Alliance for AI, IoT and Edge Continuum Innovation

IoT and Edge Computing EU Funded Projects Landscape

Release 3.0

AIOTI WG Standardisation

January 2025

Executive Summary

The main objective of this deliverable is to provide the landscape of EU funded projects focusing on IoT and edge computing, which can be used to:

1) leverage on existing IoT and edge computing research and innovation activities in Europe, and

2) provide input to IoT and edge computing standardisation gap analysis activities.

The Release 2.0 of this report, compared to Release 1.0, includes:

- a list of additional ongoing projects focusing on IoT and Edge computing that are funded by the EU.
- project descriptions of projects that were labelled as ongoing in Release 1 and were in the meantime completed, are moved to the respective sections with completed projects.
- updated figures of projects landscape in relation to Standardisation Organisations and Initiatives.

The Release 3.0 of this report, compared to Release 2.0, includes: more IoT and/or Edge computing projects, which are:

- a list of additional ongoing projects focusing on IoT and Edge computing that are funded by the EU: DS2, ODEON, P2CODE, OASEES, OpenSwarm, TaRDIS, 5G COMPLETE, 5G INDUCE, 5GMED, 5GMETA, 5G-VICTORI, AI@EDGE, Evolved 5G, SmartEdge, DECICE, Hexa-X-II, 6G-Cloud, 6G-BRICKS, SUNRISE-6G, ExtremeXP, 6G-INTENSE, 6G-DALI, A-IQ Ready, INSTAR, CORTEX2, NextGEM, OMEGA-X, PEDvolution.
- project descriptions of projects that were labelled as ongoing in Release 1 and were in the meantime completed, are moved to the respective sections with completed projects: ASSITS-IoT, IntelliIoT, BD4NRG, OpenContinuum, Unlock-CEI.
- updated figures that used for the visualization of the IoT EU funded projects landscape.

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Introduction

The integration and synergy of IoT/IIoT and edge computing, including also the applied federated learning solutions, can be considered as a part of the paradigm shift from centralised solutions to decentralised and distributed computing architectures.

The main objective of this deliverable is to briefly present the EU funded projects focusing on IoT and edge computing, which can be used to

1) Leverage on existing IoT and edge computing research and innovation activities in Europe, and

2) Provide input to IoT and edge computing standardisation gap analysis activities.

This report provides landscape visualizations of ongoing and completed projects focusing on IoT and Edge computing that are funded by the EU. For each of these EU funded completed and ongoing projects, two groups of landscape visualisations are realised, based on (1) Technology and Marketing Dimensions and (2) vertical industry domains.

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- project descriptions of projects that were labelled as ongoing in Release 1 and were in the meantime completed, are moved to the respective sections with completed projects: ASSITS-IoT, IntelliIoT, BD4NRG, OpenContinuum, Unlock-CEI.
- updated figures that used for the visualization of the IoT EU funded projects landscape.

Several of the received inputs were provided by EU funded ongoing projects, which we would like to acknowledge.

1. IoT EU funded projects landscape

This section provides information on IoT EU funded projects, which are grouped in completed and ongoing projects. The information related to each EU funded project, included in this section, has been collected using the template provided in Annex I of this report.

1.1 Completed Projects

This section provides a description of the completed IoT projects funded by the EU.

1.1.1 mySMARTLife: "Smart Transition of EU cities towards a new concept of smart Life and Economy

URL/Reference:

https://www.mysmartlife.eu/

https://cordis.europa.eu/project/id/731297

Abstract:

Activities are focusing on **"Inclusive Cities"**, offering a high quality of life to residents. **"Smart People"** are playing a vital role in their city's development. **"Smart Economy"** is an innovative and dynamic economic concept aiming at guaranteed employment and an adequate income, attracting talents and providing goods and services according to the actual requirements.

The interventions planned and carried out in the three Lighthouse Cities also include innovative technological solutions in connection with **refurbishments of buildings, usage of renewable energies, clean transport and supporting ICT solutions**.

An **integrated planning process,** where citizens are actively involved in the decision making, links the actions in different fields (e.g. mobility, sustainable energy, ICT). Following a structured city business model leads to an **integrated urban transformation strategy** which can be easily transferred to other cities.

Starting and (target) end time of project:

01/12/2016 – 30/09/2022

IoT and/or Edge Computing research challenges:

- Transforming current cities into more sustainable places where smart people and smart economy become reality.
- Making cities more environmentally friendly by reducing CO2 emissions and increasing the use of renewable energy sources.
- Making cities more inclusive and allowing a high quality of life.
- Involving citizens in the development of an integrated urban transformation strategy, which is easily transferable to other cities.
- Increasing the digitalization of the cities by using urban platforms.

Expected activities on "Dissemination and Impact on Standards":

No standardization action in public deliverables.

1.1.2 RAINBOW: An Open, Trusted Fog Computing Platform Facilitating The Deployment, Orchestration And Management of Scalable, Heterogenous and Secure IoT Services and Cross-Cloud APPS

URL/Reference:

https://rainbow-h2020.eu/

https://cordis.europa.eu/project/id/871403

Abstract:

Automation in industry, connected cars and critical infrastructure observation with drones are some of the benefits associated with advanced technologies. However, these applications require more properties that can guaranty safety, including real-time reaction, secure and effective data protection and management, and industry-specific safety guidelines as well as energy efficiency. The EU-funded RAINBOW project will plan and develop an open and secured fog computing platform that will advance the management of extensible, diverse and safe IoT services and cross-cloud applications. The project envisages extending fog computing to its real potential by supplying the development, composition, data and network management to reach secure end-applications.

Starting and (target) end time of project:

01/01/2020 – 31/12/2022

IoT and/or Edge Computing research challenges:

The vision of RAINBOW is to design and develop an **open and trusted fog computing platform** that facilitates **the deployment and management** of scalable, heterogeneous and secure **IoT services and cross-cloud applications** (i.e. microservices). RAINBOW falls within the bigger vision of delivering a platform enabling users to remotely control the infrastructure that is running, potentially, on hundreds of edge devices (e.g. wearables), thousands of fog nodes in a factory building or flying in the sky (e.g. drones), and millions of vehicles travelling in a certain area or across Europe. RAINBOW aspires to enable fog computing to reach its true potential by providing the deployment, orchestration, network fabric and data management for scalable and secure edge applications, addressing the need to timely process the ever-increasing amount of data continuously gathered from heterogeneous IoT devices and appliances. Our solution will provide significant benefits for popular **cloud platforms, fog middleware, and distributed data management engines, and will extend the open-source ecosystem by pushing intelligence to the network edge** while also **ensuring security and privacy primitives** across the device-fog-cloud-application stack. To evaluate its wide applicability, RAINBOW will be demonstrated in various real world and demanding scenarios, such **as automated manufacturing (Industry 4.0) connected vehicles and critical infrastructure surveillance with drones**. These application areas are safety-critical and demanding; requiring guaranteed extra-functional properties, including real-time responsiveness, availability, data freshness, efficient data protection and management, energy-efficiency and industry-specific security standards.

Expected activities on "Dissemination and Impact on Standards":

Released Deliverable D7.4 about standardization activities:

The goal of the RAINBOW standardization activities is to influence fog computing architectures of future applications and allow them to benefit from the outcomes of RAINBOW. There are multiple ways to achieve this goal. One option is to influence relevant standards, such as OASIS TOSCA or Trusted Computing Group TPM, while another option is to contribute to software platforms that will likely be used as a base for creating a large number of fog applications in the future, making them similar to a de facto industry standard. For RAINBOW, we are pursuing both options.

We have chosen to target the following groups as part of the RAINBOW standardization activities:

- Open Horizon software platform for managing containerized workloads on the network edge (see Section 3 of Deliverable D7.4). Originally started by IBM, Open Horizon is now part of the Linux Foundation Edge and has the potential for widespread adoption in edge/fog applications.
- Trusted Computing Group (TCG), which is the consortium responsible for the TPM standard (see Section 4 of Deliverable D7.4).

1.1.3 5G!Drones: Unmanned Aerial Vehicle Vertical Applications' Trials Leveraging Advanced 5G Facilities

URL/Reference:

https://5gdrones.eu/

https://cordis.europa.eu/project/id/857031

Abstract:

5G network infrastructures are key in the digitalization of economy and society, impacting several sectors. Deploying 5G for vertical markets in Europe has put pressure on network resources and posed challenges. The 5G!Drones project will run trials on several unmanned aerial vehicles (UAVs) to prove that 5G infrastructure can support the simultaneous running of three types of UAV services, using network slicing. Running independently and simultaneously, each UAV application will not interfere with the performance of other applications. The UAV association will then be able to use the 5G!Drones results to improve 5G services.

Starting and (target) end time of project:

01/06/2019 – 30/11/2022

IoT and/or Edge Computing research challenges:

5G!Drones aim is **to trial several UAV use-cases** covering eMBB, URLLC, and mMTC **5G services**, and to validate 5G KPIs for supporting such challenging use-cases. The project drives the UAV verticals and 5G networks to a win-win position, on one hand, by showing that **5G is able to guarantee UAV vertical KPIs**, and on the other hand, by demonstrating that 5G can support challenging use-cases that put pressure on network resources, such as low-latency and reliable communication, massive number of connections and high bandwidth requirements, simultaneously. 5G!Drones builds on top of the 5G facilities provided by the ICT-17 projects and a number of support sites, while identifying and developing the missing components to trial UAV use-cases.

The project features Network Slicing as the key component to simultaneously run the three types of UAV services on the same 5G infrastructure (including the RAN, back/fronthaul, Core), demonstrating that each UAV application runs independently and does not affect the performance of other UAV applications, while covering different 5G services. **While considering verticals** will be the main users of 5G!Drones, the project builds a software layer to automate the run of trials that exposes a **high-level API** to request the execution of a trial **according to the scenario defined by the vertical**, while enforcing the trial's scenario using the API exposed by the 5G facility, as well as the 5G!Drones enablers API deployed at the facility. Thus, 5G!Drones will **enable abstracting all the low-level details to run the trials for a vertical** and aims at validating 5G KPIs to support several UAV use-cases via trials using a 5G shared infrastructure, showing that 5G supports the performance requirements of UAVs with several simultaneous UAV applications with different characteristics (eMBB, uRLLC and mMTC). Using the obtained results, **5G!Drones will allow the UAV association to make recommendations** for further improvements on 5G.

Expected activities on "Dissemination and Impact on Standards":

Released first version of D5.3 Report on contribution to standardization and international fora.

5G!Drones consortium has established a complete landscape of the standards Development Organization (SDOs) as well as various associations relevant within 5G!Drones frameworks, including 3GPP, GSMA, GUTMA, ACJA, IEEE, CEPT/ECC, ASTM, ETSI, IETF, BNAE, Drone REGIM, 5G-PPP (Pre standardization working group), FAA, SESAR JU, NASA, EUROCAE, EASA, ASD-STAN, ISO, LAANC, ARC.

They will continue monitoring and engaging in standardization activities related to 5G!Drones project. They are committed to explore potential contributions to SDOs as the project progresses until its completion in November 2022.

1.1.4 WorkinAge: "Smart Working environments for all Ages

URL/Reference:

https://www.workingage.eu/

https://cordis.europa.eu/project/id/826232

Abstract:

WorkingAge seeks to improve the well-being of people over 45 years, focusing on office, manufacturing and teleworking workplaces. It also considers the workers' daily activities outside work. The European workforce is aging. Older workers have specific conditions that need a specific response to maintain/improve their well-being, supporting motivation to stay working at higher age and enable better productivity. The WorkingAge team has developed the WAOW tool, which aims at improving the health and well-being of older workers at work and leisure time by supervising their working conditions and providing different types of advice through personalized technologies and friendly & intelligent human interfaces. The tool covers mental, physical, social aspects and the workers environment.

Starting and (target) end time of project:

01/02/2019 – 31/07/2022

IoT and/or Edge Computing research challenges:

WorkingAge used innovative **HCI methods** (augmented reality, virtual reality, gesture/voice recognition and eye tracking) **to measure the user emotional/cognitive/health state and create communication paths**. At the same time with the use of **IoT, sensors** will be able **to detect environmental conditions**. The purpose is to promote healthy habits of users in their **working environment and daily living activities** in order to improve their working and living conditions.

By studying the profile of the >50 (Year old) workers and the working place requirements in three different working environments (Office, Driving and Manufacturing), both profiles (user and environment) will be considered. The obtained Information will be used for the creation of interventions that can lead to healthy aging inside and outside the working environment.

WorkingAge provides an **integrated solution that learns the user's behaviour, health data and preferences,** and through continuing data collection and analysis **interacts naturally with the user**. This innovative system provides workers with assistance in their everyday routine in the form of reminders, risks avoidance and recommendations. In this way, the WorkingAge project has created a sustainable and scalable product that will ease the users' life by attenuating the impact of aging in their daily activities, work conditions, health and general well-being.

Expected activities on "Dissemination and Impact on Standards":

Released Deliverable D10.4 about standards use and a gap in standardization:

Given the standards utilized in the development of the WAOW tool technologies, the pathway for obtaining CE marking for the tool is broadly outlined as a rough guideline in case commercial exploitation of the WAOW solution is pursued. Through this process, any gaps in the present standardization landscape can be better identified.

In reviewing the relevant standards, a gap exists for tools such as the WAOW tool that live in the space between purely medical and purely ICT solutions. Tools such as digital health assistants, could benefit from some level of standardization, which could enable market competition and ensure the interoperability of devices, products and services with similar scope. We believe that there is **a gap in the standardization landscape relating to non-medical devices intended for improving the well-being of humans**.

1.1.5 IoTwins: Big Data Platform for Optimized and Replicable Industrial and Facility Management Models

URL/Reference:

https://www.iotwins.eu/

https://cordis.europa.eu/project/id/857191

Abstract:

While the concept of digital twins has been around for some time, the Internet of Things managed to enable its cost-effective implementation. Digital twins refer to a virtual representation of a physical product or process. The EU-funded IoTwins project plans to build testbeds for digital twins in the manufacturing and facility management sectors. The digital models will integrate data from various sources such as data APIs, historical data, embedded sensors and open data. This will give manufacturers an unprecedented view into how their products perform. In facility management, the technology will be instrumental in improving the way buildings and their systems operate and in preventing prospective problems.

Starting and (target) end time of project:

01/09/2019 – 31/08/2022

IoT and/or Edge Computing research challenges:

The IOTWINS project delivered large-scale industrial test-beds leveraging and combining data related to the manufacturing and facility management optimization domains, coming from diverse sources, such as data APIs, historical data, embedded sensors, and Open Data sources.

The goal was **to build a reference architecture** for the development and deployment of **distributed and edge-enabled digital twins of production plants and processes**. Digital Twins collect data from manufacturing, maintenance, operations, facilities and operating environments, and use them to create a model of each specific asset, system, or process.

These models are then used to detect and diagnose anomalies, to determine an optimal set of actions that maximize key performance metrics.

IOTWINS proposes **a hierarchical organization of digital twins** modelling **manufacturing production plants and facility management deployment environments** at increasing accuracy levels:

- IoT twins: featuring lightweight models of specific components **performing big-data stream processing and local control for quality management** operations (low latency and high reliability);
- Edge twins: deployed at plant gateways and/or at emerging Multi-access Edge Computing nodes, providing higher level control knobs and **orchestrating IoT sensors** and actuators in a production locality, thus fostering local optimizations and interoperability;

- Cloud twins: performing **time-consuming and typically off-line** parallel simulation and deep-learning, feeding the edge twin with pre-elaborated predictive models to be efficiently executed in the premises of the production plant for monitoring/control/tuning purposes

Expected activities on "Dissemination and Impact on Standards":

No standardization outcomes in the public deliverables of the project.

1.1.6 ACTIVAGE: ACTivating InnoVative IoT smart living environments for AGEing well

URL/Reference:

http://www.activageproject.eu/

Abstract:

Horizon 2020 (IA) ACTIVAGE is building the first European interoperable and open IoT ecosystem enabling the deployment, at large scale, of a wide range of Active & Healthy Ageing IoT based solutions and services. To achieve this, ACTIVAGE is integrating thousands of devices to collect and analyse older adults' environmental and lifestyle information, identify their needs, and provide customized solutions, ensuring users' data privacy and security.

Starting and (target) end time of project:

01/01/2017 – 30/09/2020

IoT and/or Edge Computing research challenges:

Objectives:

- To deliver the ACTIVAGE IoT Ecosystem Suite (AIOTES), a set of techniques, tools and methodologies **for interoperability at different layers between heterogeneous existing IoT Platforms** and an Open Framework for providing **Semantic Interoperability of IoT Platforms for AHA**, addressing trustworthiness, privacy, data protection and security.
- To set a common Reference Evaluation Framework implementing the GLOCAL approach able to complement Global and LOCAL reference features and requirements. The evaluation framework will allow the assessment of interoperable IoT-enabled Active & Healthy Ageing solutions enhancing and scaling up current existing services on every Deployment Site, **for the promotion of independent living, the mitigation of frailty, preservation of quality of life and autonomy of older adults in smart living environments.** The objective is to create significant evidence and value of the benefit produced on all these aspects, **for the sustainability of the H&SCS, and for validating new business, financial and organizational models for care delivery**, both in a local/national and European scope.
- To provide a co-creation framework that enables the **identification, measurement, understanding and prediction of the demands and needs of IoT ecosystem on AHA users**: older adults, caregivers, health and social care professionals and providers, assessing their needs, preferences and perceptions regarding user acceptance, trust, confidentiality, privacy, data protection and safety. The goal of this objective is to raise and identify some unknown key success factors related also to deployment and scaling up activities.

Focused on:

- Business System Integration
- Visualization
- Development Environment
- Service Orchestration
- Advanced Analytics

- Event & Action Management
- Basic Analytics
- Storage/Database
- Device Management
- Edge Analytics
- Connectivity Network / Modules
- Edge Gateway (HW based)
- Operating System
- Modules & Driver
- MPU / MCU

Expected activities on "Dissemination and Impact on Standards":

- **Technologies & Standards Used**: OSGI, IETF, W3C, Bluetooth, OASIS, WiFi, OMA, Zigbee, OCF, Docker, W3C/OWL, SAREF, SSN, ETSI ISG CIM
- **Open-Source Software Used**: FIWARE, OpenIoT, SENSINACT, IoTIVITY, UniversAAL, NodeRed, INTER-IoT, IoT, Eclipse, OneM2M
- **Dissemination on Standards** (Not much information could be found from public sites):
- IoT technology: innovation in interoperability, security and standardization. AIOTES designed and versioning strategy, in terms of progressive delivery of architectural elements and security and privacy components, developers and deployment tools, aligned with the development and deployment roadmap to support interoperability between DS and with Open Callers, aligned with the exploitation plan and consolidated as a key "Project Asset". Evaluation activities are confirming and will demonstrate the potential and timely need of AIOTES in the IoT-AHA market.
- The evaluation framework is composed of standard methods and instruments that allow to gather and measure the results of the evaluation activities and share them with communities. The protocol and the GLOCAL approach both represent a clear innovation.

Contributions on use cases and requirements have been provided to AIOTI.

1.1.7 AUTOPILOT: AUTOmated driving Progressed by Internet Of Things

URL/Reference:

www.autopilot-project.eu

Abstract:

EC Horizon 2020 (IA) AUTOPILOT will develop an IoT connected vehicle platform and IoT architecture based on the existing and forthcoming standards, as well as open source and vendor solutions. The IoT ecosystem will accommodate vehicles, road infrastructure and connected IoT objects, with particular attention to safety critical aspects of automated driving.

Starting and (target) end time of project:

01/01/2017 – 29/02/2020

IoT and/or Edge Computing research challenges:

- The developments include techniques for the identification and **discovery of internet connected devices and non-connected physical things, technologies for modelling data and services, IoT software engineering tools, schemes for safeguarding security/privacy, as well as infrastructures for deploying and operating IoT services within cloud computing infrastructures**.
- Automated vehicles today rely largely on on-board sensors (LiDAR, radar, cameras, etc.) to detect the environment and make reliable decisions. However, the possibility of **interconnecting surrounding sensors (cameras, traffic light radars, road sensors) to reliably exchange complementary data could lead to new and improved ways of designing automated vehicle systems with reduced implementation costs**.
- Connected cars and overall ITS solutions need to become horizontally integrated with IoT platforms/systems in order to benefit from self-configuration, device discovery, IoT-based services, data filtering, brokering and shared semantic world models of their environment. These communities, however, currently face some difficulties when it comes to taking advantage of IoT technologies. This is mostly due to the **lack of open standardized and easy-to-use APIs for accessing IoT technologies, but also due to the lack of essential interoperability between ITS systems and IoT platforms**.

Focused on:

- Visualization
- Service Orchestration
- Advanced Analytics
- Event & Action Management
- Basic Analytics
- Storage/Database
- Edge Analytics
- Connectivity Network / Modules
- Edge Gateway (HW based)
- Operating System
- Modules & Driver

Expected activities on "Dissemination and Impact on Standards":

Technologies & Standards Used: Python, QT, C++, MQTT, HTTP REST, JSON,

OneM2M, 4G, NoSQL, 3GPP LTE, NB-IoT, LTE-V2X, PexSi platform

Open-Source Software Used: Mosquitto, OCEAN

Dissemination on Standards:

- Working on the needs to implement interoperable vehicle and cloud IoT platforms, together with heterogenic IoT sensor devices, triggered the success of defining a common data model. This common data model development has been carried out jointly with the SENSORIS platform, responsible to provide standards for the vehicle to cloud data.
- AUTOPILOT Platooning and Automated Valet Parking use cases are used as references in the ETSI Technical Report TR 103 508 "SAREF extension investigation: Requirements for Automotive" (note: SAREF: Smart Appliances REFerence ontology). SAREF is an essential standardisation work to ensure intra-domain and x-domain interoperability.
- Relevant standardisation contributions have also been presented to OneM2M on the AUTOPILOT use cases, requirements and Interworking Proxy Entity.

- AUTOPILOT Open Data will help standardisation organisation and researchers to define common data model for the automotive domain. In the context of the evaluation, the FESTA methodology has been enhanced for including the IoT data.
- AUTOPILOT contributed as well to AIOTI on use cases, requirements and SAREF data models

1.1.8 IoF2020: Internet of Food and Farm 2020

URL/Reference:

https://www.iof2020.eu/

Abstract:

EC Horizon 2020 (IA) IoF2020 is dedicated to accelerating the uptake of IoT technologies in the European farming and food chains and ultimately strengthening their competitiveness and sustainability. How? By demonstrating, together with end-users, the use of IoT in 19 use-cases spread throughout Europe, and focusing on 5 areas: dairy, meat, arable crops, fruits and vegetables.

Starting and (target) end time of project:

01/01/2017 – 31/03/2021

IoT and/or Edge Computing research challenges:

A smart web of sensors, actuators, cameras, robots, drones and other connected devices **allows for an unprecedented level of control and automated decision-mak**ing. The project Internet of Food & Farm 2020 (IoF2020) has explored the potential of IoT-technologies for the European food and farming industry.

The goal was ambitious: to make precision farming a reality and to take a vital step towards **a more sustainable food value chain**. With the help of IoT technologies higher yields and **better-quality produce are within reach**. **Pesticide and fertilizer use will drop and overall efficiency is optimized**. IoT technologies also **enable better traceability of food, leading to increased food safety**.

