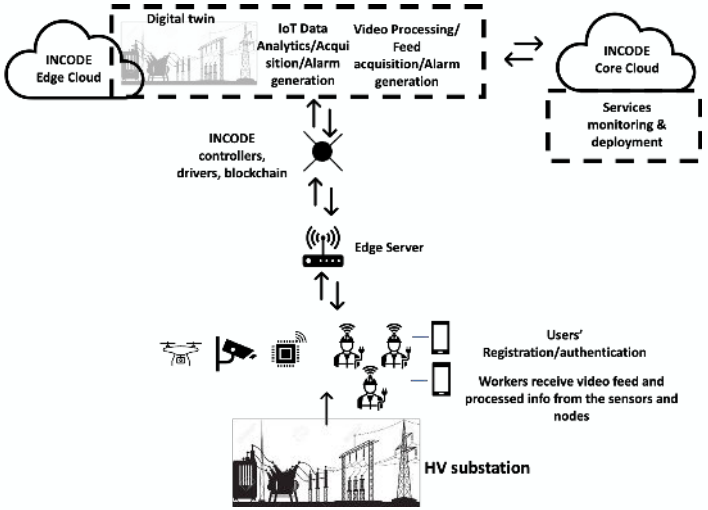
INCODE Uses Cases

Use Case of Utilities Inspection

Concept:

This UC involves the demonstration of 2 functionalities relevant to power utilities by taking advantage of novel, low-cost, high-frequency IoT equipment and computer vision algorithms bringing intelligence at the edge

- Predictive maintenance action sequence
- Intruder/equipment failure detection sequence



Benefits:

Improvement of preventive maintenance activities

Improvement of failure precautions

Improvement of safety of assets and personnel

Improvement of application interoperability

INCODE Uses Cases

Use Case of SMART worker assistant

Concept:

This UC includes the demonstration of novel technology use (IoT sensors, collaborative robots, wearables, exoskeletons), capable of detecting variables that indicate a danger / risk situation for the operator and reacting by modifying the work environment. Bringing intelligence at the edge

Benefits:

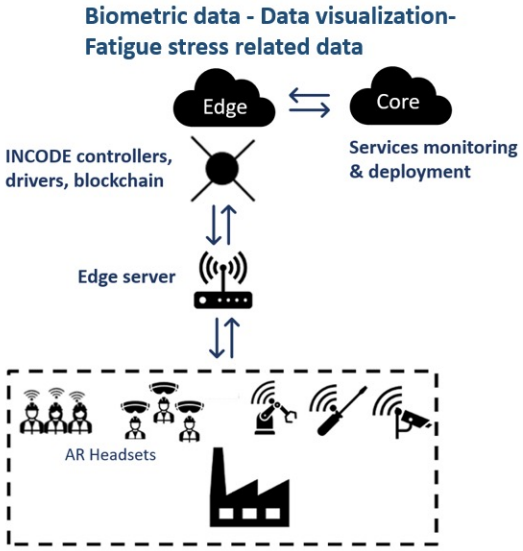
The gains of such an approach will include the following:

Introduction of actions triggered by vital signs that can detect and optimize workers' position based on production floor operational needs

Safer working environment due to prevented accidents

Improved labour efficiency due to better informed & directed workers

Improved maintenance and fault detection times



SmartEdge Uses Cases

Use case of Cooperative Perception for Driving Assist

Concept:

Like test case generation in software engineering, we breaks down driving scenarios in Advance Driving Assistance System (ADAS) into smaller actions and generate (ideally all) possible test cases.