Therefore a **reference architecture with minimum interoperability mechanisms was defined based on common IoT architectures, standards and data models but extended and adapted for farming and food**. Each use case was an autonomous implementation of this architecture ensuring maximum interoperability between and re-use of components.

Focused on:

- Business System Integration
- Visualization
- Development Environment
- Service Orchestration
- Advanced Analytics
- Event & Action Management
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- Storage/Database
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- Connectivity Network / Modules
- Edge Gateway (HW based)
- Operating System

- Modules & Driver
- MPU / MCU

Expected activities on "Dissemination and Impact on Standards":

Technologies & Standards Used: LoRa Network, 365 Farmnet, Zoner, Crop-R and Akkerrweb platforms, Cloudfarm FMIS, Arvalis platform, ThingWorx IoT platforms, UNB technology, SigFox, oData, FiWare Analytics, infrared IoT sensors, collar-based cloud-based analytics, GPRS/4G and long RF communication, SensiNact IoT Platform, wireless sensor networks

(HSPDA, UMTS, GPRS, GSM), Zigbee technology, Link Smart, Bluetooth 4.0

SmartBands, Google Fit LiveLog

Open Source Software Used: FIWARE, FIspace, CRYSTAL, SOFIA, EPCIS, Fosstrack, AgroSense, Apache Cassandra, Apache Flink, Apache Spark

Dissemination on Standards (Not much information could be found from public sites):

- Most of results are taken up by succeeding projects (e.g. Atlas, Demeter) and are further exploited through the FIWARE community.
- Contributions to standards were made and adopted by the designated organizations such as AEF, AgGateway, GS1).
- Each use case implementation is described in the IoT catalogue.
- IoF2020 contributed as well to AIOTI on use cases and requirements.

1.1.9 MONICA: Management of Networked IoT Wearables – Very Large-Scale Demonstration of Cultural and Societal Applications

URL/Reference:

www.monica-project.eu

Abstract:

MONICA is a large-scale demonstration of how cities can use existing and new IoT solutions to meet sound, noise and security challenges at big open-air cultural and sports events, which attract and affect many people. Innovations include the establishment of sound zones at outdoor concerts for noise mitigation as well as security measures improving crowd information and management.

Starting and (target) end time of project:

01/01/2017 – 31/03/2021

IoT and/or Edge Computing research challenges:

The innovations in MONICA comprise six main solutions: Sound Level Monitoring, Adaptive Sound Field Control, Crowd and Capacity Monitoring, Crowd Management and Communication, Visitor Experience and Collective Awareness Platform. The strength of MONICA lies in the comprehensiveness of the solutions in terms of features and integration capabilities, being combined and customised according to the actual needs and being founded on the ecosystems which consider technical, financial, regulatory and human aspects to ensure a wider uptake and acceptance of IoT.

Focused on:

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- Visualization
- Service Orchestration
- Advanced Analytics
- Event & Action Management
- Basic Analytics
- Storage/Database
- Device Management
- Edge Analytics
- Connectivity Network / Modules
- Edge Gateway (HW based)
- Modules & Driver

Expected activities on "Dissemination and Impact on Standards":

- **Technologies & Standards Used**: ISO/IEC/IEEE 42010:2011, AIOTI HLA, Bluetooth BLE / DASH7 / WiFi – IEEE 802.11, UWB– IEEE 802.15.4a / ETSI EN 300 220-2 V3.1.1 subGHz wristbands, ETSI EN 302 065-2 V2.1.1 for UWB wristbands, 3GPP NB-IoT /LoRA; IEEE LR-WPAN / IETF 6LoWPAN / IETF ROLL / IETF CoAP; OASIS MQTT; ETSI SAREF, W3C SSN; IETF, Oauth / OASIS XACML; oneM2M Network Service Capability Layer / GW; OGC SensorThings AP
- **Open Source Software Used**: LinkSmart, RioT, SCRAL
- **Dissemination on Standards**:

An important element of the MONICA project has been to assess/identify if the European suite of Radio Frequency (RF) IoT standards was missing some elements, which might improve the performance and value of the MONICA results demonstrated. With regards to sound, a requirement was identified for a new standard/update of existing IoT standard that provides guaranteed low latency and time jitter for RF connected end-to-end communication. In relation to MONICA, this could ensure a more dependable end-to-end latency for synchronized data interlinking of the many sensors applied with the digital MONICA sound field calculations.

Followingly, liaison activities with the ETSI technical group on Short Range Devices (TG28) have taking place and continue to take place after the project ends. The finding was included in the comprehensive study 'High Priority IoT Standardisation Gaps and Relevant SDOs' 9 released in January 2020 by AIOTI – Alliance for Internet of Things Innovation, Working Group 3 on IoT Standardisation

1.1.10 SynchroniCity: Delivering an IoT-enabled Digital Single Market for Europe and Beyond

URL/Reference:

www.synchronicity-iot.eu

Abstract:

The SynchroniCity consortium brings together 39 partners with worldwide outreach. The project represents the first attempt to deliver a digital single market for IoT-enabled urban services in Europe and beyond - in 8 European cities and more worldwide - connecting 39 partners from 13 countries over 3 continents.

Starting and (target) end time of project:

01/01/2017 – 31/12/2019

IoT and/or Edge Computing research challenges:

SynchroniCity has shown how the Minimal Interoperability Mechanisms (MIMs) introduced by the Open & Agile Smart Cities network (OASC) can help unfreeze this market, based on a minimal but sufficient common technical ground for sharing data to deliver AI- and IoT-enabled services based on trust. Such services are essential for Europe to deliver a sustainable, prosperous and inclusive future for its citizens.

Focused on:

- Business System Integration
- Visualization
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- Storage/Database
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- Edge Gateway (HW based)
- Operating System
- Modules & Driver
- MPU / MCU

Expected activities on "Dissemination and Impact on Standards":

Technologies & Standards Used: OASC, FIWARE, NGSI, DCAT AP, OAuth 2.0 and XACLM, OneM2M, CoAP

Open Source Software Used: Orion Context Broker, Biz Ecosystem, CKAN, Backend Device Management – IDAS

Dissemination on Standards:

Synchronicity led the MIM activities in Smart City domain

A Guide to SynchroniCity is available, and it shows, in practical terms, how to use the OASC MIMs to provision digital services for cities and communities.

The MIMs, as introduced in the attached "Guide to SynchroniCity", are simple, transparent mechanisms that form the foundation for sustainable, scalable and efficient deployment of AI- and IoT-enabled digital services. They are vendor-neutral and technology-agnostic, and they can be integrated with existing systems. Currently, there are three validated MIMs: Context Information Management, Common Data Models, Marketplace, and two underway as work items: Fair AI and Personal Data Management. As more cities and companies adopt them, the market grows and economies of scale reduce costs for buyers and developers. This breaks down barriers to procurement, also for smaller companies, and allows cities and communities to identify and tackle problems quickly and sustainably, to the benefit for their citizens.

The EU recently announced "Join, Boost, Sustain" political declaration for scaling digital solutions in Europe (http://living-in.eu) has adopted the work from SynchroniCity as the basis. It is an

initiative of EUROCITIS, OASC and ENoLL, together with the European Commission (CNECT, REGIO, GROW, DIGIT a.o.) and the European Committee of the Regions.

OASC was recognized by TM Forum, a global association of telecom providers as the most influential body in this space, especially for the work carried out in SynchroniCity, and the standards input to the European and global standards organisations

OASC was invited, on the basis of the SynchroniCity project, to join the G20 2019 Summit session in Osaka Japan on smart cities to present the work, which led to substantial impact in Japan and globally, and many other initiatives.

In total, SynchroniCity has shown a pathway to harnessing global dynamics to address local needs, heralding a potential new era of services similar to the mobile revolution brought about by simple, European standards.

1.1.11 U4IoT: User Engagement for Large Scale Pilots in the Internet of Things

URL/Reference:

https://cordis.europa.eu/project/id/732078

Abstract:

End-user and societal acceptance is critical to the success of the IoT large-scale pilots. U4IoT combines complementary RRI-SSH expertise encompassing social and economic sciences, communication, crowdsourcing, living labs, co-creative workshops, meetups, and personal data protection to actively engage end-users and citizens in the large scale pilots.

Starting and (target) end time of project:

01/01/2017 – 31/12/2019

IoT and/or Edge Computing research challenges:

Objectives/challenges/results

- Develop toolkit for LSPs end-user engagement and adoption, including online resources, privacy-compliant crowdsourcing tools, guidelines and an innovative privacy game for personal data protection risk assessment and awareness, online training modules.
- Direct Support to mobilize end-user engagement with co-creative workshops and meetups, trainings, Living Labs support, and an online pool of experts to address LSPs specific questions.
- Analyse societal, ethical and ecological issues and adoption barriers related to the pilots with end-users and make recommendations for tackling IoT adoption barriers, including educational needs and sustainability models for LSPs and future IoT pilots' deployment in Europe.
- Support communication, knowledge sharing and dissemination with an online portal and interactive knowledge base gathering the lessons learned, FAQ, tools, solutions and end-user feedback.
- The U4IoT platform will support IoT take-up in Europe by better aligning it with end-user and societal expectations, mutualizing information and learning experiences, and improving communication with the public, -enabling Europe to take the lead in IoT user (and market) adoption. U4IoT will work in close cooperation with the other CSA, AIOTI and the IoT Forum who will maintain the platform after the end of the project to continue serving the European IoT community.

Focused on:

- Visualization
- Development Environment
- Service Orchestration
- Advanced Analytics
- Event & Action Management
- Basic Analytics
- Storage/Database
- Device Management
- Edge Analytics
- Connectivity Network / Modules
- Edge Gateway (HW based)
- Operating System
- Modules & Driver
- MPU / MCU

Expected activities on "Dissemination and Impact on Standards":

Regarding "Dissemination and Impact on Standards", not much information has been found in public sites, some abstract information is provided below:

- created a "one-stop shop" for end-user engagement with freely accessible tools, handbooks, and e-courses
- taken an integrated approach on ready to use support tools for ongoing and near-future IoT projects
- produced a broad range of tools ranging from privacy, end-user engagement in real life situations, sustainability, and adoptions
- made impact on all levels with needs earlier being unknown now made aware and moved higher on our target groups' agendas

1.1.12 CREATE-IoT: CRoss fErtilisation through AlignmenT, synchronisation and Exchanges for IoT

URL/Reference:

www.create-iot.eu

Abstract:

CREATE-IoT's aim is to stimulate collaboration between IoT initiatives, foster the take up of IoT in Europe and support the development and growth of IoT ecosystems based on open technologies and platforms. This requires synchronisation and alignment on strategic and operational terms through frequent, multi-directional exchanges between the various activities under the IoT Focus Areas. Create-IoT provided the synchronization in different topics among the projects: ACTIVAGE, AUTOPILOT, IoF2020, MONICA, SynchroniCity.

Starting and (target) end time of project:

01/01/2017 – 30/06/2020

IoT and/or Edge Computing research challenges:

- Launch a common internet-based forum in which LSPs and other IoT stakeholders can access information and participate in ongoing activities, in areas as diverse as the debate on privacy, common standards and protocols or cascade funding.
- Map the pilot architecture approaches, as well as the ecosystem stakeholders, across all the FAs to identify areas of common interest in which coordination will be of particular benefit.
- Establish mechanisms for exchanging best practices, fast-track learning and sharing of lessons-learned on a technological and business level.
- Encourage and co-ordinate activities that stimulate innovation, creativity and adoption including the combination of ICT and Arts as well as user-centric and bottom-up methodologies.
- Enhance the provision of SMEs (including start-ups and other early-stage organisations) and developer access to the LSPs, through to the sharing of cascade funding and the support to the development of Software Development Kits (SDKs) and similar initiatives.
- Define common Key Performance Indicators (KPIs) across the LSP's that can be used to measure design, testing and validation taking into account the possibility of an iterative, rather than lineal, development and deployment process.
- Gather insights that can contribute to pre-normative activities and future policy development in the context of the Digital Agenda and promoting European IoT thought leadership.

Focused on:

- Visualization
- Service Orchestration
- Advanced Analytics
- Event & Action Management
- Basic Analytics
- Storage/Database
- Edge Analytics
- Connectivity Network / Modules
- Edge Gateway (HW based)
- Operating System
- Modules & Driver

Expected activities on "Dissemination and Impact on Standards":

See the input provided by the projects: ACTIVAGE, AUTOPILOT, IoF2020, MONICA, SynchroniCity. Moreover, see the below table that shows the perceived criticality of standard gaps per LSP (ACTivage, AUTOpilot, IoF2020, MONica, SYNChronicity).

Nature of the gap	ACT	AUTO	IoF	MON	SYNC
Competing communications and networking technologies	Low	Medium	High	Medium	Medium
Easy standard translation mechanisms for data interoperability	Medium	Medium	Medium	Low	Medium
Standards to interpret the sensor data in an identical manner across heterogeneous platforms	Medium	High	Medium	High	High
APIs to support application portability among devices/terminals	Medium	Low	Medium	Medium	Medium
Fragmentation due to competitive platforms	High	Low	Medium	N/A	Medium
Tools to enable ease of installation, configuration, maintenance, operation of devices, technologies, and platforms	Medium	Medium	Low	High	High
Easy accessibility and usage to a large non-technical public	Medium		Low	High	High
Standardized methods to distribute software components to devices across a network	Medium	Low	Medium	Low	Medium
Unified model/tools for deployment and management of large-scale distributed networks of devices	Medium		Medium	Medium	Medium
Global reference for unique and secured naming mechanisms	Medium		Low	Low	Medium
Multiplicity of IoT HLAs, platforms and discovery mechanisms	High	Low	Medium	Medium	High
Certification mechanisms defining "classes of devices"	High		Low	N/A	Medium
Data rights management (ownership, storage, sharing, selling, etc.)	High	Medium	High	Medium	Medium
Risk Management Framework and Methodology	Medium	Medium	Medium	Medium	High

Table 1: Strategy and coordination plan for IoT interoperability and standard approaches. Source: CREATE-IoT Project

1.1.13 Productive4.0 – Ambitious Project with a Unique Main Objective

URL/Reference:

https://productive40.eu/

https://cordis.europa.eu/project/id/737459/de

Abstract:

Productive4.0 is an ambitious holistic innovation project, meant to open the doors to the potentials of Digital Industry and to maintain a leadership position of the industries in Europe. All partners involved worked on creating the capability to efficiently design and integrate hardware and software of Internet of Things (IoT) devices. Linking the real with the digital world takes more than just adding software to the hardware.

What makes the project unique is the holistic system approach of consistently focusing on the three main pillars: digital automation, supply chain networks and product lifecycle management, all of which interact and influence each other.

This is part of the new concept of introducing seamless automation and network solutions as well as enhancing the transparency of data, their consistence and overall efficiency. Productive4.0 aims at hands-on solutions for the European digital industry:

- Productive4.0 tackles technological and conceptual approaches in the field of Industry 4.0. The term comprises IIoT (Industrial Internet of Things), CPS (Cyber Physical Systems) and Automation.
- The innovation project takes a step further towards hands-on solutions. In the process, practical reference implementations such as 3D printer farms, customized production or self-learning robot systems will benefit in fields like service-oriented architecture (SOA), IoT components & infrastructures, process virtualization or standardization.

Starting and (target) end time of project:

01/05/2017 – 31/10/2020

IoT and/or Edge Computing research challenges:

IoT and Edge-Computing were considered in the holistic context of a digital industry ecosystem and the whole supply chain, with 4 OEM use cases:

- Integration of vehicle individualization in a highly automated assembling process in the Automotive Industry
- Flying robots
- Industrial IoT
- Tracking, sensing and actuating services

and in 5 Tier-1 Use cases:

- Smart services for test equipment
- Simultaneous Cost Engineering for powertrain architectures
- Smart Services for Trusted Manufacturing Site
- Smart failure analysis lab

and furthermore, 16 Tier-2 Use cases and 8 Use cases along the supply chain, many of them related to/applying IoT or Digital Twin concepts.

One work package was particularly dedicated to "Innovative IoT-enabling Components (HW / SW)", with three major tasks:

- IoT enabling hardware for Digital Industry
- IoT enabling software for Digital Industry
- Integration and modelling of IIoT enabling components

Provide information about the expected activities on "Dissemination and Impact on Standards":

Some key achievements of the project with respect to IoT from the product use cases were:

- New automation industries adopting and implementing industrial IoT technologies
- Demonstration of the specific technological and conceptual approaches in filed like service-oriented architecture (SOA), IOT components & infrastructures, digital twin application or process virtualization.

Standardization activities had to cover the full spectrum of functional safety, cybersecurity, IoT and IIoT, Digital Twin, Industrial data, Digital Factory, Smart manufacturing (just evolving at this time in IEC TC65 standardization), and as further innovations the "Digital Reference Ontology" and SysML V2 contributions. Partners became aware of ISO/IEC JTC1 SC41 and SC42 standards as well as of AIOTI and ETSI activities (was reported in the (public) standardization deliverables), and Digital Twin standardization in ISO and ISO/IEC JTC1. Some joined these groups on national and international level and contributed to the evolving standards under development. As result and follow-up of Productive4.0 work, the ISO/IEC contributions on IoT, Digital Twin and Edge standards (including evolving New Work Items) were e.g., reported as AIT-contribution in the AIOTI publication "High Priority Edge Computing Standardisation Gaps and Relevant SDOs".

Acknowledgement:

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1.1.14 DataPorts: A Data Platform for the Cognitive Ports of the Future

URL/Reference:

https://cordis.europa.eu/project/id/871493

https://dataports-project.eu/

Abstract:

DataPorts is a project funded by the European Commission as part of the H2020 Big Data Value PPP programme. DataPorts brings together knowledge, expertise and innovation potential of very experienced partners in the fields of Industrial Data Platforms, IoT and Data Acquisition, Data Analytics and AI applications, blockchain, smart contracts and data sharing and trading, data providers, data protection and security, and technology integration. The consortium consists of 13 partners from 4 EU member countries: Spain, Greece, France and Germany, and an associated state: Israel. More specifically, the consortium involves 2 SMEs and 3 large-industry partners.

The project focuses on the design and implementation of a data platform and its deployment in two relevant European seaports. This platform aims at connecting to the existing digital infrastructures in order to address specific local constraints.

The DataPorts Platform main goal is to connect to the different IoT systems and to the digital infrastructures currently existing in digital seaports, enabling the interconnection of a wide variety of systems into a tightly integrated ecosystem. In addition, it offers reliable data sharing and trading based on data owners' rules and offering a clear value proposition. Finally, it also strives to leverage the collected data and provide advanced Data Analytics services whereby the different actors in the port value chain could develop novel AI and cognitive applications.

Starting and (target) end time of project:

01/01/2020 – 31/12/2022.

IoT and/or Edge Computing research challenges:

The main challenge related with IoT is the provision of all the technical tools and components through the platform for the acquisition, aggregation, processing and analysis of the data coming from the different stakeholders, sources and existing platforms. This entails the following:

- Contribute with specific activities related to standards in the freight sector, and with standardisation organisations and alliances related to IoT, security, cloud and big data and blockchain.
- Define data models, mechanisms and enablers to provide semantic interoperability with data platforms, IoT devices, and other data sources, and develop the interoperability tools needed to facilitate generation of interfaces for sensing.
- Offer an IoT SDK Framework where data providers can feed their data into the data platform. For example, this data can be obtained from sensors, IoT platforms, IT systems (open or private), PCS controlled by the ports or Market Agents.
- Provide support to develop advanced services for cognitive ports, linking the platform with existing initiatives and results from areas like IoT, Big Data analytics or Artificial Intelligence.
- Validation in two relevant European seaports connecting to their existing digital infrastructures and addressing specific local constraints.

Finally, it is important to highlight a specific scenario focused on the use of IoT sensors integrated with the DataPorts Platform. In that scenario regular containers will be fitted with permanent IoT devices, turning them into "Smart Containers". These "Smart Containers" are embedded with a set of sensors, enabling the measurement of real-time information such as identifying location, door opening and closing, vibrations, temperature, humidity, and any measured physical parameters of the surrounding environment of the containers.

These IoT devices help stakeholders to gain valuable knowledge on the exact whereabouts and status of their container, enabling them to improve their logistics. By receiving a notification that the container has been unloaded from the ship, the user is enabled to proceed to dispatch a truck to pick it up at the optimal time. In addition, having Smart Container data may also decrease cargo loss, legal costs, insurance fees and investigation processes and damage to goods. At the same time, door-to-door visibility may result in increased cargo security; better service level, on-time deliveries since the processes flow better.

Expected activities on "Dissemination and Impact on Standards":

DataPorts is created as a global frame for new cognitive services that follow the IoT Reference Architecture (HLA) functional model described by the AIOTI-WG3 which is compliant with ITU-T Y.2060 IoT Reference Model, OneM2M reference architecture, IIC's Industrial Internet Reference Architecture (IIRA) and mainly RAMI 3.0.

There are some expected activities related to the dissemination and Impact on Standards:

- Data Modeling: The DataPorts Data Model integrates concepts from existing ontologies and data models, including the Fiware Smart Data Model, the UN/CEFACT data model, the SAREF ontology and the IDSA Information Model.
- UN CEFACT Transport & Logistics: DataPorts foresees that the smart container data is generated, monitored and managed by neutral service providers who commercialize the needed IoT devices and their related data transmission technologies. These service providers have control of the data and the access to them through the Dataports Platform.
- Smart Data Models: Contributing to the Smart Data Models initiative with the concepts defined in the common DataPorts data model. The aim is to participate in the periodical meetings and to collaborate actively in the subject related to Ports.
- CEF: Alignment with CEF (Connecting Europe Facility) Digital program:
  - Fiware Orion Context Broker as core element of the component.
  - ETSI NGSI-LD API for right-time digital twin data exchange:
  - Ongoing task: From NGSI V2 to NGSI-LD. Use of Orion-LD Broker.
  - Smart Data Models initiative for description of data models: From internal project repositories to contribute to the Smart Data Models initiative.
- DSBA: Participation in the Data Spaces Business Alliance future activities, which is an initiative promoted in the scope of the Fiware, Data Spaces, Gaia-X, and BDVA activities. This initiative promotes the collaboration between organisations and projects sharing their vision on how to materialise an open standard-based, open source available and CEF-compatible software infrastructure for creation of data spaces in Europe.

1.1.15 DEMETER: IoT-based Data Analysis to Improve Farming

URL/Reference:

www.h2020-demeter.eu

https://cordis.europa.eu/project/id/857202

DEMETER Pilot Projects

https://h2020-demeter.eu/dissemination-material/

Abstract:

DEMETER's goal is to lead the digital transformation of Europe's agri-food sector through the rapid adoption of advanced IoT technologies, data science and smart farming, ensuring its long-term viability and sustainability.

Our key objective is to empower farmers and farmer cooperatives to a) use their existing platforms and machinery to extract new knowledge to improve their decision making and b) ease the acquisition, evolution and updating of their platforms, machinery and sensors by focusing their investments where these are needed. In parallel, DEMETER aims to transform the technology ecosystem for agriculture by reinforcing and establishing agreed standards, an agreed common information model, an interoperability space combined with an online/physical networked ecosystem and a set of interoperability components which will make the use of IoT technology effective and easy. This is achieved by a combination of human and digital solutions including the DEMETER Stakeholders Open Collaboration Space (SOCS) which is an online platform dedicated to all stakeholders (farmers, advisors, and technology suppliers) where they can collaborate, share best practices and participate in the co-creation processes.

In DEMETER, twenty pilot projects are used to demonstrate and evaluate how innovations and extended capabilities benefit from the interoperability mechanisms employed. Equally, these pilots monitor the evolution of the maturity level in the stakeholders involved.

A plethora of heterogeneous data is collected across pilots, ranging from simple temperature measurements to audio and video streaming. Various communication technologies are used, including LoRaWAN and 4G. Some data is processed locally, on the edge, while the main processing is done in cloud.

Starting and (target) end time of project:

09/2019 – 09/2023

IoT and/or Edge Computing research challenges:

- development of a common agricultural data model (AIM) reflecting various dominant standards and existing models
- semantic interoperability and heterogeneous data integration over IoT infrastructures
- data analytics and knowledge extraction over IoT originating data
- decision making and recommendations for farmers and agri advisors based on IoT infrastructures
- syntactic interoperability over enablers deployed over IoT
- security, privacy, trust and confidentiality over IoT
- controlled sharing of resources in the agrifood domain, including IoT resource sharing support
- processing of collected data on the edge (audio-video) to streamline and optimize the process.
- validation of edge networking/ML technologies and integration with the cloud services.

Expected activities on "Dissemination and Impact on Standards":

The DEMETER project is investigating architectures and techniques for minimal interoperability mechanisms together, including the AIM - Agricultural Information Model, with other agricultural domain projects, i.e. ATLAS and earlier IoF2020. Under the OpenDEI project umbrella, Open DEI further standardisation needs and opportunities are being elaborated also linked to StandICT. This harmonisation is also done in collaboration with the Open Geodata Consortium (OGC) and relationship to ISO standards evolution from ISO/TC211 on Geospatial services, ISO SC41 IoT and Digital Twin and ISO SC42 AI and Big Data.

1.1.16 IoTAC: Security By Design IoT Development and Certificate Framework with Front-end Access Control

URL/Reference:

https://iotac.eu/

https://cordis.europa.eu/project/id/952684

Abstract:

The IoTAC project aims to deliver a novel, secure and privacy-friendly IoT architecture that will facilitate the development and operation of more resilient IoT service environments through (i) monitoring and evaluation of applications security throughout the broader software development lifecycle; (ii) the introduction of an advanced access control mechanism based on new interactions and workflow using chip card and PKI technology; (iii) the runtime monitoring of the system as well as provisioning of security countermeasures that are implemented both at hardware- and at software-level and (iv) associated platforms which will provide security certification of the produced applications and system, based on international security standards, best practices and the research results of the project.

Starting and (target) end time of project:

01/09/2020 – 31/08/2023

IoT and/or Edge Computing research challenges:

- Advanced Security by Design concepts and implementations
- Quality Assurance and Trustworthiness of IoT Systems and Applications

Expected activities on "Dissemination and Impact on Standards":

1. IoTAC is active and contributed to ISO/IEC and ETSI in the following committees:
   - ISO/IEC JTC1/SC41 (Internet of Things and Digital Twins)
   - ETSI TC MTS (Methods for Testing and Specification)

Furthermore, one partner of the Project is member of Global Platform and its IoTopia task force, to disseminate the project's results within the organisation.

2. The project IoTAC provided comments to the IoT Reference Architecture that have been discussed and accepted in the SC41/WG3 DoC meetings.

Furthermore, project members of IoTAC initiated two new Working items at ETSI TC MTS on IoT Security module testing and IoT security architecture conformity and provided the project rapporteurs for the new working items:

https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=66188
https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=66187

3. The work is aligned with the ISO/IEC and ETSI project schedules and is expected to be finished before the end of the project duration in summer 2023.

1.1.17 IoT-NGIN: Next Generation IoT as part of Next Generation Internet

URL/Reference:

https://iot-ngin.eu

https://cordis.europa.eu/project/id/957246

Abstract:

It is well known that the Internet of Things (IoT) has been identified as one of the next big concepts to support societal changes and economic growth. To address this opportunity, the EU-funded project IoT-NGIN introduces novel research and innovation concepts to establish itself as the 'engine' that will fuel the next generation IoT. It starts by uncovering a pattern based meta-architecture and optimises IoT/machine-to-machine and 5G/machine-cloud-machine communications by extending the edge cloud paradigm. Moreover, it enables user and self-aware autonomous IoT systems through privacy-preserving federated machine learning and ambient intelligence, with augmented reality support. Finally, IoT-NGIN research towards distributed IoT cybersecurity and privacy. IoT-NGIN will be validated using dozens of heterogeneous devices, including drones and robots.

Starting and (target) end time of project:

01/10/2020 – 30/09/2023

IoT and/or Edge Computing research challenges:

Research challenges in IoT-NGIN

- IoT Meta Architecture
- Enhance IoT/5G Further Enhancement Device-to-Device (FeD2D)
- Data sovereignty and privacy "by design"
- Privacy preserving federated ML
- Protection against attacks on federated ML
- DLT-based meta-level Digital Twins

Innovation challenges in IoT-NGIN

- Optimising 5G resource allocation
- Ultra reliable IoT based on Time Sensitive Networking
- Secure edge cloud IoT micro-services execution framework
- Ambient Intelligence monitoring and control
- Dynamic machine self-learning framework

Expected activities on "Dissemination and Impact on Standards":

IoT-NGIN partners follow the activities of standardisation bodies, which have been identified as relevant to the project developments, namely GAIA-X, IDSA, ITU Smart City, IEC, OGC, NIST, ENISA, and ISO. In addition, the IoT-NGIN project plans to contribute to 5G-ACIA, ONF, and 3GPP standardisation. Moreover, the project monitors closely and has active links with clusters and associations in the field of IoT, communication, software, open source, as well as domains related to the Living Labs, indicatively 5GPPP, 6G-IA, Networld Europe, NGI, BDVA and DIHs.

The timescale for interaction is from now until the end of the project (September 2023).

1.1.18 SHAPES: Smart and Healthy Ageing through People Engaging in Supportive Systems

URL/Reference:

https://cordis.europa.eu/project/id/857159

https://shapes2020.eu/

Abstract:

Throughout Europe, many people are handicapped by reduced capabilities that are either permanent or temporary. The EU-funded SHAPES project aims to create the first European open Ecosystem enabling the large-scale deployment of a broad range of digital solutions for supporting and extending healthy and independent living for such older individuals. SHAPES builds an interoperable platform integrating smart digital solutions to collect and analyze older individuals' health, environmental and lifestyle information, identify their needs and provide personalized solutions that uphold the individuals' data protection and trust. Important aspects are semantic IoT interoperability mechanisms developed as part of the core SHAPES Technological Platform that enables interoperability among more than 37 already integrated Digital Solutions, with open interfaces for third party solutions that can be integrated via the Marketplace. The project employs innovative approach to IoT interoperability, which avoids transferring private and identifiable data via the core of the platform, instead aligning the parties directly involved in data exchange with respect to their Information Models and interfaces. Hence only types of data exchanged may be visible to potential intruders, but no actual data, since it physically is not transferred in SHAPES.

Starting and (target) end time of project:

01/11/2019 – 31/10/2023

IoT and/or Edge Computing research challenges:

As part of its IoT and edge technological developments, SHAPES project has defined and currently implements the SHAPES Technological Platform (TP), providing the architectural elements, APIs and SDKs and deployment of digital e-Health solutions, aimed at supporting seamless interoperability among IoT devices, platforms and services with respect for privacy and security of identifiable personal data.

The integration of a broad range of technological, organisational, clinical, educational and societal solutions seeks to facilitate long-term healthy and active ageing and the maintenance of a high-quality standard of life. Mediated by technology, in-home and local community environments interact with health and care (H&C) networks contributing to the reduction of H&C costs, hospitalisations and institutional care. Simultaneously, the European population is ageing, and the average lifespan is increasing. European Union (EU) citizens can remain productive and active far beyond the standard age of retirement. Longer lifespans are associated with risk of injury, frailty, and long-term chronic illnesses. As traditional communities and family structures become more dispersed, older individuals face psychological and physical effects of isolation, and loneliness. Europe must address how current and future digital solutions and innovations support planning for extended lifespans while maintaining independent, healthy and active lifestyles. SHAPES addresses this through the development of an open and interoperable platform which creates integrated networks of people, data and resources seeking to maintain good health, care and participation in society.

Overall, SHAPES results in:

- The SHAPES Integrated Care Platform is an open, EU-standardised platform based on four factors (home, behaviour, market and governance). Big data analytics and artificial intelligence (AI) analyse information pertaining to health, environment and lifestyle and individual needs, create user profiles and deliver personalised solutions. Adherence to EU data protection rules ensures user privacy, safety, security, trust and acceptance.
- SHAPES Ecosystem is a network of relevant users and key stakeholders working together to scale-up Platform and digital solutions. The SHAPES ecology - a network of networks - enables the creation of a reference architecture and standardised platform, Platform

testing and validation via large-scale piloting, the preparation of SHAPES' deployment and standardisation across Europe.

- SHAPES Marketplace seeks to connect demand and supply across H&C delivery, and to facilitate the co-creation of affordable, effective and trustworthy solutions. A dynamic catalogue of solutions and services allow the transparent expansion of the market offer, prevents vendor lock, and enhances the competitiveness of the EU H&C industry.
- SHAPES Recommendations, provide guidelines, a roadmap and an action plan, including a set of priorities dedicated to standardisation, to support key EU stakeholders to foster the large-scale deployment and adoption of digital solutions and new integrated care services in Europe. This will be based on evidence-based results from SHAPES, i.e. the recognised added-value of the SHAPES Platform to support AHA; extend independent, empowered and socially connected living; and improve the long-term sustainability of H&C delivery systems in Europe.

Expected activities on "Dissemination and Impact on Standards":

SHAPES builds the next generation EU-standardised open and interoperable digital platform, integrating state-of- the-art platforms and innovative IoT, AI, robotics, cloud and Big Data solutions to improve the health, wellbeing, independence and autonomy of older individuals, while enhancing the long-term sustainability of H&C systems in Europe. It seeks to validate and demonstrate the Platform in a large-scale piloting campaign that covers different themes associated with ageing priorities and concerns in both controlled environments and real-life use cases of high socio-economic impact to foster the take-up and large-scale deployment of SHAPES.

The take-up of SHAPES is fostered by building and expanding the SHAPES Ecosystem, namely through the promotion of new opportunities and market openings for entrepreneurs. Furthermore, EU standards, common ontologies and interoperability frameworks are at the heart of SHAPES, whose deployment across Europe allows the Consortium to contribute to suitable standardisation bodies or pre-normative activities with simple recommendations to support the large-scale deployment of eHealth solutions and the digital transformation of H&C delivery in Europe.

SHAPES promotes extensive interaction, networking and cross-fertilisation activities with fellow projects, including CSAs, contributing like SHAPES to interoperability, security and privacy approaches, standards, business validation and sustainability and methodologies and metrics. Verifiable Results: Development of and large-scale piloting of the Platform; Building and expansion of the SHAPES Ecosystem, involving relevant players in the new SHAPES approach to improved and highly efficient H&C delivery in Europe and welcoming market newcomers to avoid vendor lock and promote competitiveness; Implementation of cross-fertilisation activities with 8 projects contributing to interoperability approaches, standards, security and privacy approaches, business validation and sustainability and methodologies and metrics.

SHAPES maps EU standardisation effort developed by HL7, CEN-CENELEC, ABHS, IHE and eHealth competence centres, with support from the eHealth Network, ISO/TC 215, GS1, SNOMED International, IEEE11073 and IMI, as well as the results of relevant EU projects in the area of standards (EUROCAS, eStandards, EXPAND, GITB, epSOS, Antilope and Calliope).

Some more insights are provided below:

(1) List of IoT and/or Edge related SDO and Alliances that project will interact on standardization:

- FHIR (Fast Healthcare Interoperability Resources)[1]
- Health Level Seven International (HL7) [2]
- Open mHealth[3]
- ETSI 303645 "Cyber Security for Consumer Internet of Things: Baseline Requirements"
- ISO/IEC JTC 1/SC 38 Cloud computing and distributed platforms[4]
- IEC 60601-1-2: EMC standard for medical applications[5]
- IHE-Europe[6]
- INSPIRE Directive[7]

(2) How the project want to interact

Project partners (EDGE, Gnomon and ICOM) have established working relation with FHIR and Open mHealth consortia aiming to align IoT interoperability standards in e-Health domain. ICOM has pursued interactions with ISO/IEC and ETSI, primarily adopting their standards with possibilities of contributing to enhancements for enhanced use in e-Health domain.

(3) Timescales for this interaction:

Interactions with all above organization have started during the development of the SHAPES architecture in mid of 2020 and are expected to continue throughout its operational time frame i.e. until Q3 of 2023.

1.1.19 IM-TWIN: from Intrinsic Motivations to Transitional Wearable INtelligent companions for autism spectrum disorder

URL/Reference:

https://im-twin.eu/

https://cordis.europa.eu/project/id/952095

Abstract:

Research into autism spectrum disorder (ASD) is important since the condition affects about 1 in 10 new born children in developed countries. Previous EU-funded research resulted in the development of a prototype wearable companion robot called PlusMe for ASD treatment and daily support. The EU-funded IM-TWIN project now aims to furnish PlusMe with intelligent behaviour, give it extra embedded biosensors and cameras for detecting a child's affective state and integrate all components into an Internet of Things system itself called IM-TWIN. It will also validate the device and its components with target stakeholders and perform activities to advance the system components to a higher technology readiness level. The project's work will help to meet the needs of ASD therapy centres and families with children with ASD.

1 http://hl7.org/fhir/2016may/protocol.html

2 http://www.hl7.org/index.cfm

3 Open mHealth: https://www.openmhealth.org/organization/about/

4 https://www.iso.org/committee/601355.html

5 IEC 60601-1-2: EMC standard : https://webstore.iec.ch/publication/59644

6 IHE Europe: https://www.ihe-europe.net

7 INSPIRE: https://eur-lex.europa.eu/eli/dir/2007/2/2019-06-26

Starting and (target) end time of project:

01/11/2020 – 31/10/2023

IoT and/or Edge Computing research challenges:

The IM-TWIN project aims to develop some of the outcomes of the FET GOAL-Robots project towards market exploitation. The basic-research FET GOAL-Robots project aimed to study how intrinsic motivations ("curiosity") drive exploration and learning in children, and how such processes can be used to develop innovative autonomous robots.

This led to conceive the idea that intrinsic motivations can be used to build engaging interactive robots usable for the treatment of children with developmental disorders, in particular within the Autism Spectrum Disorder (ASD). ASD is a condition with dramatic importance for the well-being of society as it affects about 1 out of 10 new born in developed countries. We thus developed a "wearable companion robot", usable for the treatment and daily support of ASD, called PlusMe, now at the stage of prototype.

The IM-TWIN project has two sets of objectives. The first is to develop a highly-modular system pivoting on the PlusMe, called the IM-TWIN, addressing the needs of the market segment involving ASD therapy centres and, potentially, families with ASD children: this involves endowing the PlusMe with intelligent behaviour, equipping it with additional embedded biosensors and cameras for detecting the child's affective/emotional state, and integrating all components as a whole IoT system. The second set of objectives aims to validate the device and its components with target stakeholders, and to carry out a number of activities directed to advance the system components to a higher Technological Readiness Level (TRL7 for the PlusMe): this involves identifying the target groups and analysing ASD-related markets, refining and implementing an effective IPR strategy, planning the steps for individual and collective exploitation of the project outcomes, and finally creating a startup for the exploitation of the IM-TWIN system and its components. IM-TWIN will also foster the development of a lively high-tech research and application ecosystem.

1.1.20 GATEKEEPER: Smart Living Homes – Whole Interventions Demonstrator For People At Health And Social Risks

URL/Reference:

https://www.gatekeeper-project.eu/about-gatekeeper/

https://cordis.europa.eu/project/id/857223

Abstract:

The rising population of elderly in the EU member states is giving rise to new challenges in relation to independent living. The EU-funded GATEKEEPER project aims to ensure healthier independent lives for the ageing populations. It will connect healthcare providers, businesses, entrepreneurs, elderly citizens and the communities they live in. The goal is to create an open, trust-based arena for matching ideas, technologies, user needs and processes. The project will also incorporate data protection while underpinning value creation using advanced marketing patterns. The solutions deployed will involve 40 000 elderly citizens, as well as authorities, institutions, companies, associations and academics, and 8 regional communities from 7 EU member states.

Starting and (target) end time of project:

01/10/2019 – 31/03/2023

IoT and/or Edge Computing research challenges:

- To deliver the GATEKEEPER DIGITAL PLATFORM implemented through fault tolerant, secure, flexible and scalable micro-services infrastructure, based on open source and data standards, built on top of reference W3C-Web of Things architectural models and including services referred to the health domain through HL7-FHIR and to the home domain through SAREF.
- To deliver the GATEKEEPER HEALTHCARE SPACE, where intuitive and self-configuring dashboards, intelligent services for early risk detection and care plans, and a federated data infrastructure are provided to healthcare professionals.
- To deliver the GATEKEEPER CONSUMER SPACE, where certified solutions, services and devices are provided to citizens for the management and prevention of health and social risks.
- To deliver the GATEKEEPER BUSINESS SPACE, where certified companies are able to develop solutions, services and devices alone or in partnership, following a set of standards in order to reach and boost the Digital Single Market.
- To deliver the GATEKEEPER ECOSYSTEM TRANSACTION SPACE, where services for data storage and processing, big data analytics and advanced visualization of business-oriented KPIs are provided for the exchange of solutions among providers and suppliers, based on data sharing and Value-based healthcare paradigms.
- To execute a series of PILOTS to demonstrate the effect, benefit, value and scalability of the GATEKEEPER solutions around REFERENCE USE CASES COVERING PRIMARY, SECONDARY and TERTIARY PREVENTION, initially deployed in 8 regions of 7 European countries.
- To provide an ECOSYSTEM COCREATION framework, resulting from Responsible and Social Innovation principles, aiming at engaging and generate TRUST from Citizens, Healthcare Professionals, Supply and Demand Side, extended through open calls to SMEs, Start-ups, and new regions in an open innovation fashion.
- To implement a STANDARDIZATION STRATEGY that allow the GATEKEEPER solution to be aligned with SDOs around legal and privacy aspects, healthcare, ageing, homes, cities and energies, IoT, Big Data and other Key Enabling Technologies, as well as value-based procurement.
- To transform and process GATEKEEPER results in a reference and sustainable IMPACT FRAMEWORK for decision making about procurement of innovative solutions, integrating elements from Value-based Healthcare, Real World Data, and Health-Technology Assessment, involving relevant actors inside and outside the consortium through Communication and dissemination activities, for worldwide outreach of project activities and achievements.

Expected activities on "Dissemination and Impact on Standards":

- To identify and analyse the relevant standards and standardization tracks for GATEKEEPER,
- To coordinate and support the standardisation of relevant GATEKEEPER technology,
- To analyse and support an effective certification strategy to develop trust in data processing and, Interoperability of GATEKEEPER solutions.
- To develop and specify a model of procurement process for the outcomes of the GATEKEEPER platform.

1.1.21 CHARM: Challenging environments tolerant Smart systems for IoT and AI

URL/Reference:

https://charm-ecsel.eu/

https://cordis.europa.eu/project/id/876362

Abstract:

CHARM project will develop condition monitoring, predictive maintenance, automation, real-time manufacturing control and optimisation and virtual prototyping system demonstrators and test them in industrial settings. The ECS (Electronics, Components and Systems) technologies must be designed to withstand combinations of severe thermal, mechanical and chemical stress present during the manufacturing processes used in the industry.

Starting and (target) end time of project:

01/06/2020 – 31/05/2023

IoT and/or Edge Computing research challenges:

Digitalization has been identified as one of the key enablers for renewal and competitiveness of European manufacturing industries. However, grasping the digitalization and IoT-related opportunities can be limited by the harsh environmental conditions of the manufacturing processes and end use environments. The ECSEL-IA 2019 project initiative CHARM aims to contribute to solving this problem by **developing ECS technologies that tolerate harsh industrial environments**.

The project concept centres around real industrial challenges from different types of end use industries. The synergies and impacts arise from similarities in technology solutions serving different applications and industry sectors.

The CHARM Use Cases include six different industry sectors, majority of them presented by innovative cutting-edge large enterprises that belong to the world-wide market leaders of their own sectors – while most of them being new to the ECSEL ecosystem: mining (Sandvik Mining and Construction Oy, FI), paper mills (Valmet Technologies Oy, FI), machining (Tornos SA, CH), solar panel manufacturing lines (Applied Materials Italia SRL, IT), nuclear power plants maintenance and decommissioning (ÚJV Řež a.s. CZ), and professional digital printing (Océ-Technologies B.V NL). The planned demonstrators engage these big players with European ECS value chains and showcase capabilities that serve manufacturing industries' needs at large. The **new technologies to be developed include novel multi-gas sensors, robust high temperature and pressure sensors, flexible sensors for paper machine rolls, wireless power transfer systems, connectivity solutions for rotating parts, advanced vision systems, and enablers for autonomous driving**.

Expected activities on "Dissemination and Impact on Standards":

No information about standardization work.

1.1.22 ATLAS: Agricultural Interoperability and Analysis System

URL/Reference:

https://www.atlas-h2020.eu/

https://cordis.europa.eu/project/id/857125

Abstract:

Advanced digital technology and data play a vital role in ensuring sustainable production in today's agricultural industry. The EU-funded ATLAS project aims to develop an **open platform and create a sustainable environment for innovative agriculture**. The project will address the lack of **data interoperability in agriculture** by combining the use of agricultural equipment with sensor systems and data analysis. The ATLAS platform aims to deliver a service offering hardware and software interoperability using data from sensors to demonstrate the benefits of digital agriculture in a wide range of sectors affecting modern agriculture.

Starting and (target) end time of project:

01/10/2019 – 31/03/2023

IoT and/or Edge Computing research challenges:

The overall objective of ATLAS is the development of an open digital Interoperability Network service for agricultural applications and to build up a sustainable ecosystem for innovative data-driven agriculture using the Network.

The Interoperability Network will allow the flexible combination of agricultural machinery, sensor systems and data analysis tools to overcome the problem of lacking interoperability and will enable farmers to increase their productivity in a sustainable way by making use of the most advanced digital technology and data.

It will also define a service architecture, providing hardware and software interoperability layers which enable the acquisition and sharing of data from a multitude of sensors and the analysis of this data using a multitude of dedicated analysis approaches.

The technology developed in ATLAS will be tested and evaluated within pilot studies on a multitude of real agricultural operations across Europe along several use cases, e.g:

- precision agriculture tasks,
- sensor-driven irrigation management,
- data-based soil management,
- behavioural analysis of livestock.

Expected activities on "Dissemination and Impact on Standards":

Many areas of sensor technology depend on a network connectivity, as sensors are an indispensable part of the digitized and sustainable agri-food value chain. For this to be of fundamental importance in this area, compatibility and interoperability is an important factor.

ATLAS offers the opportunity to serve as a central component so that data-driven agriculture can be further promoted. The purpose of this survey was to determine the technical requirements of sensor manufacturers and sensor platform manufacturers due to the next generation of sensors. The aim of future systems is to promote successful interoperability between sensors and agricultural technology. In order for this to be possible, **the standardization of interfaces and data protocols is a crucial basis in which a valuable contribution to data-driven agriculture is made**.