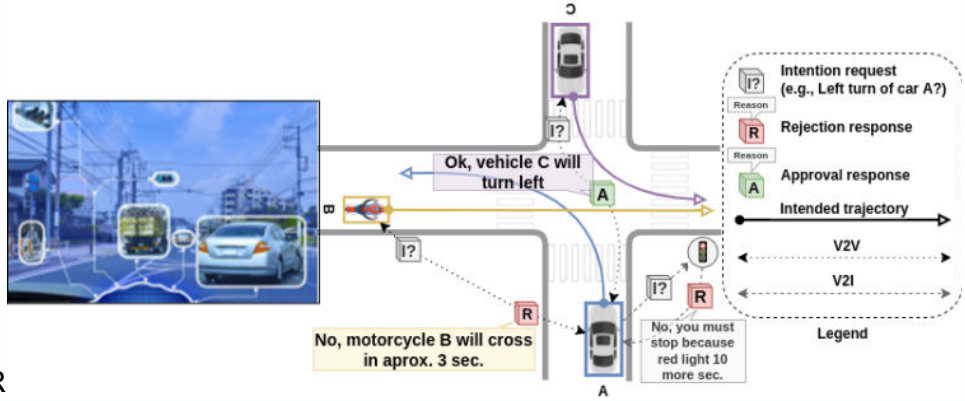
More specifically, we propose to represent expert knowledge, e.g. traffic rules, as well as abstract situations extracted from the data using **semantic-based declarative languages** and employ **reasoning systems** to construct exhaustive sets of test cases for ADAS.

Additionally, this abstract knowledge can be combined with the real-time data to create realistic test cases on-the-road.

This enables us to provide more complicated scenarios without the requirement of complex testing environment.

Benefits:

The constructed test cases verify the ability of ADAS to make decisions about valid (sequences of) actions in certain complex situations, as well as evaluate their planning capacities in a dynamic environment with the goal of making **ADAS** more robust and, safe.



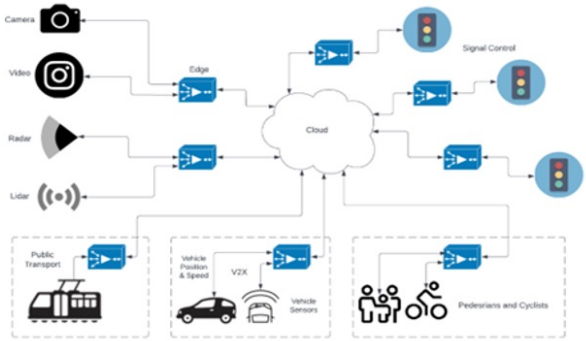
SWAR

SmartEdge Uses Caes

Use case of Active Option-zone Management

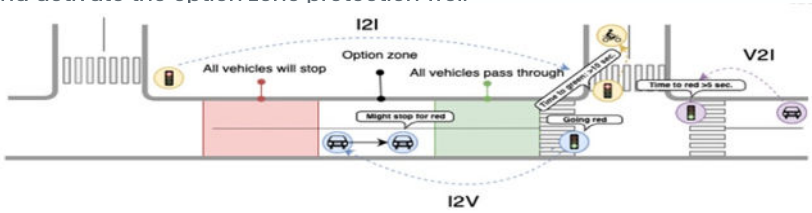
Concept:

The intersections are equipped with radar sensors and edge-devices that constitute a swarm intelligence solution together with their neighboring signal controllers (I2I) and the connected vehicles (I2V). The signal controllers can send messages to the vehicles to slow down (prepare to stop at the traffic signals) in order to actively create a safety gap between the last vehicle to go through and the first one to for the signals. As a result, the risk of rear-end collision is removed, while at the same time the optimal signal timing can be maintained. This system, can be called Active option zone management for improved safety and fluency, which consists of the following parts.



Benefits:

This option zone protection can be started well in time before the vehicles enter the option zone. Based on its radar data, the previous signal controller can monitor the vehicles leaving the previous intersection. This data can be relayed to the next intersection, in which the signal controller can anticipate the approaching traffic flow and hence plan and predict the optimal green end moment and activate the option zone protection well in time.