Under preparation: **D9.3** Report on the advances of next generation machine interconnectivity standardization. Not yet published.

1.1.23 TERMINET: nexT gEneRation sMart INterconnectEd ioT

URL/Reference:

https://terminet-h2020.eu/

https://cordis.europa.eu/project/id/957406

Abstract:

Tens of billions of devices are connected to the Internet of Things (IoT), and the number of connections is growing every second. Information is being constantly sent and received from one smart device to another. Based on cutting-edge technologies such as software-defined networking (SDN), multiple-access edge computing, and virtualisation for next-generation IoT, the EU-funded TERMINET project will develop a novel next-generation reference architecture. Its main aim is to simplify the connection of a vast number of different devices through a flexible SDN-enabled middleware layer. To improve supply chain processes, the project will design an IoT-driven decentralised and distributed blockchain framework within manufacturing. TERMINET's approach will be tested in real-life situations such as energy, smart buildings, smart farming, healthcare and manufacturing.

Starting and (target) end time of project:

01/11/2020 – 31/10/2023

IoT and/or Edge Computing research challenges:

- natural sciences/computer and information sciences/internet/internet of things
- social sciences/economics and business/business and management/business models
- engineering and technology/materials engineering
- engineering and technology/electrical engineering/electronic
- engineering/information engineering/electronic engineering/robotics/autonomous robots/drones
- natural sciences/biological sciences/ecology/ecosystems

Expected activities on "Dissemination and Impact on Standards":

Some potential technical areas for further work on standardisation include:

- Digital Twins
- IoT Analytics
- AI Services
- Federated Machine Learning
- Knowledge Representation and Reasoning
- AR/VR
- Hardware Abstraction
- Software defined networking
- Secure processing of low latency data flows
- Streaming analytics
- Orchestration and provisioning
- End to End Management of Services

Including:

- Remote attestation techniques, Lightweight Crypto Primitives (LCP), Control Flow Attestation

There is potential for applying open-source tools/standards to:

- SDN-enabled container network interfaces (CNIs) in cloud environments
- SDN control plane and data plane interfaces for managing OpenFlow-based networks accommodating IoT traffic.
- Support local AI/ML model training with the use of distributed FL techniques

1.1.24 Hexa-X: A flagship for B5G/6G vision and intelligent fabric of technology enablers connecting human, physical, and digital worlds

URL/Reference:

https://hexa-x.eu/

https://cordis.europa.eu/project/id/101015956

Abstract:

2030 and beyond the world will face tremendous opportunities and challenges of sustainable growth. The Hexa-X vision is to Connect human, physical and digital worlds with a fabric of 6G key enablers. The key objectives of the Hexa-X project are: (1) Foundation for an end-to-end system architecture towards 6G; (2) Radio performance towards 6G; (3) Connecting intelligence towards 6G; (4) Network evolution and expansion towards 6G; (5) Impact creation towards 6G.

Starting and (target) end time of project:

01/01/2021 – 30/06/2023

IoT and/or Edge Computing research challenges:

Figure 1. illustrates the key value areas as stated in the Hexa-X vision and associated KPIs and capabilities. Each key value area reflects multifaceted aspects for which KVIs need to be developed. The key values are sustainability, inclusiveness and trustworthiness, where sustainability is explicitly considered from two perspectives in Hexa-X. 6G in itself needs to be sustainable, which could, for example, be mapped to the network energy efficiency as a KPI. In addition, 6G is an enabler for sustainability and sustainable growth in other markets and value chains, potentially covering aspects of inclusiveness and trustworthiness. Trustworthiness as another core value for Hexa-X, in the context of security considerations for 6G. In addition, the value of new capabilities enabled with 6G needs to be captured; this includes integrated sensing, embedded devices, local compute integration and integrated intelligence, as illustrated in the lower right. Flexibility is seen as a core capability. As core capability, flexibility covers, for example, the applicability of 6G to a new value chain, including ease of deployment and operation in that environment and, consequently, the goal of enabling new business opportunities. Flexibility as new capability of 6G impacts, for example, AI-based network management and operation.

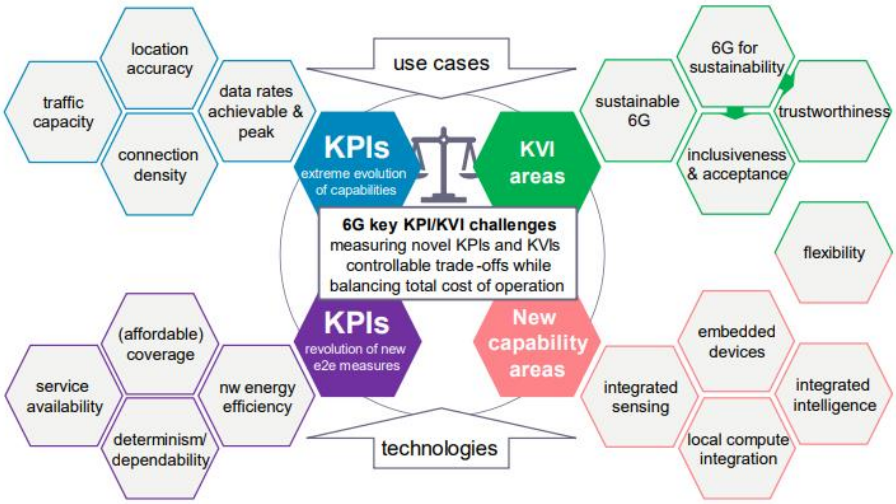


Figure 1: Clustering of Hexa-X Key Performance Indicators s and Key Value Indicators, copied from

In addition to the novel concept of KVIs, KPIs and performance goals need to go beyond what 5G can do to address new use cases discussed in the previous chapter. This includes increasing peak data rates and data rates achievable at the cell edge, density of connections, traffic capacity, and location accuracy to a substantial extent. For some performance goals, for example, dependability and determinism, service availability, affordable coverage, and network energy efficiency, the focus will shift more towards new end-to-end KPIs in specific use cases, and extreme performance in terms of data rates might be confined to specific scenarios rather than being a general, system-wide goal. Depending on the use case, novel KPIs for this end-to-end perspective will be defined. In addition, the relation between the fulfilment of KPIs and the associated total cost of operation becomes increasingly complex, given the number of stakeholders involved and the potential of networked intelligence and service-oriented ownership and business models on a local and global scale.

Expected activities on "Dissemination and Impact on Standards":

The standardisation dissemination targets and overall achievements of Hexa-X during the first project year (2021) are listed in **Table 2**.

Table 2: Standardization, Industrial impact and IP achievements of Hexa-X

Type	Target by the end of the project	Achieved
Standards and industry groups impacted	3GPP RAN, 3GPP SA, ETSI ENI, ETSI ZSM, ETSI PDL, ETSI OSM. ETSI NFV, ETSI MEC, NGMN, GSMA ITU, IETF, IEEE, TMF	3GPP, GSMA, ETSI, IETF, ITU-R
Total number of standards contributions by participants based on work in Hexa-X	More than 100	16
Number of patent applications	At least 50	6

1.1.25 InterConnect: Interoperable Solutions Connecting Smart Homes, Buildings and Grids

URL/Reference

https://interconnectproject.eu/about/

https://cordis.europa.eu/project/id/857237

Abstract:

The EU energy market is conditioned by digitalisation. New rules and technological developments allow the proliferation of energy service providers in the EU member states with users having full knowledge and control over their appliances. However, interoperability represents a serious problem as a change of provider could mean the replacement of installations. The EU-funded InterConnect project proposes effective energy management using a resilient and practical ecosystem that is user-centric and market-driven. The project involves a range of specialised stakeholders, including advanced technology actors, manufacturers, providers and energy users. Via seven pilots, they will showcase an effective digital market for ensuring energy-efficiency at reduced costs that is beneficial to end-users.

Starting and (target) end time of project:

01/10/2019 – 30/09/2023

IoT and/or Edge Computing research challenges:

- Large-scale pilots leading to market driven deployments
- Establish interoperability framework validating SAREF and semantic interoperability
- Marketplace of integrated digital platforms bringing the gap between IoT and Energy
- User centric energy and non-energy devices

Expected activities on "Dissemination and Impact on Standards":

The expected Interconnect activities on "Dissemination and Impact on Standards" are depicted in **Figure 2**.

Figure 2: Interconnect Ecosystem Strategy. Source: Interconnect project

1.1.26 ASSIST-IoT: Architecture for Scalable, Self-*, human-centric, Intelligent, Secure, and Tactile next generation IoT

URL/Reference:

https://assist-iot.eu/

https://cordis.europa.eu/project/id/957258

Abstract:

ASSIST-IoT will provide an innovative reference architecture, envisioned as a decentralized ecosystem, where intelligence is distributed among nodes by implementing AI/ML close to data generation and actuation, and hyperconnecting nodes, in the edge-cloud continuum, over softwarized smart network. Smart network will be realized by means of virtualized functions, with clear separation of control and data planes, facilitating efficient infrastructure programmability. Moreover, the action will follow a DevSecOps methodology to ensure the integration of security, privacy, and trust, by design, in all aspects of the envisioned ecosystems.

ASSIST-IoT will be supported by several pillars: (i) innovative IoT architecture, to adapt to the NGI paradigm, with three-dimensional approach, including intelligence, security and privacy by design, supporting decentralized collaborative decision-making; (ii) moving from semantic interoperability to semantically-enabled cross-platform, cross-domain data transactions, within decentralized governance, DLT-anchoring transaction security, privacy and trust; (iii) development and integration of innovative devices, supporting context-aware computing, to enable effective decision making close to events; (iv) introduction of self-* mechanisms, supporting self-awareness and (semi-)autonomous behaviours across IoT deployments, and (v) Tactile Internet support for latency applications, like AR/VR/MR, and human-centric interaction with IoT components. Results of the action will provide foundation for a comprehensive practice-based methodology, for future designers and implementers of smart IoT ecosystems.

Finally, to validate research results, and developed solutions, and to ensure their wide applicability, extended pilot deployments with strong end-user participation will take place in: (i) port automation; (ii) smart safety of workers, and (iii) cohesive vehicle monitoring and diagnostics, bringing about domain-agnostic aspect of the approach.

Starting and (target) end time of project:

01/11/2020 – 31/03/2024

IoT and/or Edge Computing research challenges:

Growth of volume of unstructured data, sent by IoT devices, exceeds that of structured data. Many existing applications do not benefit from opportunities and flexibility offered by the existence of multiple data sources/streams. As data grows in size and heterogeneity, issues of scalability and interoperability become a rising concern. Modern AI uses Big Data to support users, self-train, and continually improve its performance. Increasing need for near-real-time reaction, and automatic decision making, suggests/enforces application of AI close to events, utilizing edge computing, smart networking and smart devices. These challenges require novel approaches, leading to highly decentralized ecosystems, supported transversely by security, privacy and trust enablers, to facilitate data sharing and protect the growing attack surface. Last but not least, human-centricity and new ways of interacting with IoT ecosystems have to be a core part of an innovative proposal, like the decentralized and multi-plane architecture that ASSIST-IoT introduces.

The challenges in the project are particularly:

- Design, implementation and validation of an NGIoT Reference Architecture, decentralised architecture (and its reference implementations), validated in three real-life pilots backing the NGI approach,
- Definition and implementation of distributed smart networking components,
- Definition and implementation of decentralized security and privacy exploiting DLT,

- Definition and implementation of smart distributed AI enablers, AI components (including smart devices), to be deployed in the "proper locations" across the IoT ecosystem continuum,
- Definition and implementation of human-centric tools and interfaces,
- Support Tactile IoT/AR low latency networks are needed, since interaction between users, devices and systems has to be smooth enough to be considered real-time,
- Interoperability will be addressed in terms of scalability, security, privacy and heterogeneity of data sources.

Expected activities on "Dissemination and Impact on Standards":

Participation in ETSI:

- Further active participation in ETSI work.
- Follow up for new Specialist Task Forces and new work items.
- Participation in Working Groups for forthcoming standard actions.
- Cooperation using AIOTI for contribution to ETSI TR and evaluation of the ETSI reports and standards.

Participation in ITU-T:

- Active participation and follow up using OPL membership in ITU-T SG13 and SG20.
- Contributions to ITU-T, SG20 potential contributions under preparation.
- ITU-T SG meetings participation.
- New work items identification and analysis of new proposed subjects.

Participation in IEEE SA:

- Contributing to IEEE SA Open (GitLab)
- Contact IEEE SA Operational Program Management Team
- Explore membership of IEEE Societies to fostering Project submission.
- Participation as Working Groups for forthcoming standard actions.
- Participation as balloting stakeholder in 2 standardisation processes.
- Participation as public reviewer in 1 standardisation action of each relevant identified active project.

Participation in AIOTI:

- Participation in the AIOTI Board that will take place in IoT Week 2022 (Dublin, Ireland).
- Enrol in AIOTI WG Standardisation to participate in the SDOs exploration and alignment.
- Enrol in AIOTI WG Standardisation to actively contribute to the next release of HLA (v6.0).
- Contribution to white papers in data spaces subject.
- Participation (as external contributors) to next events/actions of WG Urban Society.
- Enrol and actively contribute in AIOTI WG Mobility to deliver a new scope-wide document.
- Observe and contribute to the next documents emphasising on the role of IoT in combination with BIM and as an indoor geo-localisation commodity.

Participation in BDVA/DAIRO:

- Enrol in TF7.SG7 and TF7.SG11 to align technical work of pilots 1, 3A and 3B and potentially contribute with relevant inputs via UPV (member of BDVA).
- Follow closely the reports of TF6.SG6 Standardisation.
- Participate in TF6-SG1 Data technology and architectures.
- Collaborate in the edition of the forthcoming SRIDA – Strategic Research, Innovation and Deployment Agenda of DAIRO.
- Contribution to position paper about data spaces and interoperability.

Participation in ESCO/ENISA:

- Active participation and follow up by S21SEC.
- New work items: WG identifies the capacities and capabilities to sustain EU digital autonomy by developing and fostering trusted technologies.
- Next contribution to define the cyber security EU R&I roadmap and vision to strengthen and build a resilient EU ecosystem.
- Contribution to new white papers about best practices in cybersecurity.

1.1.27 IntellIoT: Intelligent, distributed, human-centred and trustworthy IoT environments

URL/Reference:

https://intelliot.eu/

https://cordis.europa.eu/project/id/957218

Abstract:

The Internet of Things (IoT) merges physical and virtual worlds. The European Commission is actively promoting the IoT as a next step towards the digitisation of our society and economy. The EU-funded IntellIoT project will develop a framework for intelligent IoT environments that execute semi-autonomous IoT applications, enabling a suite of novel use cases in which a human expert plays a key role in controlling and teaching the AI-enabled systems. Specifically, the project will focus on agriculture (tractors semi-autonomously operated in conjunction with drones), healthcare (patients monitored by sensors) and manufacturing (automated plants shared by multiple tenants who utilise machinery from third-party vendors). It will establish human-defined autonomy through distributed AI running on intelligent IoT devices.

Starting and (target) end time of project:

01/10/2020 – 31/01/2024

IoT and/or Edge Computing research challenges:

The following 3 key features of IntellIoT's approach are highly relevant for the work programme as they address the call's challenges:

- Human-defined autonomy is established through distributed AI running on intelligent IoT devices under resource-constraints, while users teach and refine the AI via tactile interaction (with AR/VR).
- De-centralised, semi-autonomous IoT applications are enabled by self-aware agents of a hypermedia-based multi-agent system, defining a novel architecture for the NG IoT. It copes with interoperability by relying on W3C WoT standards and enabling automatic resolution of incompatibility constraints.

- An efficient, reliable computation & communication infrastructure is powered by 5G and dynamically manages and optimizes the usage of network and compute resources in a closed loop. Integrated security assurance mechanisms provide trust and DLTs are made accessible under resource constraints to enable smart contracts and show transparency of performed actions.

Expected activities on "Dissemination and Impact on Standards":

We list below the preliminary contributions or investigation of selected SDO, which either develop standards that IntellIoT needs to use, or where IntellIoT could contribute.

- 5G ACIA - contributed to the activities of the 5G ACIA standardization group with use cases for Edge computing in a 5G environment of a manufacturing shop floor as well as distributed AI.
- W3C WoT WG - The IntellIoT use cases have been presented to the W3C WoT WG and are in the process of being included into the W3C WoT use cases and requirements document.
- 3GPP – 3GPP recently completed its rel.16 5G NR specification and is actively working on its rel.17. In a nutshell, 3GPP rel.15 provided the specification of 5G NR, with minor support for services and functions required by IntellIoT. 3GPP rel.16 proposed extended functions of 5G NR, such a Vehicular-to-Everything (V2X) architecture, preliminary URLL mechanisms or architecture for Private 5G Networks. It will however require to wait for rel.17 and rel.18 to actually see functions that would be beneficial to IntellIoT either in its tight integration of AI, private network management or extended Device-to-Device support.
- AIOTI - IntellIoT use cases have been presented by EURECOM. Currently, contributions are being prepared to the AIOTI TF Landscape maintenance. EURECOM contributed as input to the AIOTI survey Edge Computing OSS with its OpenAirInterface platform.

1.1.28 Visualization of the IoT EU funded completed projects landscape

This section provides a landscape visualization of the completed IoT projects funded by the EU, which are introduced in this report.

Figure 3 shows the "IoT EU funded completed projects landscape (Technology and Marketing Dimensions)", where these completed projects are projected in two dimensions. The horizontal axis represents the market type, while the vertical axis represents the technology/solution/knowledge area that these completed projects cover and focus. Notably, the extremity of the left-hand side of the horizontal axis represents the customer (i.e., Business to Customer: B2C) market. The part at the extremity of the right side of this axis, on the other hand, represents the industrial internet (i.e., Business to Business: B2B) market. Also, it should be noted that the top part of the vertical axis represents the technology areas that are related to services and applications, while the bottom part of the same axis represents the technology areas that are related to connectivity.

The projection of these completed projects on these two dimensions has been accomplished based on discussions among experts participating in both AIOTI WG Standardisation and relevant completed project participants.

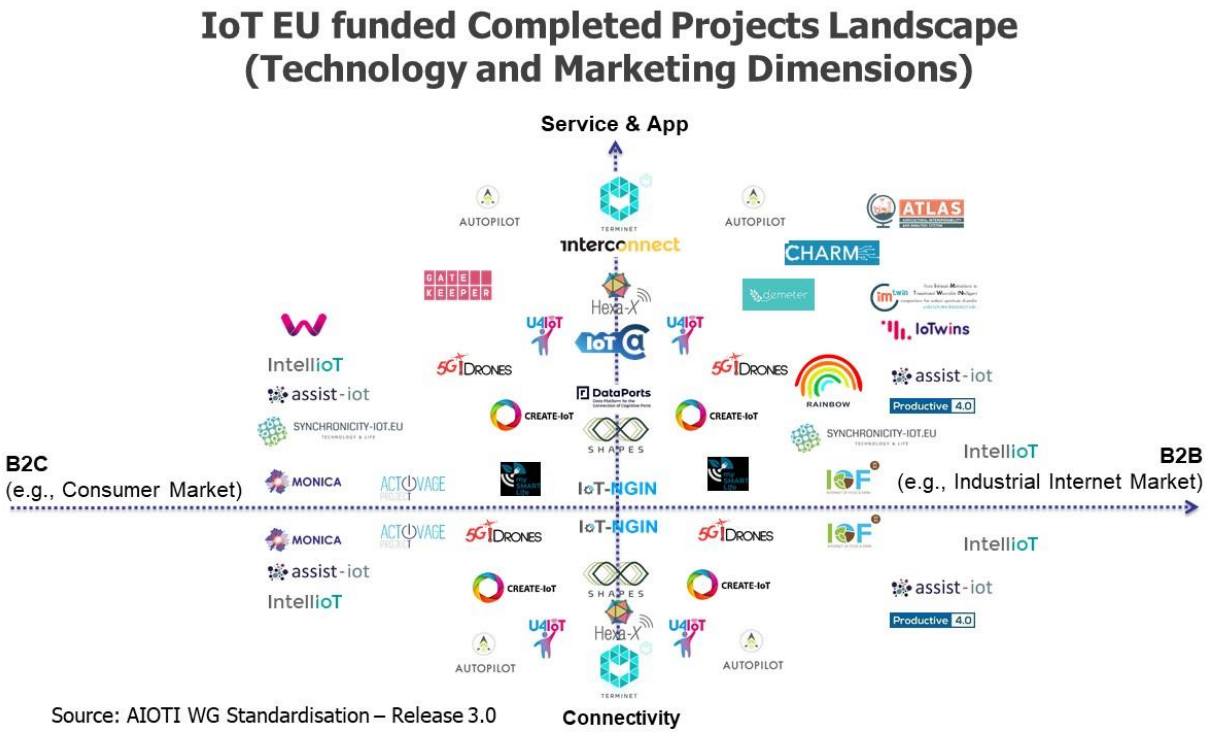


Figure 3: IoT EU funded completed projects landscape, when Technology and Marketing Dimensions are used

In addition to the IoT EU funded completed projects landscape shown in **Figure 3** a projection of these completed projects into vertical industry domains is shown in **Figure 4: IoT EU funded Completed Projects Projection on Vertical and Horizontal Domains**

Moreover, the IoT EU funded completed projects landscape projection in relation to activities in standardisation organisations and initiatives is shown in **Figure 5.** This is a graphical representation aiming at highlighting the standardisation activities (up to the day of generating this representation) of the completed projects with respect to different SDO's and standardisation initiatives like: ETSI, AIOTI, ISO/IEC, BDVA, IEEE SA, IETF, 3GPP, ITU-T, W3C, OneM2M as well as open-source projects and standards.

The "IoT EU funded Completed Projects Landscape (Vertical and Horizontal Domains)" is a graphical representation aiming at highlighting the main activities (up to the day of generating

this representation) of the completed projects with respect to the industrial domains/sectors represented as "verticals" and Telecommunication Infrastructure domain represented as "Horizontal/Telecommunication".