SW

SmartEdge Uses Cases

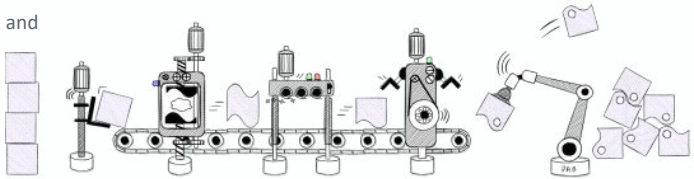
Use case of Smart Factories with Intelligent Mobile Robots

Concept:

Smart factories use Robotic Flexible Assembly Cells (RFACs), which can be **rapidly reconfigured** to manufacture a broad range of products.

Moving material between RFACs requires equally flexible and intelligent robotic product mover solutions, which can operate in **autonomous swarms** and without fixed infrastructure to adapt to dynamically changing environments.

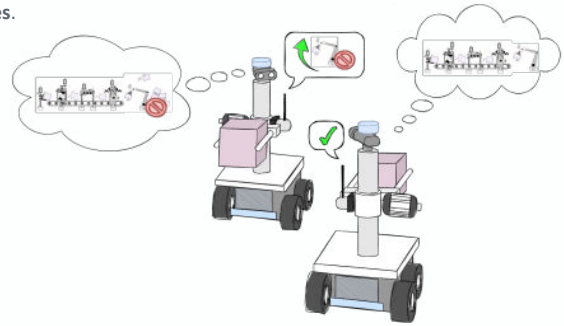
These mobile robots will **understand their environment** at a semantic level and share that knowledge with other robots in the swarm, allowing them to collectively solve problems.



Benefits:

Smart factories can produce a **broader range of products** in **smaller batch sizes**.

This allows products to be manufactured **locally** where they are consumed, shortening European supply chains, promoting the circular economy, and reducing CO_2 transport emissions.



SmartEdge Uses Cases

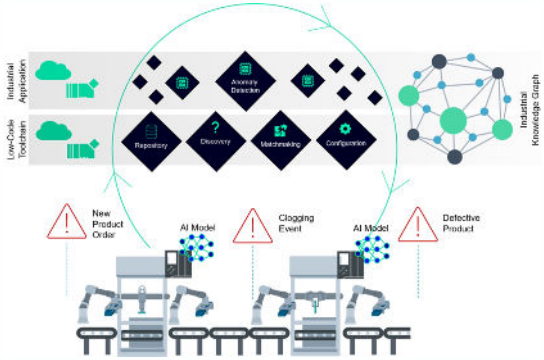
Use case of Smart Factory with Low-Code Edge Intelligence

Concept:

Smart factory is based on the convergence of Information Technology with Operational Technology (IT/OT).

Shop floor (OT) data is integrated, semantically enriched, and processed with IT systems. Low-code toolchain is provided to enable an easy creation of template-based (AI) applications.

They can be deployed either at the edge or cloud. Their output may, in return, influence control processes (OT).



Benefits:

Smart factory provides **continuous standard-based semantic integration**, **low-code applications**, and **edge intelligence** in order to enable **flexible** production. Such production is **adaptable** within **short time** at **low costs**. It allows **small series** of highly **individualized** products. The concept also provides a **modular** production, supporting the local production with reduced CO_2.

SmartEdge Uses Cases

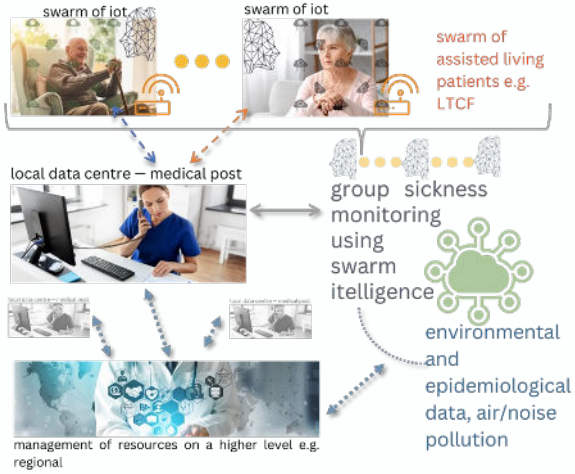
Use case of Edge/Swarm Intelligence in Health

Concept:

Using automatic data collection from **swarm of IOT devices**, collect evidence-based real time health status assessment and prediction, with personal and collective advisory & care.