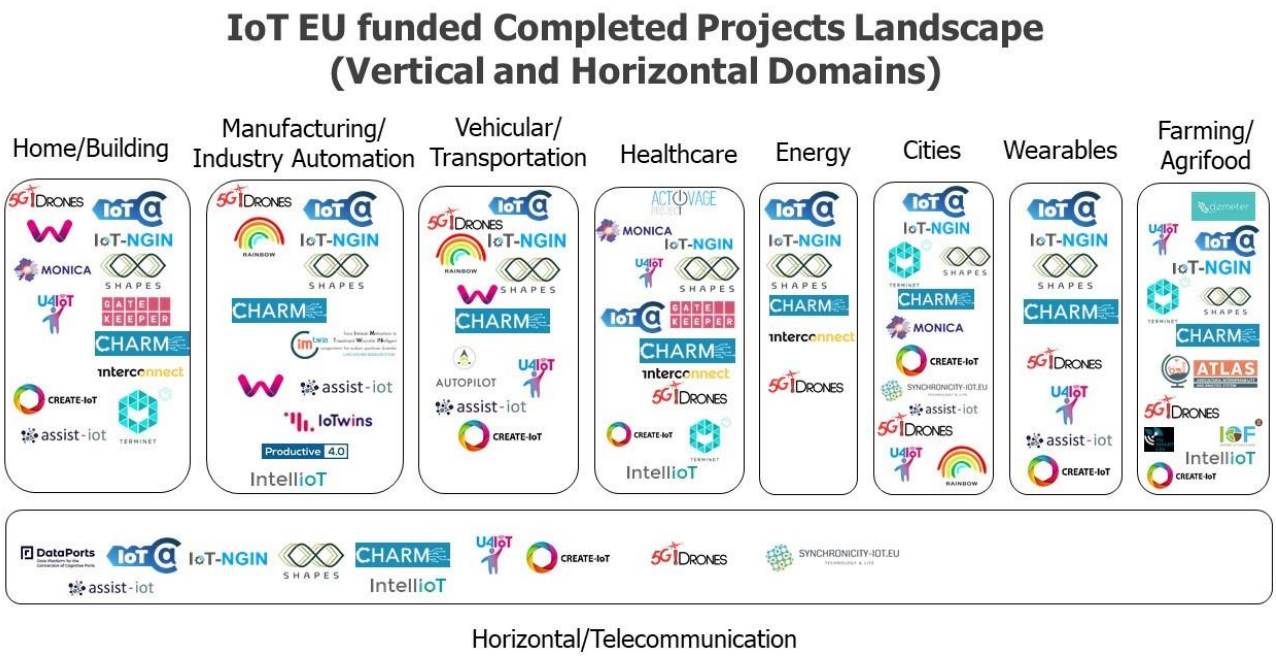


Figure 4: IoT EU funded Completed Projects Projection on Vertical and Horizontal Domains

Moreover, the IoT EU funded completed projects landscape projection in relation to activities in standardisation organisations and initiatives is shown in **Figure 5**. This is a graphical representation aiming at highlighting the standardisation activities (up to the day of generating this representation) of the completed projects with respect to different SDO's and standardisation initiatives like: ETSI, AIOTI, ISO/IEC, BDVA, IEEE SA, IETF, 3GPP, ITU-T, W3C, OneM2M as well as open-source projects and standards.

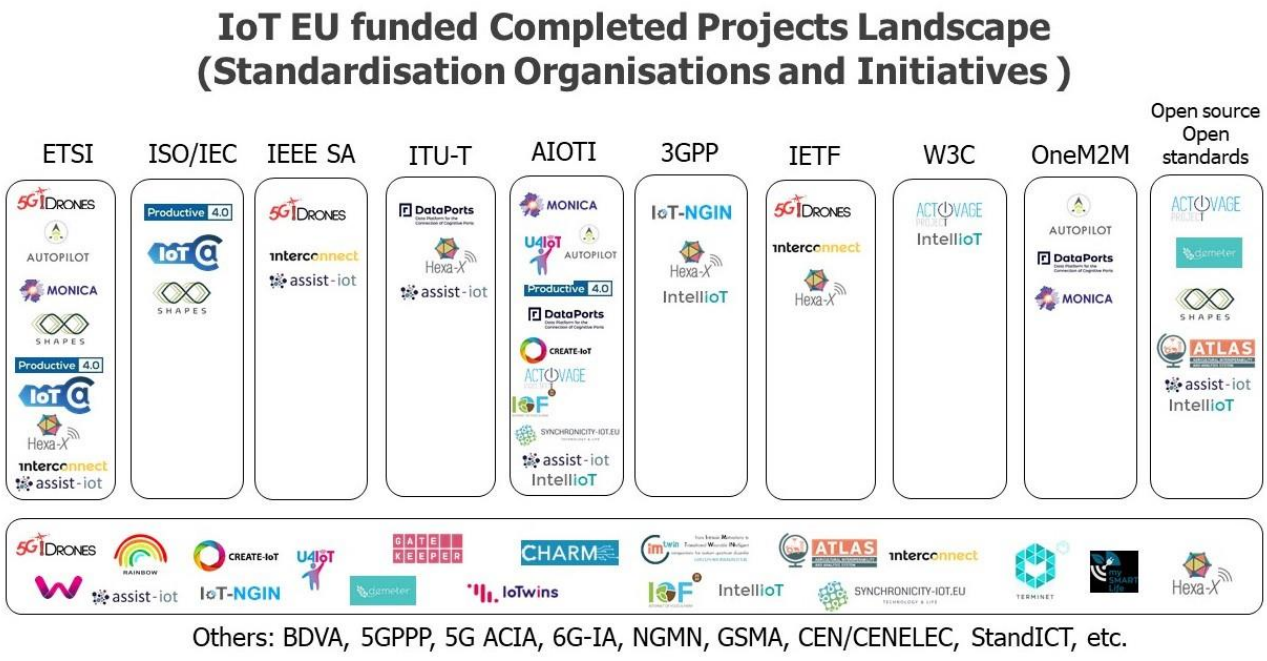


Figure 5: IoT EU funded Completed Projects Projection on Standardisation Organisations and Initiatives

1.2 Ongoing Projects

This section provides a description of IoT projects funded by the EU that are still ongoing.

1.2.1 European Distributed Data Infrastructure for Energy (EDDIE)

URL/Reference:

https://eddie.energy/

https://cordis.europa.eu/project/id/101069510

Abstract:

The *Clean Energy for all Europeans Package* has established the right to access energy-related data for customers and eligible parties of their choice. This can enable new data-based services which leverage energy-related data from IoT sensing devices in households, such as smart meters and home automations systems.

EDDIE aims at enabling such services by creating an open-source Data Space aligned with the work of the EU Smart Grids Task Force on the Implementing Acts on Interoperability and other European activities. This Data Space will focus on lowering the data integration costs of energy data-based services by allowing energy companies to work and compete in a common European market. In addition, an Administrative Interface for In-house Data Access (AIIDA) will be designed (which is expected to be deployed in-house thus running on edge computing resources) that has the prime goal to ensure consent-based secure and reliable access to valuable real-time data.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

Various challenges will be tackled within the context of EDDIE which are mostly related to achieving interoperability for accessing IoT data from smart meters and IoT sensors. Such challenges are:

- **Access to historical energy data**: At the moment, the main barrier in the way of creating services which rely on energy data is the lack of uniform procedures for accessing IoT data from households, i.e., access to smart metering information. Currently, actors are tied to acquiring data from national energy providers that use different procedures. This limits the interoperability and growth perspective of energy services. Such constraints have an industrial, economic, and social dimension on a European level and beyond.
- **Access to uniform energy data**: Even when the access to IoT data from smart meters is possible, it is still hard to exploit this data due to the variety of existing data formats (i.e., utilized syntax, structure, and file types). This becomes especially difficult when the goal is to acquire energy data (e.g., energy production and consumption patterns) from households in different counties that may use differs formats.
- **Access to real-time energy data**: Many actors also face problems when trying to access near real-time measurements of smart meters and in-house IoT sensors. This can be a problem because, typically, smart metering consumption data becomes available by the energy provider after a significant period of time, thus losing its values as real-time information.

Expected activities on "Dissemination and Impact on Standards"

The results that will be produced throughout the duration of EDDIE are expected to be submitted for publication in the proceedings of international conferences, workshops and selected high-level journals from various relevant fields including energy economics, computer science, IoT, software engineering, big data, machine learning, and AI. In addition, it is expected to participate in technical working groups such as the AIOTI WG Energy, the Digital Taskforce of the SmartEn (the European demand response association) and the Working Group 4 of the ETIP Smart Network platform.

1.2.2 NEMO: Next Generation Meta Operating System

URL/Reference:

https://meta-os.eu

https://cordis.europa.eu/project/id/101070118

Abstract:

Artificial Intelligence of Things (AIoTI) is one of the next big concepts to support societal changes and economic growth, being one of the fastest growing ICT segments. A specific challenge is to leverage existing technology strengths to develop solutions that sustain the European industry and values. NEMO establishes itself as the gamechanger of the IoT-edge-cloud continuum by introducing an open source, modular and cybersecure meta-operating system, leveraging on existing technologies and introducing novel concepts, methods, tools, testing and engagement campaigns. NEMO will bring intelligence closer to the data and make AI-as-a-Service an integral part of network self-organisation and micro-services execution orchestration. Its widespread penetration and massive acceptance will be achieved via new technology, pre-commercial exploitation components and liaison with open-source communities.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

Research challenges in NEMO

- mOS Architecture
- On-device federated MLOps and TL via CF-DRL as core part of mOS
- SLO based meta-Orchestrator
- Federated micro-services//unikernels SEE
- Micro-service sovereignty
- Intent-based migration SDK
- Cybersecurity vertical

Innovation challenges in NEMO

- Federated mNCC offering self-configured/-healing clusters
- Network Control and management IoT/5G/B5G adapters
- IoT/5G Time Sensitive Networking (TSN)
- Policies for optimal micro-services/unikernels migration
- Plugins Lifecycle Manager
- Monetization and Accountability (MOCA)
- Policy Enforcement vertical

Expected activities on "Dissemination and Impact on Standards":

NEMO partners follow the activities of standardisation bodies, which have been identified as relevant to the project developments, namely GAIA-X, AIOTI, ETSI, IETF and 3GPP standardisation. Moreover, the project monitors closely and has active links with clusters and associations in the field of IoT/Edge/Cloud Continuum, communication, software, open source, as well as domains related to the Living Labs, indicatively 5GPPP, 6G-IA, Networld Europe, NGI, DAIRO/BDVA, Eclipse IoT & Edge WG, and European Cloud Edge & IoT Continuum. The timescale for interaction is from now until the end of the project (August 2025).

1.2.3 Security-by-design IoT operation with supply chain control (DOSS)

URL/Reference:

https://cordis.europa.eu/project/id/101120270

https://dossproject.eu/

Abstract:

The DOSS project aims to develop a secure-by-design methodology and technology for complex IoT architectures, focusing on supply chain monitoring, component testing, and architecture modeling. The project will establish a "Supply Trust Chain" to facilitate secure information exchange in the IoT supply chain. It will also include security verification of hardware and software components, define a "Device Security Passport" for third-party hardware, and test and assess third-party software. The project will develop a Digital Cybersecurity Twin that can simulate IoT architectures, employ AI to model attack scenarios, and provide pre-certification for IoT architectures based on security standards and KPIs. The project will validate the procedures and technology in automotive, energy, and smart home domains and contribute to policy recommendations and standardization efforts.

Starting and (target) end time of project:

01/09/2023 – 31/08/2026

IoT and/or Edge Computing research challenges:

- Advanced security-by-design methodology for complex IoT architectures
- Establishing a "Supply Trust Chain" for secure information exchange in the IoT supply chain
- Designing a "Digital Cybersecurity Twin" to simulate IoT architectures, model attack scenarios, and enable information sharing with the supply chain
- Defining a "Device Security Passport" (DSP) as a standardized mechanism to assess and ensure the security of third-party hardware and its components used in IoT architectures
- Designing a "Component Tester" to test and assess third-party software, open-source applications, and in-house developments to ensure their security and suitability for integration into the modelled IoT architectures

Expected activities on "Dissemination and Impact on Standards":

DOSS partners are active in the following SDOs and standardization interest groups:

- AIOTI
- CEN
- DIN
- ENISA
- ETSI
- EUOS
- Global Platform
- NIST

- StandICT

The objective is to provide context-relevant recommendations for future standards and submit project results for consideration by relevant working groups. The consortium already has several contacts in the relevant SDOs and standardization interest groups as listed in 1. By actively engaging with the mentioned SDOs and standardization interest groups, the project seeks to ensure that both the Supply Trust Chain concept/technology and the DSP specifications reach a mature stage that aligns with standard requirements. In addition, collected findings can be further processed and published in SDOs. It is planned, for example, to achieve this by creating technical specifications and technical reports in ETSI technical committees, for example for the Component Tester or the Digital Cybersecurity Twin.

The work, which is oriented towards ETSI and DIN, for example, will start as early as the beginning of 2024. The DOSS project aims to start the work as early as possible to be able to complete it within the project duration and thus generate an immediate impact.

1.2.4 NEPHELE - A lightweight software stack and synergetic meta-orchestration framework for the next generation compute continuum

URL/Reference:

https://nephele-project.eu/

https://cordis.europa.eu/project/id/101070487

Abstract:

The next generation IoT and Edge Computing technologies are evolving at a rapid pace. This evolution moves in parallel with the increase in the heterogeneity of the IoT technologies. To efficiently manage hyper-distributed applications across heterogeneous infrastructure in the Cloud-to-Edge-to-IoT continuum, convergence of IoT technologies and development of synergetic orchestration mechanisms has to take place. NEPHELE aims to tackle these challenges and enable the efficient, reliable and secure end-to-end orchestration of hyper-distributed applications over programmable infrastructure across the compute continuum, considering the integration of IoT devices with the rest part of the infrastructure. NEPHELE aims to introduce two core innovations, namely: (i) an IoT and edge computing software stack for leveraging virtualization of IoT devices at the edge part of the infrastructure and supporting openness and interoperability aspects in a device-independent way; and (ii) a synergetic meta-orchestration framework for managing the coordination between cloud and edge computing orchestration platforms, through high-level scheduling supervision and definition, based on the adoption of a "system of systems" approach. A set of use cases across various vertical industries are considered, including disaster management, logistic operations in ports, energy management in smart buildings and remote healthcare services.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

Two main challenges are considered in NEPHELE.

The first challenge regards the need for convergence of IoT technologies based on novel architectural approaches, able to guarantee continuous and seamless openness and interoperability of the plethora of existing and emerging solutions, models and devices, while enabling analytics for their lifecycle's costs, measured in time and resources (from seconds or watts to CO2). To tackle this challenge, NEPHELE aims to develop an IoT and edge computing software stack, called as VOStack.

VOStack is a multi-layer stack that covers IoT interoperability and openness aspects in two levels, namely (i) the IoT device level based on the provision of virtual counterparts of IoT devices and (ii) the level of integration of IoT functions with edge and cloud computing applications. By supporting these two levels, we aim to achieve, on one hand, convergence of IoT technologies considering both protocol and semantic interoperability challenges, and, on the other hand, enhanced interoperability of IoT technologies with emerging edge and cloud computing specifications.

The second challenge regards the need for the provision of an integrated meta-orchestration environment for hyper-distributed applications, where a synergy between cloud and edge computing orchestration platforms takes place to optimally manage applications' end-to-end deployment and data provision over the continuum. Nowadays, multiple orchestration platforms exist, targeting orchestration needs on the cloud, the edge or the IoT part of the compute continuum. Such frameworks are not suitable per se for tackling the orchestration challenges of hyper-distributed applications, since they usually have the responsibility but not the control of the reserved resources across the continuum, nor the knowledge and authorization for proper horizontal scheduling of the various application parts. Furthermore, as applications become more distributed, the coherence of failures begins to decrease, while the distance between cause and effect increases. A meta-orchestration level is required for enabling the synergy among different orchestration systems/platforms by generalizing and modelling their orchestration modules. In NEPHELE, the meta-orchestration framework will follow a "system of systems" approach, where a set of complex systems (orchestration modules in the various parts of the continuum) are managed by a large-scale concurrent and distributed system.

Expected activities on "Dissemination and Impact on Standards":

Based on the specification of the NEPHELE VOStack, two instantiations are under development that aim to be aligned with the specifications of the W3C Web of Things (WoT) working group and the OMA LwM2M specifications respectively. Interaction with other standardization bodies is also targeted (e.g., participation at the ETSI IoT Conference 2023). Contribution to working documents of AIOTI is also highly envisaged.

In terms of implementation, the software releases are made available in the GitLab repository of Eclipse Research Labs[8]. A stable release of VOStack is envisaged by the end of October 2023, while a continuous development and integration approach is followed in NEPHELE.

Interaction with the participants of the W3C WoT working group is in progress mainly through dedicated conference calls, while participation to related events and conferences is targeted (e.g., ETSI IoT conference 2023, EclipseCon 2023). The interaction will be active during the lifetime of the NEPHELE project, while a sustainability plan will be provided for maintaining and extending this interaction upon the lifetime of the project.

1.2.5 COMMECT - Bridging the digital divide and addressing the need of Rural Communities with Cost-effective and Environmental-Friendly Connectivity Solution

URL/Reference:

https://www.horizoneurope-commect.eu/

https://cordis.europa.eu/project/id/101060881

Abstract:

Over the last few years, the importance and need for broadband and high-speed connectivity have constantly increased.

[8] https://gitlab.eclipse.org/eclipse-research-labs

The Covid-19 pandemic has even accelerated this process towards a more connected society. But this holds mainly true for urban communities. In Europe, a 13% lack of access persists and mainly concerns the most rural and remote areas. Those are the most challenging to address since they are the least commercially attractive. COMMECT aims at **bridging the digital divide** by providing quality, reliable, and secure access for all in rural and remote areas. The **goal of extending broadband connectivity in rural and remote areas** will be achieved by *integrating Non-Terrestrial Networks with terrestrial cellular XG networks and low-cost Internet of Things (IoT). Artificial Intelligence, Edge and Network Automation will reduce energy consumption both at the connectivity and computing level.*

A participatory approach with end-users and ICT experts working together on development challenges will be the key **to the digitalization of the sector**. To ensure the rich exchange of best-practice and technical knowledge among the actors of the agro-forest value chain, COMMECT will set up **five Living Labs across and outside Europe**, *where end-users' "pain" and (connectivity) "gains" will be largely discussed, from different perspectives.*

COMMECT aims to contribute to a balanced territorial development of the EU's rural areas and their communities by making smart agriculture and forest services accessible to all. COMMECT will facilitate that by developing a ***decision-making support tool*** *to advise on the best connectivity solution according to technical, socio-economic, and environmental considerations. This tool, incorporating collaborative business models, will be a key enabler for jobs, business, and investment in rural areas and for improving the quality of life in areas such as healthcare, education, and e-government, among others.*

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

OBJECTIVE 1: Empower rural and remote communities and train them toward digitalization:

- COMMECT will adopt a twofold approach toward digital inclusion of rural communities: (1) easy access to fast and reliable broadband Internet (making it affordable for all and able to meet different end-user needs*)- including IoT and edge computing features*, and (2) educate rural communities and business toward the adoption of the digital technologies.

OBJECTIVE 2: Increase the competitiveness of rural communities and give them access to new services and business opportunities:

- COMMECT will design innovative, cost-effective, and energy-efficient (5G, last mile, and *edge*) connectivity solutions that can increase the attractiveness of rural and remote areas to businesses and individuals. COMMECT will enhance the communities' capability to create and innovate business models to impact remote and rural areas socially and economically in a sustainable way. New forms of entrepreneurship in agriculture and forestry, based on environmental and social values, will also be promoted.

OBJECTIVE 3: Facilitate decision-making in the selection of the most appropriate Internet connectivity:

- The choice of the most appropriate technology (*including IoT and Edge computing features*) depends on economic, geographic, and technical factors, the type and number of services required, the infrastructure already available, etc. COMMECT will validate such a concept in five Living Labs deployed in five countries with different regional, socioeconomic, and environmental conditions. *Technical and non-technical actors will closely work together in the Living Labs, exchanging their complementary knowledge (scientific and practical).* COMMECT will develop a **DST** that advises farmers, forestry, municipalities, and decision-makers on the best connectivity solution, according to technical requirements and the foreseen socio-economic and environmental impact.

OBJECTIVE 4: Contribute to climate change mitigation and increase the resilience and sustainability of rural communities:

- Connectivity solutions *(including IoT and Edge computing features)* will be designed considering criteria such as energy efficiency, climate change impact and total cost of ownership to improve their sustainability performance. The benefits of the connectivity solutions (i.e. Green ICT and ICT for Green) will also be assessed and compared to sustainability targets (European Green Deal and Fit for 55 package) for the agricultural and forestry sectors (e.g. reaching climate neutrality by 2050 in the EU). The socio-economic and environmental indicators will be included in the DST to guide the end-users towards more sustainable choices.

Provide information about the expected activities on "Dissemination and Impact on Standards":

- Standardisation activities on facilitating decision-making in the selection of the most appropriate Internet connectivity in rural communities in the context of SDOs and alliances such as 3GPP, oneM2M, 5GACIA, NGMN.
- Standardisation activities on autonomous networks across hybrid networks (mainly TMForum and ETSI ZSM)
- Bringing COMMECT interoperability standardisation challenges in the context of the Alliance for IoT and Edge Computing Innovation (AIOTI), in reports such as the updated version of the report **"IoT and Edge Computing EU funded projects landscape"** and (2) bringing COMMECT insights in the joint cooperation of AIOTI with European Telecommunications Standards Institute (ETSI) Environmental Engineering (EE) Eco Environmental Product Standards (EEPS) and ITU-T SG5 Q9 (Study Group 5 Question 9) group, in activities such as:
  - future updates of) **L.1480**: "Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors"
  - (updates of) **L.1410** => **L.1410rev** - "Methodology for environmental life cycle assessments of information and communication technology goods, networks and services"
- Contributions towards:
  - Third Generation Partnership Project (3GPP) Radio Access Network (RAN) Radio Layer 2 and Radio Layer 3 RRC (WP2)
  - Next Generation Mobile Networks (NGMN) Alliance Green Future Networks project
- Some examples are, see AIOTI Days 2024:
  - Towards NGMN:
    - Energy Efficiency White Paper, Phase 3: Energy Efficiency Roadmap - Green Future Networks: A roadmap to Energy Efficient Mobile Networks
  - Towards AIOTI:
    - AIOTI WG Standardisation: Landscape + Gaps
    - AIOTI WG Agriculture: 6G IA and AIOTI joint White Paper: The role of 6G in agriculture
    - AIOTI WG ICT for Co2 reduction Methodologies (ICM): Discussion on examples of LCA for carbon emissions in COMMECT use cases
  - Towards 3GPP:
    - RAN2 R2-2304155 Discussion on CHO (handover) procedure enhancements in case source/target cell is in NES (energy saving) mode
    - RAN2 R2-2308054 Discussion on the NTN – TN cell reselection enhancement
    - Joint ETSI TC EE/ ITU-T SG5: targeted contribution towards L.1480(rev) via AIOTI

1.2.6 AIMS5.0: Artificial Intelligence in Manufacturing leading to Sustainability and Industry5.0

URL/Reference:

https://www.aims50.eu/

https://cordis.europa.eu/project/id/101112089

Abstract:

AIMS5.0, a collaborative Innovation Action, aims at strengthening European digital sovereignty in comprehensively sustainable production. The project and its well-balanced consortium with 53 ambitious academic and industry partners intends to boost the economy by adopting, extending and implementing AI-enabled hardware and software components and systems across the whole industrial value chain.

New technologies from IoT and based on Semantic Web ontologies, enhanced Digital Twin, ML (Machine Learning) and AI (Artificial Intelligence) will help European manufacturers to shift from Industry4.0 to Industry5.0, creating human-centric workplace conditions and a climate-friendly production. Above all, sustainability and resilience will be improved.

We will see AI enabled fabs way more productive and eco-efficient. This will go hand in hand with shorter supply chains, a better resilience, a higher sustainability and global competitiveness keeping the main production in Europe.

AIMS5.0 a collaborative Innovation Action aims at strengthening European digital sovereignty in comprehensively sustainable production, by adopting, extending and implementing AI-enabled hardware and software components and systems across the whole industrial value chain to further increase the overall efficiency.

Vulnerability of existing supply chains in crisis shows the need for shorter supply chains and for keeping production in Europe. AI enabled fabs will be given more output and higher sustainability, which makes them more competitive on a global scale.