Setting edge distributed operating with **federation** of object identities (IDs) of multiple **heterogeneous** IoT devices and smart systems for high resilience, security and trust in embedded AI applications.

Apply agile, secure **collaborative swarm intelligence** of many personal AI-driven Digital Health Twins of individual patients linked by wireless communication networks.



Benefits:

Monitoring the swarm enables targeted medical assistance and improves the efficiency of recourse utilization in healthcare. Application of the **collaborative caregiving** and knowledge sharing in swarm group where collective intelligence of the digital twins provides for machine learning of local factors affecting patients collectively.

Dynamic management and optimization of home visits and outpatient care by utilizing up-to-date medical data and **collective trends**.

.

TaRDIS Uses Cases

Use case of Intelligent Homes

Concept:

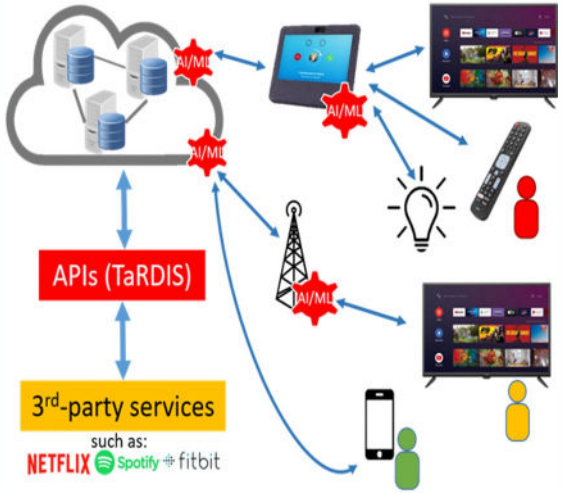
The smart home paradigm usually includes a **range of highly heterogeneous devices** designed to work together as a **swarm**, through **artificial intelligence** (AI) algorithms, to assist us and make our lives more comfortable.
Common concerns in this setting include the privacy of personal information and the heterogeneity of computational resources.

Benefits:

The TaRDIS toolkit will be used to abstract the infrastructure, data distribution, and learning algorithms from the developer. The benefits are:

1. Collaborative intelligence irrespective of heterogeneity in local data, resources, user behaviour, learning goals, among others;
2. A correct-by-design development environment implementing privacy-preserving solutions without the need to consider the underlying heterogeneity.

.



TaRDIS Uses Cases

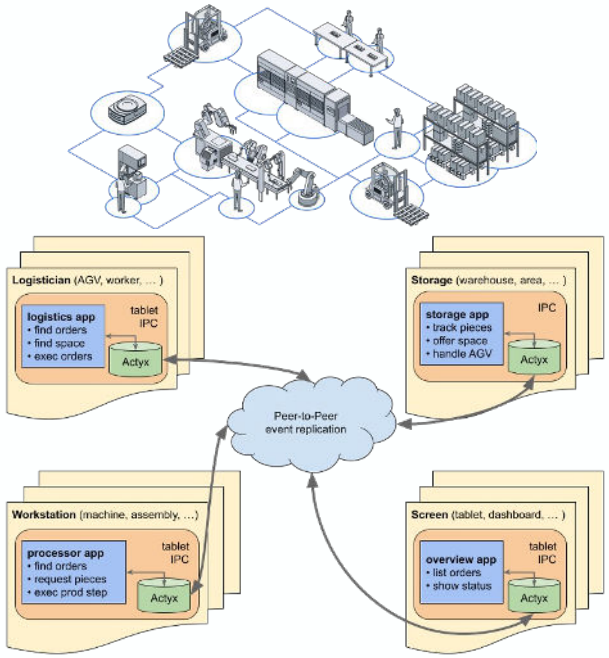
Use case of Highly resilient factory shop floor digitalisation

Concept:

We facilitate peer-to-peer cooperation between machines, humans, and material by giving the factory automation developer the tools to do this reliably, i.e. providing resilience and correctness. To this end, we outfit intelligent agents with local-first data storage, communication, and computation.

Benefits:

Next-generation factories can much more quickly react to changing market demands (**agility**) down to variability between production orders or lot size one (**flexibility**). All processes become not only fully transparent but intelligently steerable in real-time, allowing stringent **optimization of resource usage and minimizing waste**.

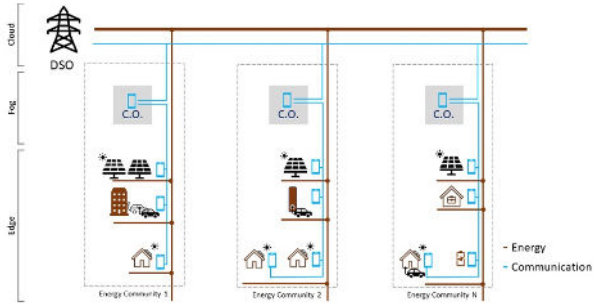


TaRDIS Uses Cases

Use case of Energy

Concept:

The goal is to overcome the foreseen grid imbalance arising from Electric Vehicle charging. The concept is divided into 3 core layers to provide a local energy balance, by matching generation with local **flexible loads** – energy consumers with controlled usage of energy. At the edge layer, connected devices can customize load profiles and exchange energy with the upper layer. In the fog, using TaRDIS, the **energy community** orchestrator manages different consumers and prosumers requests. Finally, in the cloud level, the **Distribution System Operator** reduces grid imbalances and provide monitoring and analytics.



Benefits:

The DSO can manage the increasing load on the grid and balance local demand with available power, deferring infrastructure rehabilitation. The use of local renewable energy and distributed algorithms can lead to a more sustainable and resilient energy system, reducing CO2 emissions and benefiting grid stability. Increased participation of citizens promotes engagement and awareness towards sustainable energy practices. The efficient use of resources through vehicle-to-grid bidirectional chargers and optimization algorithms can lead to a more cost-effective and efficient energy system.

Actors

- Community Orchestrator (CO)
- Distribution System Operator (DSO)
- Consumers, Producers

TaRDIS Uses Cases

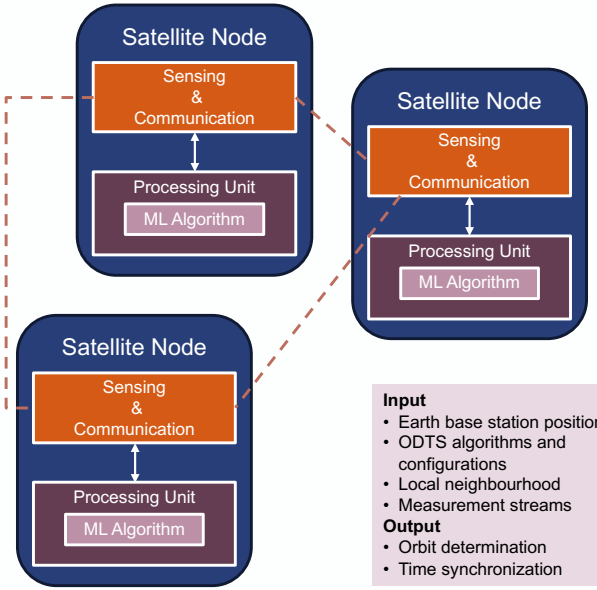
Use case of Distributed navigation for LEO satellite constellations

Concept:

We facilitate the design, tuning, and testing of distributed Orbit Determination and Time Synchronization (ODTS) algorithms for **swarm satellite constellations**, by providing space engineers a swarm simulation tool covering a wide parameter space. The simulation tool, built on top of the TaRDIS swarm technology, allowing the integration of computational resources from multiple entities with minimal configuration effort.

Benefits:

Speed up and improve distributed ODTS algorithm design, test, and tuning, by leveraging machine learning tools and a **distributed simulation tool** that requires low expertise and can be easily scaled using off-the-shelf machines.