20 use cases in 9 industrial domains will validate the project's findings in an interdisciplinary manner. A professional dissemination, communication, exploitation and standardization will ensure the highest impact possible.

Fields of Science (EU Cordis assignment): Internet of things, AI, semantic web, ontology

Starting and (target) end time of project:

01/05/2023 – 30/04/2026

IoT and/or Edge Computing research challenges:

A selection of challenges to meet (focus on IoT, Digital Twin, Edge, Edge-AI; of course, there are other challenges too):

- AI-Ready Edge Hardware ("AI at the Edge"): creation of necessary components to run the edge parts of the AIMS5.0 systems.
- Efficient system integration and communication: co-design of the edge and cloud parts of use-case demonstrators.
- Test and Validation environment (Digital Twin): a powerful test and validation environment to assess a planned system environment before performing costly installation procedures.
- Micro-service-based edge System of Systems (SoS) architectures and implementation platform **extended** for efficient integration of AI algorithms and AI hardware. Challenges addressed are related to system of systems (SoS) composability and associated tools and management support enabling efficient **integration and deployment at the edge.**

- Implementing Internet of Everything (a network of connections between people, things, data, and processes that provide general intelligence and improved cognition across the networked environment, for Industry 5.0, across domains and applications)
- Trustworthiness of IoT, Digital Twin and AI systems

Expected activities on "Dissemination and Impact on Standards":

Dissemination, exploitation and standardization are combined in a dedicated work package to increase/demonstrate the impact of AIMS5.0. It includes also the societal, ethical and environmental aspects ("Green Deal", Resilience, Sustainability). Main tasks and standardization activities are:

- Raise awareness of existing and evolving standards in the addressed areas of interest (including IoT, Edge/cloud computing, connectivity, AI at the edge, Safety, Cybersecurity, Trustworthiness, and others) and their application, including ethical and societal aspects.
- Collaborate with/participate in/join relevant standardization groups in ISO, IEC, ETSI, and ISO/IEC JTC1 SC41 (IoT and Digital Twin), SC 38 (Cloud computing and distributed platforms) and SC42 (AI) and related automotive standardization groups in ISO TC22 SC32 (road vehicles, e.g., automated driving systems, connected vehicles end-to-end safety), ISO TC22 SC31 (Extended Vehicles) and particularly Smart manufacturing standards (IEC TC65 WG 23, WG 24 and JWG 21, ISO TC184 (Industrial automation), ISO TC299 (Robotics) and IEC TC56 (Dependability)(not exhaustive). The goal is to be pre-informed on evolving standards (to become "early adopters", facilitate futureproof development) as well as transferring experiences and results from AIMS5.0 (development, use cases) to standardization. Key issues are:
  - Trustworthiness of IoT, Digital twin and AI systems
  - Safety, security, performance and dependability of components and systems (of systems).
  - Acceptance, trust & ethics for explainable industrial AI leading to human-centred sustainable manufacturing.
- Dissemination of the results among stakeholders, including standardization committees and authorities, and the industrial and scientific communities on fares, exhibitions and conferences.
- Align stakeholders and relevant groups in the semiconductor industry, industrial production, logistics, supply chain management, the automotive, aviation, machinery and other industries (e.g., food production, exo-skeleton robots to enhance human capabilities, luminaire manufacturing, consumer electronics) to support the Green-Deal initiative, initiatives towards sustainable industry 5.0, Sustainable Development Goals and a resilient society and economy.
- Collaboration between related projects particularly in the standardization area, achieve and show synergies (e.g., done in this context at the EEAI-Conference and other occasions for the cluster AI4CSM, AIMS5.0, (Edge-)A-IQ Ready and PowerizeD, all KDT/Chips JU projects of the EU Horizon Europe Programme).

Acknowledgement:

The project has been accepted for funding within the Key Digital Technologies Joint Undertaking (Chips JU), a public-private partnership in collaboration with the HORIZON Europe Framework Programme and the national Authorities from 12 involved countries under grant agreement number 101112089.

1.2.7 DS2: Data Space, Data Share 2.0

URL/Reference:

www.dataspace2.eu

Abstract:

DS2 brings together experts from various fields across Europe to ensure smooth and secure data sharing, aggregation and tracking, while respecting data owners' rights and adhering to European data regulations. Our modular software infrastructure connects different data sources, facilitating efficient cross-sector data sharing with ease.

Using the Intersector Data Space Toolkit (IDT), DS2 enables seamless communication between data sources. The IDT Toolkit consists of a Broker for fail-safe network operation and various modules for executing complex data lifecycles, including filtering and labelling, with options for both automated and human-in-the-loop processes.

In the context of AIOTI DS2 will accommodate far-edge-to-cloud, supporting the collection, processing, and the analysis of data from edged devices (IoT nodes) and their integration with cloud-based data processing and analysis systems. This concept is further enhanced through the use of data curation and data transformation technologies that reduce human intervention to a minimum. AI and Machine Learning tools will be developed to monitor data quality, that help to improve the efficiency and accuracy of data, enable data healing, and provide edge classification of data.

The project will be co-created and trialled via 3 use cases – City Scape, Green Deal, and Precision Agriculture – to demonstrate its effectiveness across sectors.

Starting and (target) end time of project:

01/01/2024 – 31/12/2026

IoT and/or Edge Computing research challenges:

IoT and Edge Computing research challenges encountered in DS2 include:

- The lack of IoT infrastructure and IoT sensors in some pilot locations,
- Diverse IoT devices and their capabilities,
- Developing an interconnected framework that allows smart devices, edge computing units, and cloud platforms to work together effortlessly
- Reducing the resources needed for services that operate throughout the IoT and edge,
- Ensuring privacy and security of data,
- Ensuring control over data.

Expected activities on "Dissemination and Impact on Standards":

- In terms of standardization activities, DS2 will interact with different standardisation bodies & policy makers such as ISO, IEEE, ETSI, DIN, CEN CENELEC, IEC, W3C, DIN, DKE.
- DS2 hopes to provide standardisation input to e.g. IEEE, ETSI, DIN, CEN CENELEC, etc. for various topics including 1 potential CEN CWA (CEN Workshop Agreement).
- Furthermore, DS2 will transfer its know-how to EC communities & networks (BDVA, IDSA, GAIA-X, FIWARE, AIoTI) outreached during the project and will investigate open-source solutions with other projects such AI4EU.

1.2.8 ODEON – federated data and intelligence Orchestration & sharing for the Digital Energy transitiON

URL/Reference:

https://odeonproject.eu/

https://cordis.europa.eu/project/id/101136128

Abstract:

Even if significant progress has been made towards the Twin Transition, the recent energy crisis revealed the EU energy system's vulnerability and dependence on external energy sources and highlighted the need for intensifying the integration of RES in electricity, transport and building (heating) sectors. To achieve on this, the energy system shall transform from a centralised/fossil-fuel-based to an energy efficient, RES-based and interdependent system, operating with a high degree of flexibility offered by distributed assets. ODEON is conceived under the principle that this can only be realized through the creation of an inclusive ecosystem of stakeholders characterized a mesh of Data, Intelligence, Service and Market flows, jointly enabling the resilient operation of the energy system under increased RES integration and distributed flexibility.

ODEON introduces a sound, reliable, scalable and openly accessible federated technological framework (i.e. ODEON Cloud-Edge Data and Intelligence Service Platform and corresponding Federated Energy Data Spaces. AI Containers, Smart Data/AIOps orchestrators) for the delivery of a wealth of services addressing the complete life-cycle of Data/AIOps and their smart spawn in federated environments and infrastructures across the continuum. It will integrate highly reliable and secure federated data management, processing, sharing and intelligence services, enabling the energy value chain actors and 3rd parties to engage in data/intelligence sharing, towards the delivery of innovative data-driven and intelligence-powered energy services in accordance to the objectives set by the Digitalisation of Energy Action Plan. ODEON results will be extensively validated in 5 large-scale demonstration sites in Greece, Spain, France, Denmark and Ireland involving all required value chain actors, diverse assets, heterogeneous grid and market contexts, and multi-variate climatic and socio-economic characteristics to support its successful replication and market uptake.

Starting and (target) end time of project:

01/01/2024 – 31/12/2027

IoT and/or Edge Computing research challenges:

- Federated Energy Data Spaces
- AI-enabled orchestration mechanisms to control both cloud computing resources and edge/IoT devices supporting automated deployments and dynamic offload of DataOps and AIOps.
- Development of standards-based open IoT Gateway to streamline IoT devices installed at the edge nodes.

Expected activities on "Dissemination and Impact on Standards":

- Project Liaison to CEN-CENELEC/ETSI
- DAIRO WG on Energy Data/Spaces (contributions and enhancements proposal to standards in terms of notation, data model, service type). The timescales are to be defined.
- BRIDGE Data Management WG (contributions and enhancements proposal to standards in terms of notation, data model, service type). The timescales are to be defined.
- GAIA-X Energy Working Group (contributions and enhancements proposal to standards in terms of notation, data model, service type). The timescales are to be defined.

ODEON intends to participate in the Energy related working groups of the before mentioned initiatives. Its participation will depend on the different action plan defined of the initiatives.

The timescale to these interactions goes from the beginning of the project (January 2024) to the end of the project (December 2027). These interactions will be aligned to the different plan's actions.

1.2.9 P2CODE - Programming Platform for Intelligent Collaborative Deployments

URL/Reference:

https://p2code-project.eu/

Abstract:

The P2CODE project aims at innovating and creating a wide-open, secure and trusted IoT-to-edge- to-cloud compute continuum that will realize the true potentials of edge intelligence.

To this aim, the P2CODE 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. The platform will do so by implementing innovative design approaches and will constitute a fully-integrated infrastructure under the cloud–managed P2CODE architecture.

P2CODE will contribute to the wider scope of reinforcing Europe's position in the market of next generation smart systems (sensors and devices) integrated in an evolving Internet of Things and cyber-physical ecosystems with strong capacities at the edge.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

Utilities inspection - The objective of Application Area 2 is to create of a prototype digital HV substation.

Technologies/assets involved: High-frequency IoT & industrial sensors, legacy metering equipment, cameras, applications for analytics, predictive maintenance, intruder detection, smart time-scheduling of field works, blockchain, cloud support, programmability features and registration.

P2CODE aims to showcase how to provide advanced industrial services on top of critical infrastructure through a super-slice among core & edge services.

Collection of industrial data from both legacy and new IoT sensing devices

P2CODE Use Case | SMART worker assistant

The objective is to achieve effective management and improving adaptive human-machine interaction in smart factories while boosting healthy operators.

- Deployment of multiple IoT nodes serving as sensor gateways with enhanced on board processing
- Registration of operator status data (biometric, fatigue, cognitive stress)
- Multiple optimized applications over common IoT-edge
- Demonstrate real-time actions through collaborative edge-IoT nodes
- Demonstrate advanced monitoring capabilities

Expected activities on "Dissemination and Impact on Standards":

FIWARE actively collaborates on the P2CODE project, leveraging its open-source platform to maximize its impact. The Foundation's specialization in Context Information Management significantly contributes to the P2CODE platform, which focuses on secure, interoperable data exchanges and the development of a continuum from IoT to edge to cloud computing.

A cornerstone of our contribution is implementing the NGSI-LD API standard by the ETSI ISG CIM group. This standard allows for the provision, consumption, and subscription of context information in diverse scenarios involving multiple stakeholders. Context information is modelled as "digital twins" attributes that represent real-world entities, enhancing real-time data interactions and decision-making processes.

FIWARE's Data Models are not just crucial, they are transformative, ensuring interoperability across various systems and industries, and offering a unified framework for data representation and exchange. Our Smart Data Models program is not just setting a universal standard for data interoperability, it is paving the way for a future where data can be seamlessly shared and utilized across different sectors.

This project not only furthers our technical expertise but also fosters collaboration with partners, contributing to the evolution of the ETSI ISG CIM standards and expanding our influence in the context broker federation context.

1.2.10 OASEES - Open Autonomous programmable cloud appS & smart EdgE Sensors

URL/Reference:

https://oasees-project.eu/

Abstract:

The IoT, connected smart devices interacting with each other and people and collecting all kinds of data, is exploding. The massive amount of data created is processed centrally at the cloud, which helps scalability by providing on-demand access to computing resources. Centralised processing and cloud hosting bring data governance and identity management issues to the user. Similarly, existing edge device authentication solutions require a centralised entity to authenticate data. The EU-funded OASEES project aims to create an open, decentralised, intelligent, programmable edge framework for swarm architectures and applications. The framework will leverage the decentralised autonomous organisation paradigm and integrate human-in-the-loop processes for efficient decision-making.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

Use case **e-Health**

The outcome of this pilot will be an intelligent edge device capable of sensing, recording and analysing patients' utterances, as well as providing smart, adaptive and personalised guidance on rhythm and intonation. The system will usable both in rehabilitation centres during sessions with therapists and at home. We will adopt a privacy-by-design approach when collecting and treating patients' acoustic data.

Energy

The real-field pilot will demonstrate the capability of deploying and coordinating in a scalable yet near the real-time way the operation and management of swarms of IoT-based devices (e-vehicles), which will be coordinated and programmed through the OASEES SDK and orchestration platform.

Wind Energy

Blockchain can be used in the distribution and operation of IoT networks as a target for DAO paradigms, providing a backend for distributed data structures to securely store transactions in a decentralized manner. Smart metering is a key enabler for integrating smart energy renewable systems to existing infrastructure. In the OASEES project, novel IoT-based meters will be implemented to support on-the-fly programmability, using IoT sound transducer (microphones) applied to wind turbines

Expected activities on "Dissemination and Impact on Standards":

OASEES followed the process to become a project candidate for HSBooster service.: HSBooster service to OASEES The OASEES partners previous experience with standards:

- The participation on behalf of OTE and MonB5G EU project in ETSI ZSM PoC 7 "Zero-touch closedcontrol security management of attacks detection and mitigation" - Demonstration of closed loop automation for mitigating against DDoS attacks from MTC (Machine Type Communication) devices on 5G Core Network (CN) components.
- Project Partner - NCSR Demokritos - member of the ISG MEC.
- CTN-UNE 71/SC 14 "Tecnologías Cuánticas"
- CEN/CLC/JTC 22- Quantum Technologies
- ISO/IEC JTC1/WG 14 OASEES Priority Topics for Standardization:

Recommendation to consider the European standards organization, as CEN (the European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization and ETSI, the European Telecommunications Standards Institute), rather than ISO (International Organization for Standardization) o Selected relevant standards: o CEN-CLC/JTC 21 - Artificial Intelligence o CEN/CLC/JTC 22 – Quantum Technologies o CEN-CLC/BTWG 6 – ICT standardization policy Intermediate, Final OASEES Version 1.0 Date 26/04/24 Page | 12 o CTN-UNE 71/SC 14 "Tecnologías cuánticas" o ISO/IEC JTC1/WG 14. o First identification by OASEES related to potential contribution to Standardization: o Quantum Computing (Tecnalia and Fraunhofer from Munich) o Cloud Accelerators / Orchestration – AI o DAO – Digital Autonomous Organization – many areas within this, the main one. HSBooster Expert

Recommendation for OASEES Regarding Potential Contribution to Standardisation In consideration of OASEES's potential contribution to standardisation, it is recommended to focus efforts on engagement with the following: ETSI ISG Working Groups (WGs):

- Topic 3: Edge Infrastructure Sharing and Monetisation. It is advised to convene a Proof of Concept (PoC) team consisting of representatives from NCSRD, IMEC, OTE, and other interested/relevant members of the consortium.
- This team should collaborate to draft and submit a proposal to the ETSI MEC ISG as an initial step towards contributing to standards development. OASEES Consortium members will monitor and/or contribute to the standardisation bodies that align most closely with its interests, while ensuring that the OASEES framework remains consistent with the standards.

The following is a description of the standardisation organisations that are relevant to the project. Proposed Standardisation Developing Organisations:

- 3GPP The 3rd Generation Partnership Project (3GPP) brings together seven telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC) and provides a stable environment for its members to produce the Technical Reports and Specifications that define 3GPP technologies. 3GPP includes three Technical Specification Groups (TSG), namely: Core Network & Terminals (CT), Services & Systems Aspects (SA), and Radio Access Networks (RAN). Including radio access, core network, and service capabilities, the project provides a comprehensive system description for mobile telecommunications cellular technologies. 3GPP TSG Service and System Aspects (SA) is responsible for the overall architecture and service capabilities of systems based on 3GPP specifications.

1.2.11 OpenSwarm - Orchestration and Programming ENergy-aware and collaborative Swarms With AI-powered Reliable Methods

URL/Reference:

https://openswarm.eu/

Abstract:

Low-power wireless technology tends to be used today for simple monitoring applications, in which raw sensor data is reported periodically to a server for analysis. The ambition of the Horizon Europe OpenSwarm project is to trigger the next revolution in these data-driven systems by developing true collaborative and distributed smart nodes, through groundbreaking R&I in three technological pillars:

- Efficient networking and management of smart nodes
- Collaborative energy-aware Artificial Intelligence (AI)
- Energy-aware swarm programming.

The EU-funded OpenSwarm project aims to take the technology further by developing collaborative and distributed smart nodes. To do so, it will explore efficient networking and management of smart nodes, collaborative energy-aware AI and energy-aware swarm programming. The energy-aware, collaborative swarms will be demonstrated in labs equipped with two 1 000-node test beds. They will then be validated in five real-world use cases in application domains such as industrial, health, environmental and mobility.

Starting and (target) end time of project:

01/01/2023 – 30/04/2026

IoT and/or Edge Computing research challenges:

OpenSwarm is a project dealing exclusively with the internet of things (IoT). OpenSwarm will be developing the technological components to pave the way for future innovations within the IoT. Particular emphasis will be placed on smart sensors, which have the capacity to interact within dynamic, connected networks. The technology is set to revolutionise robotics and OpenSwarm will demonstrate its potential on a range of use cases, with a particular focus on swarm robotics, which involves large numbers of coordinated robot units working together on complex tasks.

OpenSwarm will begin by developing new algorithms with the capacity to reduce the time taken to transfer information between sensors within dynamic networks, aiming for near-real-time.

OpenSwarm will then harness the potential of recent innovations in embedded systems, centred around artificial intelligence for the IoT, giving them significantly higher processing capacities. Lastly, we will develop a specific compiler for programming swarms. This is something that doesn't currently exist.

OpenSwarm is seeking to develop generic solutions that can be configured and adapted for a wide range of uses, the aim being to demonstrate the robustness and effectiveness of their innovations in four sectors: the environment, occupational health and safety, mobility and smart cities.

Expected activities on "Dissemination and Impact on Standards":

A comprehensive dissemination, exploitation, and communication plan (including a diverse range of activities related to standardization, educational and outreach, open science, and startup formations) amplifies the expected impacts of OpenSwarm, achieving a step change enabling novel, future energy-aware swarms of collaborative smart nodes with wide range benefits for the environment, industries, and society.

1.2.12 TaRDIS - Trustworthy and Resilient Decentralised Intelligence for Edge Systems

URL/Reference:

https://www.project-tardis.eu/about-tardis/

Abstract:

Developing and managing distributed systems is a complex task requiring expertise across multiple domains. This complexity considerably increases in swarm systems, which are highly dynamic and heterogeneous and require decentralised solutions that adapt to highly dynamic system conditions. The project 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.

TaRDIS proposes a language-independent event-driven programming paradigm that exposes, through an event-based interface, distribution abstractions and powerful decentralised machine learning primitives. The programming environment will assist in building correct systems by taking advantage of behavioural types to automatically analyse the component's interactions to ensure correctness-by-design of their applications, taking into account application invariants and the properties of the target execution environment. TaRDIS underlying distributed middleware will provide essential services, including data management and decentralised machine learning components. The middleware will hide the heterogeneity and address the dynamicity of the distributed execution environment by orchestrating and adapting the execution of different application components across devices in an autonomic and intelligent way. TaRDIS results will be integrated in a development environment, and also as standalone tools, both of which can be used for developing applications for swarm systems.

The project results will be validated in the context of four different use cases provided by high impact industrial partners that range from swarms of satellites, decentralised dynamic marketplaces, decentralised machine learning solutions for personal-assistant applications, and the distributed control process of a smart factory.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

- unforeseen load on the grid due to rising number of Electric Vehicles (EV**)** is a huge concern for Electric Distribution System Operators (DSOs) across Europe since they represent an unforeseen load on the grid. Grid reinforcement becomes risky as investment needs to be placed where demand naturally grows. To solve this charging problem, TaRDIS proposes multi-level smart charging, divided into three core layers: the Edge (HEMS, EV chargers); the Fog (end-users community or building level aggregator); and the Cloud (centralised controlling systems, SCADA).
- Programming abstractions for the cloud–edge continuum
  - The toolbox by defining a high-level approach towards formulating and implementing the behaviour of intelligent, heterogeneous swarm systems; it then continues to provide a set of tools that aid in applying this approach.

Expected activities on "Dissemination and Impact on Standards":

The diverse target groups TaRDIS plans to address, which have a very different level of knowledge and expectations with respect to data-centric research, require the definition and use of tailored mechanisms and tools able to properly convey the right message for each TaRDIS.

Open-source communities and standardisation bodies: Open-source communities, such as CNFC, the Linux Foundation, and Apache (Arrow, Parquet, Ranger, Atlas, Egeria). Standards Developing Organizations (SDOs), such as ETSI, 3GPP, IRTF, etc.

1.2.13 A-IQ Ready: Artificial Intelligence using Quantum measured Information for real-time distributed systems at the edge

URL/Reference:

https://www.aiqready.eu

https://cordis.europa.eu/project/id/101096658

Abstract (IoT project):

The onset of climate change and widespread geopolitical conflicts and social inequalities showcase the need for innovation and change that require a better world.

Global environmental issues, social inequality and geopolitical changes will pose numerous problems for our society in the future. To face these new challenges and deal with them, there is a need to understand and appropriately utilize new digital technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), robotics and biotechnologies.

The EU-funded project A-IQ Ready proposes cutting-edge quantum sensing, edge continuum orchestration of AI and distributed collaborative intelligence technologies to implement the vision of intelligent and autonomous Electronic and Software-Based Systems for the digital age. Intelligent quantum sensing will improve timing and accuracy of autonomous agents and reduce false alarms or misinformation by means of AI and multi-agent system concepts. Edge continuum orchestration by AI will allow decentralizing the development of applications, while ensuring an optimal use of the available resources. The edge continuum will be equipped with innovative, multi-physical capabilities to sense the environment, distributed intelligence will enable emergent behaviour and massive collaboration of multiple agents towards a common goal. By exploring the synergies of these cutting-edge technologies through civil safety and security, digital health, smart logistics for supply chains and propulsion use cases, A-IQ Ready will provide revolutionary means for most services and industries. These technologies and their combination will propel the transition to a Europe of Society 5.0.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

A-IQ Ready will utilize crucial and disruptive technologies in combination to revolutionize most services and industries by its foundational contributions. These are Edge continuum orchestration for AI systems with AI, distributed collaborative intelligence (IoT) and quantum sensing. The work is following 5 objectives:

- Increase sensing accuracy, reliability and trustworthiness in complex environments with new multi-physics (quantum) sensors.
- Provide AI methods for multi-agent autonomy in uncertain environments.
- Provide a reference open AI Edge Continuum platform integrating quantum sensors, neuromorphic (cognitive) computing and AI algorithms at the edge.
- Demonstrate the approach to build the digital society.
- Increase Europe's competitivity in developing a safe, resilient, and prosperous digital society.