Input
- Earth base station positions
- ODTS algorithms and configurations
- Local neighbourhood
- Measurement streams

Output
- Orbit determination
- Time synchronization

OASEES Uses Cases

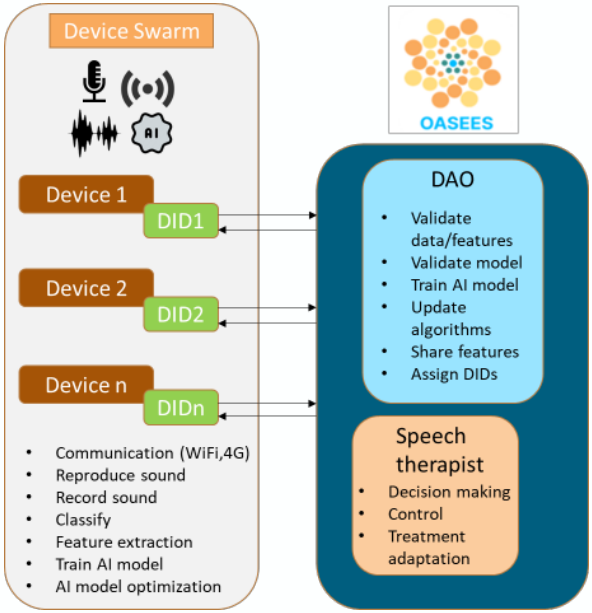
Use case of Analysis of Voice, Articulation and Fluency disorders in Parkinson disease

Concept:

An **intelligent wearable device for the acoustic analysis of voice** in Parkinson Disease + smart, adaptive and personalized guidance on rhythm and intonation. The wearable edge devices will operate and be monitored over the **OASEES Decentralized Autonomous Organization (DAO) a Distributed Ledger Governance Model** at the edge. Devices operate in the form of swarm and be able to be updated automatically

Benefits:

Enabling real-time monitoring of the health information in a trusted and private manner – leveraging DLT at the edge. **Allows the medical practitioner to take the crucial decisions** through DAO governance at the edge. Leverage the AI edge accelerators of OASEES for **advanced processing and insights**. Recognition of voice impairments with a **success rate of 80% compared to speech therapists**. **30% of reduction of training time** using the edge device compared to a speech therapist

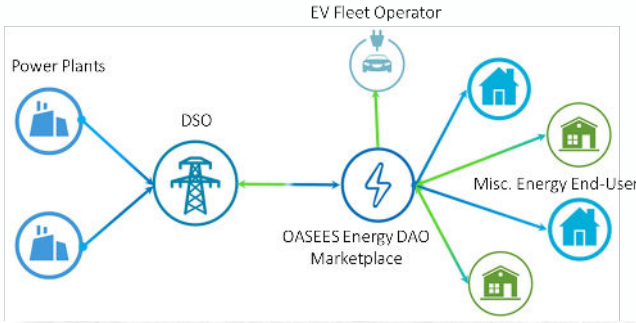


OASEES Uses Cases

Use case of EV fleet and Gris Optimisation

Concept:

Demonstrate the capability of deploying and coordinating the operation and management of swarms of IoT-based devices (e-vehicles), which will be coordinated and programmed through the OASEES SDK.The EV fleet operator (Cloud operated) and respective EV drivers community manager (Edge operated), will optimize EVs' recharging schedule to address local technical requirements from the electricity grid operator, in presence of local congestion, or maintenance of electricity grid branches.



Benefits:

Demonstrate the **capability of deploying and coordinating the operation and management of swarms of IoT-based devices (e-vehicles),** which will be coordinated and programmed through the OASEES SDK. The EV fleet operator (Cloud operated) and respective EV drivers community manager (Edge operated), will **optimize EVs' recharging schedule to address local technical requirements** from the electricity grid operator, in presence of local congestion, or maintenance of electricity grid branches.

OASEES Uses Cases

Use case of Drone inspection

Concept:

Autonomous drone inspections can provide telecom operators and edge service providers with the data and insights they need to expand their infrastructure. OASEES aims to operate a drone swarm at the edge in a self-organized manner based on Decentralized Autonomous Organizations (DAOs). Combine different acceleration technologies, i.e., (Cloud –based) Quantum optimization for route optimization and (Edge-Based) Spiking Neural Networks for Energy Efficient Object Detection.

Benefits:

Extend and leverage novel edge acceleration technologies, i.e., Quantum Computing and Spiking Neural Networks (SNN). Demonstrate **energy consumption reduction from the usage of SNN for object detection** mechanisms deployed at the drone. Deploy **optimized route missions for Drone Swarms**, which can result in reduced energy consumption of the drone fleets

OASEES Uses Cases

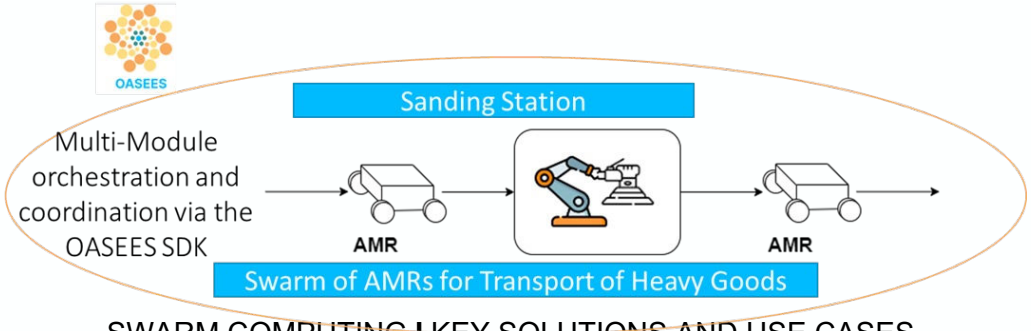
Use case of Robotic Swarm at a Smart Factory

Concept:

The use case is based on a sanding factory floor, where complex wood parts are produced and need to be processed, in an automatic and efficient manner. The use case consists of two parts the sanding part and the transferring of heavy goods. During the whole process the robot's perception algorithms (located at the edge) and mobile bases position and situation is communicating with the OASEES system based on the cloud applying AI algorithms for the optimization of the process.

Benefits:

Automated manufacturing process for Semi-finished wood panels coordinated and programmed by the OASEES orchestrator and SDK for line supervision, thus **quickly implementing line configuration and reconfiguration inputs and relieving human operators from burdensome tasks**. **Innovation at Automated Mobile Robot (AMR) and sanding coordination** through OASEES (Decentralized Autonomous Organization) DAO.



OASEES Uses Cases

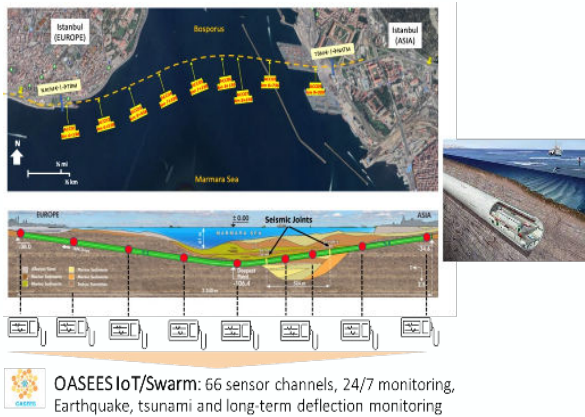
Use case of Structural Safety for Buildings and Critical Infastructure

Concept:

The use case focuses on structural condition of critical infrastructures at the Eurasia Road Tunnel. A decision support software (DSS) located at the cloud collects the structural data from sensors place at the edge and helps in decision making in critical times, i.e., traffic diversion, emergency group coordination (such as post-earthquake, strong winds, heavy snows etc.).