Innovations to be evolving are structured into eight groups building clusters of disruptive solutions:

- Safe co-existence of automated and manual transport at industrial sites
- Search & Rescue (SAR) and emergency response for civil safety.
- Digital Health and emergency recognition (for driver and operator)
- Propulsion Health and availability in safety critical systems
- Quantum Sensor for multi-modal, multi-physical sensing at highest precision
- Hybrid Computing (Quantum Computing & High-Performance Computing)
- Cooperative Multi-Agent Systems (Decentralized AI for Emergent Industrial Solutions)

- AI, Architectures, Tools and Methodologies (for open source and cross-domain fertilization)

Expected activities on "Dissemination and Impact on Standards":

Standardization is forming a key activity in A-IQ Ready. It covers activities in the technical area as well as the important aspects of ethical design, societal/human centred aspects of the technologies and intended solutions, and also the environmental impact. Each of the work packages following the indicated objectives and the solution clusters will on the one hand be supported by the standardization task and on the other hand motivated to provide input to standardization groups by transferring experiences and results from development and demonstrators.

A-IQ Ready strives to support the EU Policies towards a sustainable, human centric and resilient European Society 5.0, with the goal to achieve wider societal goals beyond jobs and growth, thus supporting the vision as expressed by Ursula von der Leyen in her initial speech on a human centred, sustainable, resilient society and economy, and the Green Deal.

Partners are active in numerous standardization groups of ISO/IEC JTC1 SC41 (IoT and Digital twin), SC42 (AI), SC38 (Cloud computing, Distributed platforms and their application), JTC3 (Quantum technologies, recently founded), but also CEN/CENELEC JTC21 (AI, working for the EC AI Standardization Requests according to the AI-Act), and in many domain-specific AI and IoT standardization groups (ISO TC22 SC32 WG13, Automated Driving Systems; WG 14 Safety and AI Systems; IEC TC62, SC62D Health and REHA Robotics, including AI in medical devices; IEC TC 65 SC65A JWG21 with JTC1 SC42 JWG4 on "Functional safety and AI systems", IEC TC65 WG 23, 24 and JWG21 on Smart manufacturing and Asset Administration Shell, etc.). Impact is expected in both directions: Information flow from evolving standards to project work, and vice versa.

Acknowledgement: The project has been accepted for funding within the Chips JU Programme, a public-private partnership in collaboration with the HORIZON Europe Framework Programme and the national Authorities from 15 involved countries under grant agreement number 101096658.

1.2.14 INSTAR: Shaping international standards for advanced technologies

URL/Reference:

https://www.instarstandards.org/

https://cordis.europa.eu/project/id/101135877/

Abstract (IoT project):

INSTAR is an EU-funded project that aims to support the implementation of Europe's Digital Partnerships and the EU-US TTC by working together with Australia, Canada, Japan, Singapore, South Korea, Taiwan and the USA to drive international common standards for AI, Cybersecurity, Digital ID, Quantum, IoT, 5G, 6G and data technologies. Following the EU Standardisation strategy of February 2022 that "*Europe needs to bring the European angle of standardization at international level, rather than create EU-specific standards.*" (Commissioner Thierry Breton), **INSTAR** helps achieve this by

- **promoting EU's thought leadership for a common ICT standardization vision with strategic international partners** on key advanced technologies,
- shaping the **definition & uptake** of standards in relevant target entities,
- **delivering studies & analyses** on ICT standards,
- **monitoring international standards** in trade & cooperation agreements

INSTAR works with Task Forces built up by a number of European experts in the following areas of advanced technologies to be addressed:

- TF1 – AI: Secure, trustworthy and ethical development and use of AI systems (ML algorithms, neural networks, analytics, autonomous systems), AI Act, ETSI's Operational Coordination Group on AI (OCG AI), CEN/CENELEC, ISO/IEC, and others.
- TF2 – Cybersec-eID: Cybersecurity & electronic identification in industries like healthcare, manufacturing, financial services, energy, automotive European Cyber Resilience Act (CRA).
- TF3 – Data: Data quality, syntactic, semantic and pragmatic characteristics of data (ISO 8000-1), Standards impact on policy & regulation, investment & innovation, cross-industry scenarios.
- TF4 – IoT Edge: Cloud, Edge (near vs. far edge), IoT in smart manufacturing, precision agriculture, mobility, energy grids, smart cities, healthcare etc.
- TF5 – 5G+: Convergence of communications, sensing, sustainable services & AI, Human-centric, cognitive network of networks system.
- TF6 – Quantum: Quantum computing, communication, sensing and cryptography, as well as post-quantum cryptography techniques, Specific focus on technologies that can be integrated into European infrastructure and interoperability aspects.

Key activities include setting up Roadmaps for each area, pointing at priority areas for standardization from the European point of view (ETF – European task Forces of experts) and then aligning with the international partners (ITF – International Task Force) in a collaborative communication process.

Starting and (target) end time of project:

01/01/2024 – 30/06/2026

IoT and/or Edge Computing research challenges:

A key research aspect is not only to set up Roadmaps, identify priorities on international level, and align this with the other dedicated relevant entities in Canada, USA, Japan, Taiwan, Singapore and Australia to form a strategic alliance to shape the international standardization strategies, but also to consider the many overlaps and joint challenges for systems and systems-of-systems raised by the interconnections between various areas of AI, IoT and Edge, cybersecurity, data spaces, communications and so on. The IoT/Edge priorities' Task Force Recommendations on Standardisation Priorities in Cloud, Edge, IoT domain:

Cloud/Edge:

- (IoT) Edge computing on Unmanned Aircraft Systems
- Edge devices and sensors, especially for medical use
- Architecture consideration for IoT, Edge, Cloud
- IoT/CEI reference architecture
- Interoperability of IoT and Edge devices and protocols
- Electrical energy efficient products
- Privacy and Security framework for consumer wireless devices

IoT:

- Guidance on IoT and digital twin integrations in data spaces
- Architecture consideration for IoT, Edge, Cloud
- IoT/CEI reference architecture
- Evaluation schemes for IoT
- Electrical energy efficient products
- Privacy and Security framework for consumer wireless devices

Challenges related to IoT/Edge/Cloud are also addressed in the AI and other roadmaps.

Expected activities on "Dissemination and Impact on Standards":

Since INSTAR particularly addresses the strategic and policy view on standardization, developing roadmaps and building international connections between European Union official entities and the selected international relevant entities mentioned above, there is long term influence on standardization expected. SDOs addressed are ISO, IEC, ISO/IEC JTC1, CEN/CENELEC, ETSI, IEEE, and corresponding partner organizations outside Europe. Dissemination includes webinars, international workshops, activities at conferences and 3rd-party events, and one impact event. The targeted priorities (specific flyers), the ETFs and the roadmaps will be presented and distributed, for comments as well as support for joint standardization activities. This will generate accessible materials like reports and papers and ultimately, a standard dashboard that can provide transparency and help the community and industry to keep up to date with the latest standards in the target technologies.

Acknowledgement: INSTAR is funded by the EC in the Horizon Europe Programme, International cooperation for digital standardization, under "Digital, Industry and Space"(Grant Agrement ID: 101135877).

1.2.15 Cooperative Real-Time Experiences with Extended reality (HORIZON-CL4-2021-HUMAN-01 "CORTEX2")

URL/Reference:

https://cordis.europa.eu/project/id/101070192

https://cortex2.eu/

Abstract:

Video conferencing and mixed reality are both forms of communication but based on very different technologies. Video conferencing does not provide an in-person feel to meetings and has several other drawbacks. In contrast, mixed reality has emerged as a technology that can provide a genuine feeling of presence, and better collaboration tools. The EU-funded CORTEX² project will bridge the divide between widespread video conferencing tools and innovative XR-based solutions to democratise the adoption of next-generation eXtended Reality tele-cooperation by industrial sectors and SMEs. The initiative will use and extend the widespread Rainbow teleconferencing solution from Alcatel Lucent Enterprise to allow for fully interactive XR-based cooperation. This will be demonstrated in three pilots: industrial production, business meetings, and remote training respectively.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

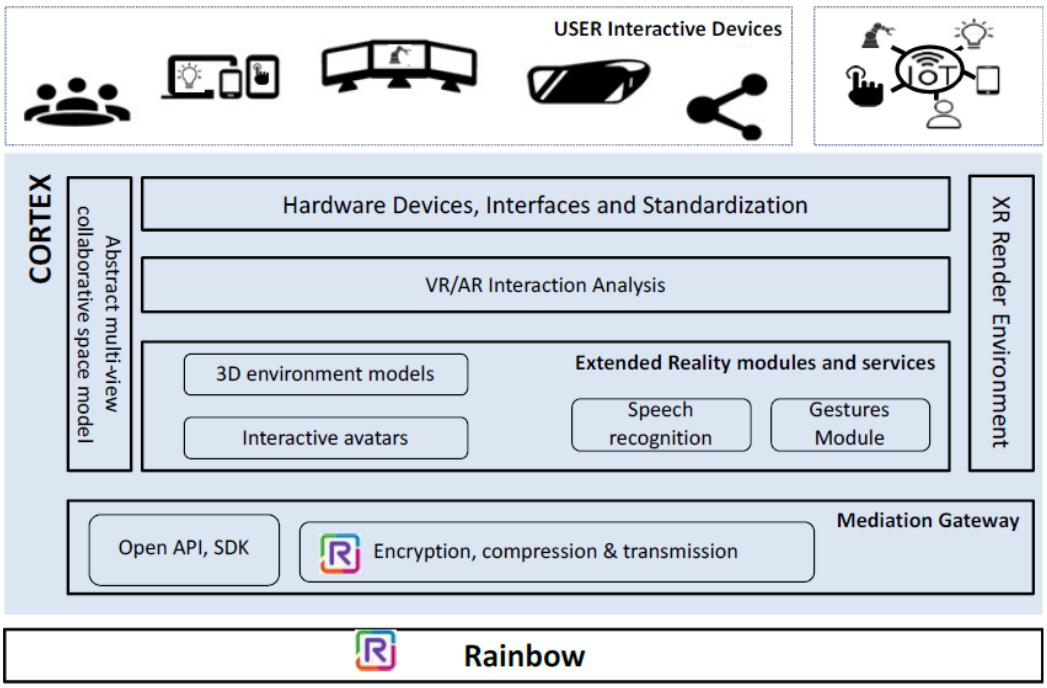
IoT and/or Edge Computing research challenges:

The mission of CORTEX² is to bridge the divide between widespread video-conferencing tools and state-of-the art XR-based solutions, democratising the uptake of next-generation eXtended Reality tele-cooperation among many industrial segments and SMEs. To this aim, our project will provide:

- Full support for AR experience as extension of videoconferencing systems when using heterogeneous services end devices through a novel Mediation Gateway platform.
- Resource-efficient teleconferencing tools through innovative transmission methods and automatic summarization of shared long documents
- User-friendly and powerful XR experiences with instant 3D reconstruction of environments and objects and simplified use of natural gestures in collaborative meetings
- Fusion of vision and audio for multi-channel semantic interpretation and enhanced tools such as dialoguing virtual conversational agents and automatic meeting summarization

- Full integration of IoT devices in XR experiences to optimize interaction with systems and processes.
- Optimal extension possibilities and wide uptake opportunity through the delivery of the core system with open APIs and the organisation of Open calls for extensions towards more technical modules and more use cases in various segments.

To ensure large adoption and fast scaling of our extended remote cooperation solution, we will use the widespread teleconferencing solution Rainbow from Alcatel Lucent Enterprise as a backbone for our innovative extended reality based tele-cooperation concept, which counts today more than 3 million users worldwide. CORTEX will extend Rainbow to allow for fully interactive XR-based cooperation and will be demonstrated in three pilots: industrial production, business meetings and remote training. Wide uptake will be guaranteed by funding of third-party projects to allow for more technical extensions, wider use-cases and deeper evaluation and assessment.



Expected activities on "Dissemination and Impact on Standards":

CORTEX² will set out a roadmap for contributing to different standardisation bodies. This activity will identify significant opportunities to push contributions into future standards, pre-normative activities and open collaborative development environments.

Standards body/forum	Planned CORTEX² contributions
WebRTC Janus	ALE contributes to code and conference of the Janus component. Janus is a core component of the overall solution as it performs the media routing and there may be dependency with the XR behaviours of augmented devices.
AIOTI	As a member of AIOTI and AIOTI WG Standardisation, ICOM will raise .awareness to the role of CORTEX2 in the integration of IoT information in XR applications
ETSI	ICOM is participant of the Experiential Networked Intelligence Industry Specification Group (ENI ISG) and will contribute in intent-based Edge Service Management for resource and energy efficiency considering a Proof of Concept (PoC) for XR services.

1.2.16 Next Generation Integrated Sensing and Analytical System for Monitoring and Assessing Radiofrequency Electromagnetic Field Exposure and Health (HORIZON-HLTH-2021-ENVHLTH-02 "NextGEM")

URL/Reference:

https://cordis.europa.eu/project/id/101057527

https://www.nextgem.eu/

Abstract:

Electromagnetic fields (EMFs) produced by man-made devices are all around us. Especially with the next generation of radiofrequency EMFs, further investigations regarding EMF and possible health risks are required. In this context, the EU-funded NextGEM project will generate relevant knowledge of EMF exposure in residential, public and occupational settings. The project will design a new framework for the generation of health-relevant scientific knowledge and data on new scenarios of exposure to EMF in multiple frequency bands. Its overall aim is to provide a healthy living and working environment, under safe EMF exposure conditions. The project will create the NextGEM Innovation and Knowledge Hub for EMF to provide a standardised way for European regulatory authorities to store and assess project outcomes.

Starting and (target) end time of project:

01/07/2022 – 30/06/2026

IoT and/or Edge Computing research challenges:

While emerging technologies that use radiofrequency electromagnetic fields (EMF, 100 kHz-300 GHz), particularly in telecommunications are vital for the European way of life, there is an increasing consideration of its possible adverse effects to human health and the environment, which may be potentially exacerbated by aggregation of different types of EMF signals. Some concerned citizen groups even perceive fifth generation (5G; 5G New Radio; 5G NR) of networking as a greater threat to public health compared to previous generation systems. The exposure standards issued by the International Commission for Non-Ionizing Radiation Protection (ICNIRP) and the International Committee on Electromagnetic Safety of the Institution of Electrical and Electronic Engineers (ICESIEEE), are set to prevent the occurrence of such effects. These guidelines are based on comprehensive reviews of the relevant scientific literature, providing exposure reference levels and basic restrictions for workers, and for the general population; the latter include an additional safety factor to account for vulnerable groups. Regarding occupational exposures, the European Union (EU) follows ICNIRP guidelines (directive 2013/35/EU). As for the public exposure, the EU published a Recommendation (1999/519/EC) for exposures to EMF (0 Hz to 300 GHz), with limits derived from ICNIRP 1998 guidelines. Due to non-binding nature of the recommendation, the related policies vary across European countries.

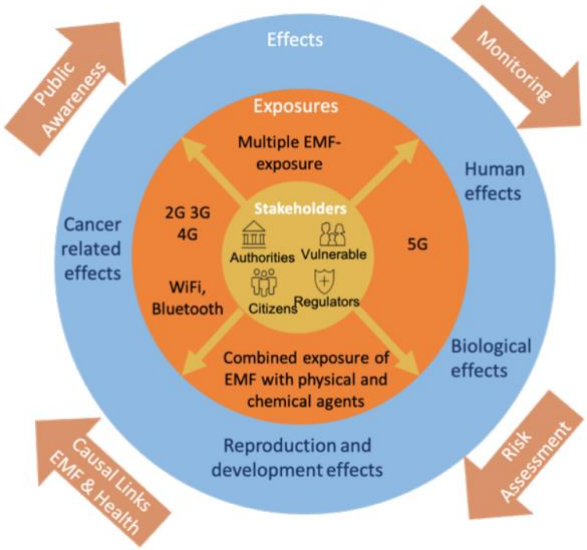
Considering all the above, adoption of new telecommunication technologies such as 5G requires extensive investigations regarding potential causal effects between EMF and health to address needs of:

- **Updated appraisal of the scientific evidence:** regarding possible links between EMF exposure level, duration. And health effects for (i) the public (ii) workers, and (iii) vulnerable groups to aid public authorities in the implementation of evidence-based policies, risk assessment and communication.
- **New quality criteria, standards, and methodologies:** (i) to assess EMF exposure and health effects and (ii) for biological investigations fulfilling the 3R standards.
- **Understanding interaction mechanisms:** between EMF and biological systems including combined exposures with other agents and with multiple signals.

Adequate scientific communication to improve awareness among authorities, employers and citizens, counteracting EMF misinformation. The NextGEM vision is to assure safety for EU citizens when employing existing and future EMF based telecommunication technologies.

This will be accomplished by generating relevant knowledge that ascertains appropriate prevention and control/actuation actions of EMF exposure in residential, public, and occupational settings.

Fulfilling the vision will provide a healthy living and working environment, under safe EMF exposure conditions, that can be trusted by people and be in line with the regulations and laws of the public authorities. For that, NextGEM will provide a framework for the generation of health-relevant scientific knowledge and data on new scenarios of exposure to EMF in multiple frequency bands and develop and validate tools for evidence-based risk assessment. NextGEM will also create the NextGEM Innovation and Knowledge Hub (NIKH) for EMF and Health offering a standardised way for European regulatory authorities and the scientific community to store and assess project outcomes and provide access to FAIR data. NextGEM is part of the European cluster on EMFs and health.



Expected activities on "Dissemination and Impact on Standards":

NextGEM's main scope is related to compliance and contribution to the development of quality criteria and standards (CEN/ISO), to updating of EU recommendations/directives and international guidelines (ICNIRP), to establish links with the WHO and other international and national organizations. Its KPIs shall be scrutinised against rationalized contributions and established links to international and national organizations, working groups and standardisation bodies (e.g. WHO, ICNIRP, ETSI, IEEE, ISO).

Conscious of the importance of producing high quality research leading to interpretable and conclusive results, NextGEM will implement quality assurance procedures during experimental work and publish them in peer review journals. These procedures will be defined within T1.4 and implemented within T8.4. The work will be carried out in collaboration with the DMP Task Force, as described in 1.2.10. SC being accredited 17025, ISO 15189 and ISO 17043, external auditors will check the organisational ISO 9001-like and ensure the quality at this level: for example, supplier evaluation and staff training. This will concern implementation of GLP-based SOPs for detailing laboratory experiments, study protocols for human studies and calibration of equipment. Moreover, selected conditions of in vitro studies will be replicated independently in another laboratory involved in the project (external verification).

Related to exposure assessment and modelling, Modelling of the environment with the aim of assessing realistic statistical exposure models (T3.1) and validation with in-situ measurements and personal exposure assessment through the development of dedicated sensors (T3.3) will be performed based on recognised methodologies for exposure assessment, in compliance with ICNIRP guidelines.

NextGEM will also contribute information that can be used as input for the standardisation processes in Technical Committees TC106X of CENELEC and IEC, especially for assessment (through measurement and/or calculation) of exposure as defined in ICNIRP 2020.

In addition, NextGEM will also contribute by generating new data and methodologies to be used for the critical review of literature on EMFs and health risk assessment through the involvement of CNR and ISS in international working groups such as WHO (The International EMF Project) and Swedish Radiation Safety Authority (Scientific Council on EMF).

1.2.17 Orchestrating an interoperable sovereign federated Multi-vector Energy data space built on open standards and ready for Gaia-X ("OMEGA-X")

URL/Reference:

https://cordis.europa.eu/project/id/101069287

https://omega-x.eu/

Abstract:

Large amounts of valuable data are available in energy systems but are often underused. For example, there is no single data platform connecting data from the generation, transmission, distribution and consumption domains in Europe's electricity sector or across the various energy vectors – electricity, gas, heat, etc. The barriers also imply the lack of proper mechanisms and policies that ensure secure, sovereign and fair data sharing. Relying on European common standards, the EU-funded OMEGA-X project aims to implement an energy data space. This includes federated infrastructure, data marketplace and service marketplace, involving data sharing between different stakeholders and demonstrating value for concrete energy use cases while guaranteeing scalability and interoperability with other data space initiatives.

Starting and (target) end time of project:

01/05/2022 – 30/04/2025

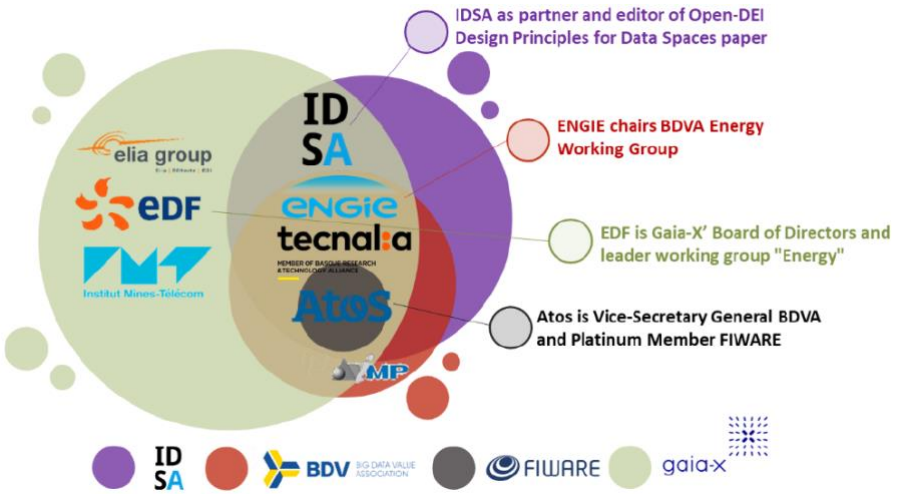
IoT and/or Edge Computing research challenges:

Orchestrating an interoperable sovereign federated Multi-vector Energy data space built on open standards and ready for Gaia-X. The aim of OMEGA-X is to implement a data space (based on European common standards), including federated infrastructure, data marketplace and service marketplace, involving data sharing between different stakeholders and demonstrating its value for real and concrete Energy use cases and needs, while guaranteeing scalability and interoperability with other data space initiatives, not just for energy but also cross-sector.

- The proposed concept and architecture heavily rely on the approaches adopted by IDSA, GAIA-X, FIWARE, BDVA/DAIRO and SGAM as major EU references regarding data spaces. It will pursue the GAIA-X label, which ensures highest standards on protection, security, transparency, openness and trust, avoids vendor lock-in and restricted to EU countries.
- Federated infrastructure for data ingestion. There are a lot of independent platforms for data ingestion/storage, open and private. The goal is to define the minimum interoperability and federation requirements needed for these platforms to adhere to the Energy Data Space and be able to share data in a trusted and secure way.
- Data Space Marketplaces. This is the common ground where data, which is already harmonized semantically, is indexed, and referenced, maintaining always the required standards of identity, trust and sovereignty. Using the data space as baseline, a marketplace is implemented for stakeholders to share, use and monetize data and services. Data/service providers will be able to advertise their data/services, and data/service users will be able to discover multiple data sets and services.
- Advanced Energy Use Case demonstration. Using all underneath layers, four (4) use case families (Renewables, LEC, Electromobility and Flexibiilty) will showcased o prove the value of having a common data space for a particular problem identified by energy stakeholders.