Benefits:

Through OASEES, sensor data will be **locally pre-processed** at the edge and then only the product data will be forwarded to the cloud for high-level monitoring. This approach is expected to yield a much **more robust system, preventing congestions**. **Higher reliability in terms of operation and data processing** as critical data are processed at the edge, as well as **less dependence on human intervention is reduced.**



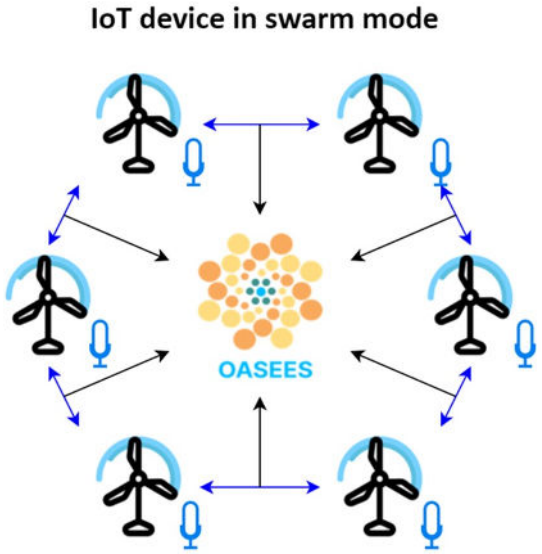
OASEES IoT/Swarm: 66 sensor channels, 24/7 monitoring, Earthquake, tsunami and long-term deflection monitoring

OASEES Uses Cases

Use case of Smart Energy Harvesting and Predictive Maintenance of Wind Turbines

Concept:

The use case aims to extend the capabilities of wind turbines, to be able to function as an IoT device in swarm mode to reduce the costs of maintenance. Simultaneous capture and data processing from several smart edge nodes at the wind turbines' location, reducing processing time. The acquired data will be processed at the edge, and analyzed using machine learning algorithms so that the sensors are able to learn from each other (improved calibration, noise suppression, etc.) using **federated learning** based on cloud and edge nodes, **to improve and obtain better metrics while optimizing the failure prediction on the blades of the wind turbine.**



Benefits:

The use case aims to extend the capabilities of wind turbines, to be able to function as an IoT device in swarm mode to reduce the costs of maintenance. Simultaneous capture and data processing from several smart edge nodes at the wind turbines' location, reducing processing time. The acquired data will be processed at the edge, and analyzed using machine learning algorithms so that the sensors are able to learn from each other (improved calibration, noise suppression, etc.) using **federated learning** based on cloud and edge nodes, **to improve and obtain better metrics while optimizing the failure prediction on the blades of the wind turbine.**

The **European Cloud, Edge & IoT Continuum** is supported by the effort of two Coordination and Support Actions (CSAs):

OpenContinuum

OpenContinuum supports the cloud-edge-IoT domain by focusing on the supply side of the computing continuum landscape. Its goal is to foster European strategic autonomy and interoperability through an open ecosystem for the computing continuum, with open source and open standards as two key enablers to be supported and leveraged throughout the community. Such an ecosystem will contain R&I projects in the cloud-edge-IoT portfolio to be coordinated, the diverse community evolved from the current cloud and IoT ones, with the addition of actors, initiatives, and significant alliances. The supply-side nature of OpenContinuum's agenda will orient the themes and focus of project activities but will not limit the scope of community building. The project's active landscaping and engagement work will bring the cloud and IoT communities together and express all points of view with a common understanding. It will then provide guidance to European actors to contribute to and lead open-source projects and standardisation efforts.

Unlock-CEI

Unlock-CEI's ambition is to unlock the potential for accelerating the deployment of the cloud-edge-IoT (CEI) computing continuum in Europe by focusing on demand-side drivers and challenges to identify technology driven innovation and business opportunities driving demand value chains. The project represents the cloudedge-IoT demand constituency, provides insights and guidance to Horizon Europe R&I projects, and contributes to a proactive dialogue with suppliers to encourage the development of an open European cloud-edge-IoT ecosystem. It focuses on emerging value chains where investment is needed to foster the deployment of the cloud-edge-IoT continuum through forthcoming large-scale pilots, which will ultimately foster European autonomy in the digital economy.

EUCloudEdgeIoT.eu