OMEGA-X will develop an Energy Data Space that enables multiple actors sharing data and services while ensuring privacy, security and sovereignty. This will specifically address the current problem of low availability of data for innovative uses in the energy sector and beyond. OMEGA-X will collaborate with stakeholders to identify where energy-based service improvements and innovation are required, and how OMEGA-X could potentially be used and adopted to address these needs:

- This will guarantee that companies and organizations can share their data safely. At the same time, it will help existing market actors (including SMEs and start-ups) to have access to a variety of datasets to improve their AI models, and thus be able to upgrade existing services and/or bring innovative services that otherwise could not be developed.
- The availability of data will empower new participants and market roles such as aggregators and local energy community managers. This will facilitate the large-scale penetration of renewables in the local grid without significant investments in grid infrastructure and will also create an opportunity for new business models to emerge.
- OMEGA-X will put a prominent focus on developing and promoting inclusive and collaborative behaviours, which will lead to a multitude of societal and economic benefits, such as, an increase in energy autonomy and a reduction in CO2 emissions.



Expected activities on "Dissemination and Impact on Standards":

The project will ensure that the interoperability of the Data Space can be replicable both inside and outside the project. Inside the project, use cases will be, to the possible extent, replicated in multiple pilot sites, ensuring the re-usability of solution under different environments, regulations and involving different actors. External interoperability is also considered as core objective of the project. This is achieved through the interoperable nature of the solution proposed, using IDSA and Gaia-X as reference, but also working with Open-Source developments, open standards, standard interfaces, APIs and semantic ontologies (SAREF, IEC CIM, IEC 61850...) for collaboration. Tasks dedicated to defining, implement and validate a common use case with the other projects is where OMEGA-X will prove interoperability amongst the different developed data spaces creating a single European Energy Data Space. Interoperability with other existing EU funded projects will be proven also through BRIDGE.

The Data Space is set to have vertical interoperability, that is, offering open definition of protocols and standards to be used for external data ingestion platforms to become federated nodes.

The Data Space is set to have horizontal interoperability, that is, providing standardized protocols and APIs to collaborate with similar Data Spaces at EU level, including those coming from sister projects. This also includes the usage of Information Models based on standards such as IEC CIM, IEC 61850 and IEC COSEM, among others.

The Data Space will be developed using Open Source and standardized protocols and APIs, to maximize the interoperability both inside and outside the Data Space.

1.2.18 Interoperable solutions to streamline PED evolution and cross-sectoral integration (HORIZON-CL5-2023-D4-01 "PEDvolution")

URL/Reference:

https://cordis.europa.eu/project/id/101138472

https://pedvolution.eu/

Abstract:

In urban energy transitions, positive energy districts (PEDs) are constantly evolving due to environmental changes. This presents a significant challenge as PEDs must adapt to evolving social contexts, legislation, energy markets, technologies and energy prices, among others. Despite PEDs' potential, their effectiveness is hindered by this ever-changing landscape. In this context, the EU-funded PEDvolution project will integrate PEDs with social, technological, interoperability and market factors. Through seven interoperable solutions, including planning tools and social innovation strategies, PEDvolution aims to enhance PED readiness and adaptability. Real-life PEDs across Europe will serve as testing grounds, fostering replication and mainstreaming.

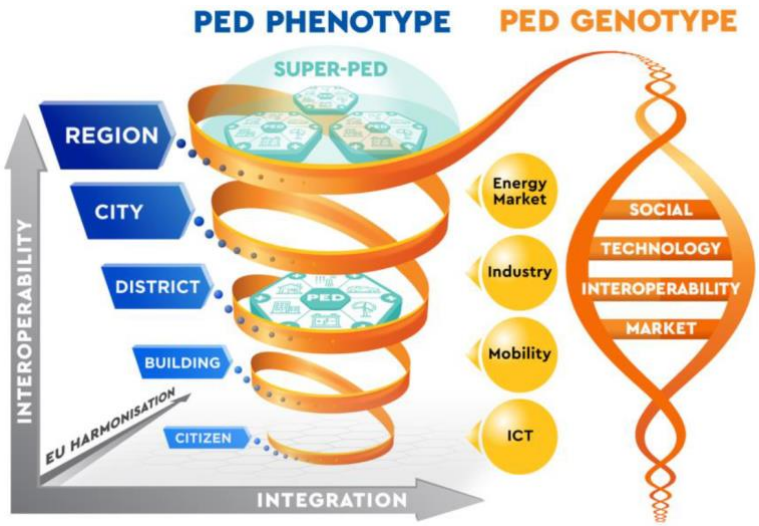
Starting and (target) end time of project:

01/01/2024 – 31/12/2026

IoT and/or Edge Computing research challenges:

The pinnacle of community driven urban energy transition is Positive Energy Districts (PED). They improve energy efficiency, integrate local renewables and excess heat more effectively and enable interaction with the energy and non-energy sectors like mobility, ICT and industry. A crucial, and often neglected complication is that PEDs are in constant evolution. This is due to ever-evolving changes in their environment: social context, legislation, energy market, increased electric vehicles, etc. As such, there is a strong analogy with the theory of evolution. Although the DNA between PEDs varies, the implementation and evolution of different PEDs is not a process of chance: the environment determines the probability of success in the urban energy transition.

The PEDvolution project paves the way for cross-sectoral integration of ever-evolving PEDs. This over a duration of three years, consisting of three consecutive phases: analyse, co-develop and demonstrate. European pioneers in PED conceptualisation, implementation and tool development will co-develop and implement seven interoperable solutions accommodating the constant evolution of PEDs: 1) PED Design and Planning Toolset, 2) PED Readiness Assessment, 3) Dynamic Decision Support Guideline for PED Development, 4) PED Energy Manager, 5) Data Exchange, Integration and Interoperability Platform, 6) PED Business Models, 7) Social Innovation tool.



These PEDvolution solutions will evaluate and improve the 'PED Readiness Level' according to the four genes of the PED genotype: social, technology, interoperability, and market. These are influenced by their interaction within the PED and its environment (PED phenotype).

Expected activities on "Dissemination and Impact on Standards":

BRIDGE will aim to overcome regulatory barriers can be highly country dependent if the right legislative frameworks are not developed at EU level. Harmonisation of requirements in the electricity markets is key for the development of robust business models. To achieve this aim, the project will provide recommendations on the regulatory barriers and potential risks of existing legislation in the commercial implementation of the PEDvolution EU-wide. We will share findings with the policy-making community at EU level, including BRIDGE, energy communities and PEDs networks, TSO and DSO associations and European Commission. Project partners are largely involved in multiple EU and international initiatives, including the three Green Deal Area 4.1 sister projects, BRIDGE, AIOTI, IEA Annex 83, JPI Urban Europe, PED-EU-NET (COST), as well as with interoperability and standardization initiatives and national/international bodies (InterConnect, FlexCommunity.eu). Early networking activities of PEDvolution will serve to take advantage from other running initiatives' results, regarding exploitation and replication potential.

Liaison with these initiatives will play an important role in the development of the PED Readiness Assessment methodology aimed to support PEDs on the energy transition, guiding them on their pathway to fulfil their goals and better adapt to a challenging environment. In phase 1 of the project, PED-RA (as well as the other PEDvolution solutions) will be co-designed. In this phase BRIDGE, AIOTI and other EU initiatives will be approached, and existing knowledge gathered. In phase 2, PED-RA will be co-developed in close cooperation with PEDvolution partners, co-developer PEDs and BRIDGE (and all entities engaged through T11.3). In phase 3, results of the testing and validation of the PED-RA in the PEDs will be presented to BRIDGE and other EU-initiatives to further improve and discuss the potential standardisation and replication of this results around Europe.

PEDvolution will support the provision of advice and evidence for EU policy making through its active involvement in the BRIDGE initiative Data Management Working Group (ICOM member of the WG), the BRIDGE Consumer and Citizen engagement WG (SIN leader of the WG) and BRIDGE Business Models WG (SIN member of the WG). Involvement in BRIDGE will also include participation to the BRIDGE annual general assembly, contributing to its annual work programme and related reports and exchange of experiences and best practices with other projects. Through different AIOTI WG (the most relevant is WG Energy) PEDvolution, and namely INLE who is AIOTI member, can contribute to: research agenda on energy, buildings; IoT vision and roadmap relating to energy efficiency in buildings; energy efficiency and integration of local renewables and local excess heat sources within the district; research initiatives and research concept continuation based on current and future energy efficiency targets; contribute to environmental/energy related policies.

1.2.19 Visualization of the IoT EU funded ongoing projects landscape

This section provides a landscape visualization of the ongoing IoT EU funded projects, introduced in this report.

The "IoT EU funded ongoing projects landscape (Technology and Marketing Dimensions)", shown in Figure 6, is a graphical representation that highlights the main activity (up to the day of generating this representation) of the ongoing projects in the area of IoT, according to the Business to Consumer (B2C) vs. Business to Business (B2B) (horizontal axis) and the Connectivity vs. Service & App (vertical axis) classifications.

The projection of these ongoing projects into vertical industry domains is shown in **Figure 7** and for standardisation activities in different SDO's and initiatives is shown in **Figure 8**.

The dimensions, the vertical/horizontal domains and standardisation organisations and initiatives of the landscapes and the method used to visualize ongoing projects into these landscapes shown in **Figure 6**, **Figure 7** and **Figure 8**, respectively, are the same ones as defined in Section 1.1.28.

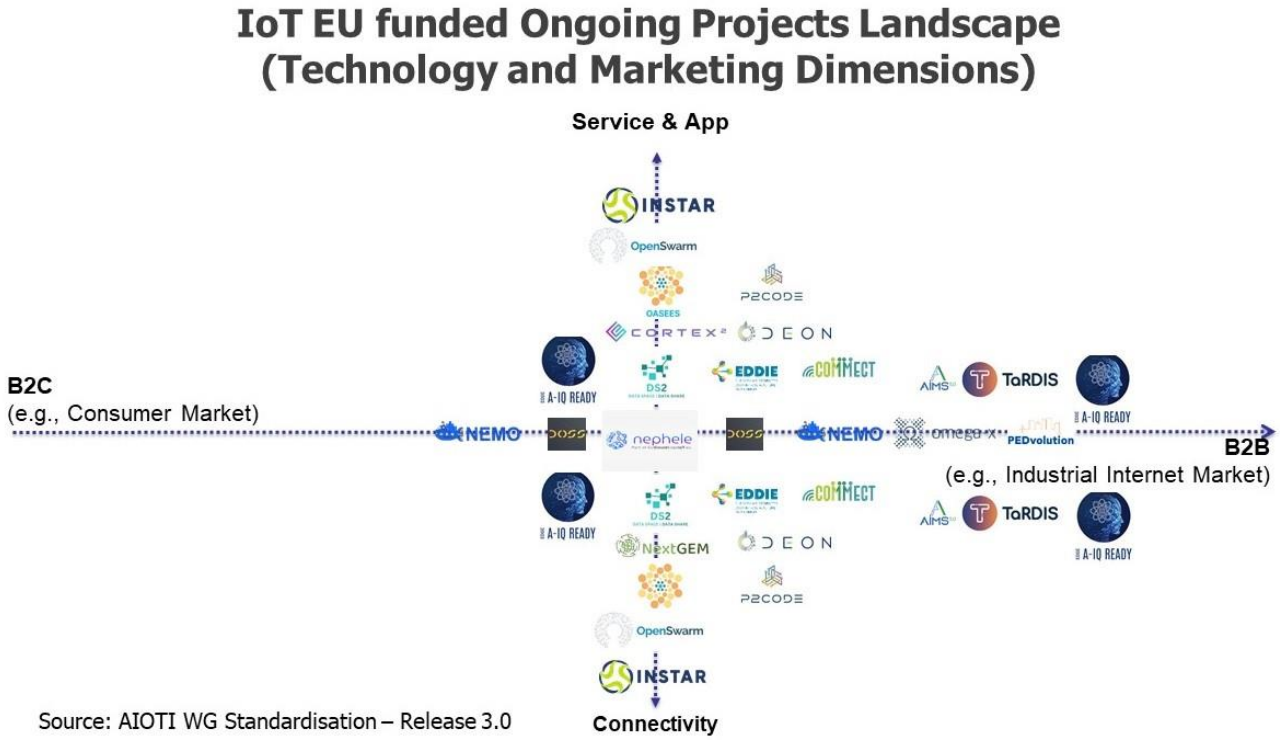


Figure 6: IoT EU funded ongoing projects landscape, when Technology and Marketing Dimensions are used.

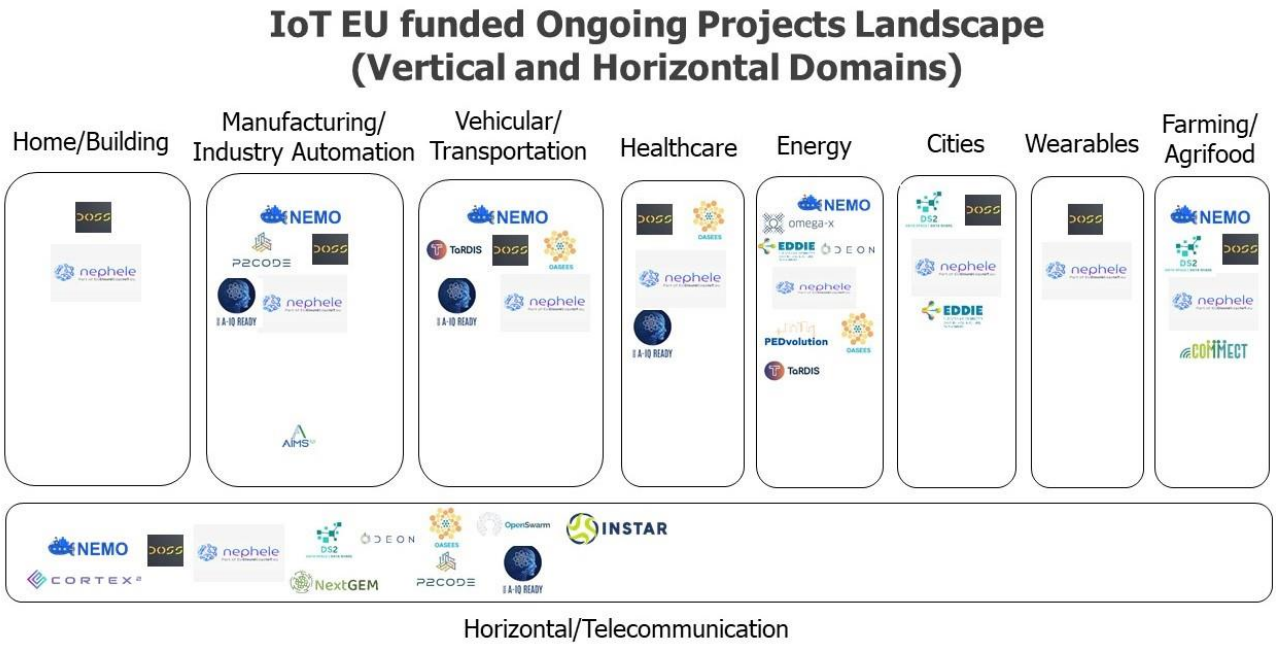


Figure 7: IoT EU funded Ongoing Projects Projection on Vertical and Horizontal Domains.

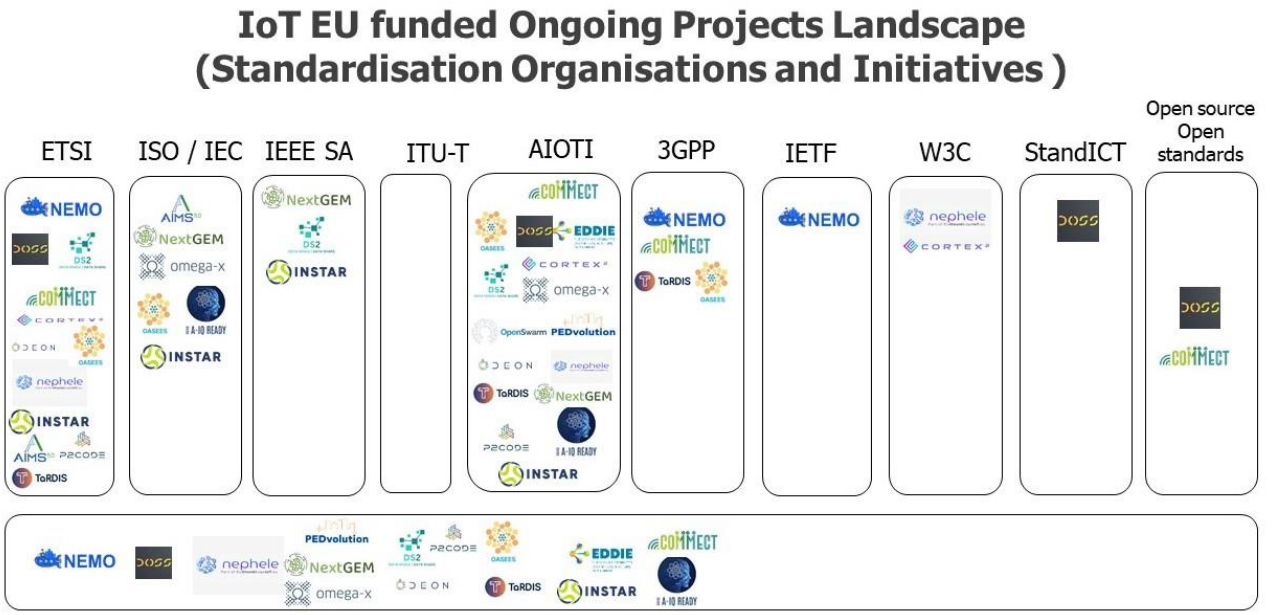


Figure 8: IoT EU funded Ongoing Projects Projection on Standardisation Organisations and Initiatives.

2. Edge Computing EU funded projects landscape

This section provides information on Edge Computing EU funded projects, which are grouped in completed and ongoing projects. The information related to each EU funded project, included in this section, has been collected using the template provided in Annex I of this report.

2.1 Completed Projects

This section provides a description of Edge Computing EU funded projects that are completed.

2.1.1 AFarCloud: Aggregate Farming in the Cloud

URL/Reference:

http://www.afarcloud.eu/

https://cordis.europa.eu/project/id/783221

Abstract:

Farming is facing many economic challenges in terms of productivity and cost-effectiveness, as well as an increasing labour shortage partly due to depopulation of rural areas. Furthermore, reliable detection, accurate identification and proper quantification of pathogens and other factors affecting both plant and animal health, are critical to be kept under control in order to reduce economic expenditures, trade disruptions and even human health risks.

AFarCloud provided a distributed platform for autonomous farming that will allow the integration and cooperation of agriculture Cyber Physical Systems in real-time in order to increase efficiency, productivity, animal health, food quality and reduce farm labour costs. IoT and Edge-computing (AI at the edge) are the basic technologies enabling this platform. This platform will be integrated with farm management software and will support monitoring and decision-making solutions based on big data and real time data mining techniques., enabling modern precision farming in an optimized way.

The AFarCloud project also made farming robots accessible to more users by enabling farming vehicles to work in a cooperative mesh, thus opening up new applications and ensuring re-usability, as heterogeneous standard vehicles can combine their capabilities in order to lift farmer revenue and reduce labour costs. Sensor technologies applied in the field are implemented in a secure manner as "secure IoT" devices.

It needed to take into account different application capabilities like the data collection and cloud computing, a sensing-on-the-move approach, cyber physical systems, secure IoT actuation, decision support systems, autonomous vehicles like UAVs and other partially and fully automatic devices for most aspects of agricultural processes, with the objective of realizing farming-as-a-service, adding a real-time monitoring level in a farm viewed as a whole.

Starting and (target) end time of project:

01/09/2018 – 30/11/2021

IoT and/or Edge Computing research challenges:

Many IoT models and communication approaches were implemented and further developed to be integrated in smart farming and precision farming context under different environmental and infrastructure conditions. The achievements from AFarCloud were demonstrated in three holistic demonstrators (Finland, Spain and Italy), including cropping and livestock management scenarios and eight local demonstrators (Latvia, Sweden, Spain and Czech Republic) in order to test specific functionalities and validate project results in relevant environments located in different European regions. IoT data models of the FIWARE[3] initiative and the domain model of the European Lighthouse Project IoT-A were used for describing the main IoT concepts and their relationships.

The platform combined data streams provided not only by deployed IoT-aided groups of devices (distributed sensors and vision systems deployed in the infrastructure and the automated and partially autonomous vehicles or UAVs operating in the farm) but also by data streams provided by cloud and data analytic components, that integrate the information coming from other farms and external heterogeneous data sources (e.g. meteorological data, logistics, etc.). In this way, a comprehensive representation of the actual status of cropping areas and livestock facilities can be achieved.

In communications, among others, the rising Sub-GHz IoT communication technologies (e.g., LoRA, in the 868–870 MHz band), were implemented in a secure manner.

The SED (Security Evaluation Demonstrator) was demonstrated in real environments, providing the following security features:

- Detection of unauthorised moving of the IoT device.
- Ensuring the physical integrity of the IoT device.
- Detection and notification of low power supply voltage level
- Inhibit unauthorised reuse of manipulated IoT device, Prevent manipulation of the IoT device communication data.

These features are applicable for future agriculture IoT devices, located unsupervised in the field and are also targeting especially at unsupervised unmanned and autonomous vehicles with IoT cooperating devices as enablers of new functionality, supervision and control.

Internet of Things networks such as SigFox, NB-IoT and LoRa offered a breakthrough solution especially to the extensive livestock farmers, including livestock movement control and health monitoring & behaviour analysis, e.g., with developed IoT-wearables.

The connection of IoT networks with the Cloud allows large data retrieval useful to the farmers to drive their activity and the actions of the IoT and vehicles, as cooperating devices in the farm in autonomous manner and analysis of the data in a useful way for optimization of farming services.

Expected activities on "Dissemination and Impact on Standards":

AFarCloud technological results generate impact in the value-chain and accomplish the concept of *Farming-as-a-Service*:

- Automated farming equipment, vehicles, UAVs (Drones), robots, altogether with IoT networks and Cloud connectivity;
- Farming (crop) and Livestock Management optimization (Semi-autonomous optimized management of farming and livestock) using general IoT and wearables (IoT sensors and devices);
- Dependability and security of IoT sensors, networks and devices;
- IoT cloud and fog computing, particularly agri-IoT and IIoT;
- Cloud service offerings intermediation and orchestration services coming from multiple cloud service providers;
- Tracking and monitoring/control - GIS application;
- Hardware and SW Development;
- IoT and edge intelligence for smart and precision farming, animal and crop health, IoT;
- High Quality of Service (QoS) characteristics for controlling over every aspect of data.

Standardization was managed and supported by a separate task. Several partners are not only active in international and national mirror standardization committees of ISO, IEC and particularly in ISO/IEC JTC1 SC41 (IoT) and SC42 (AI), but also members of AIOTI (WG Standardization, WG Agriculture, WG Mobility), ETSI and OASIS.

Results were disseminated to these groups and international conferences, by ERCIM News (Special Theme: "Smart farming", 2018) and other articles, and this is continuing beyond the project.

Acknowledgement:

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 783221. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Austria, Belgium, Czech Republic, Finland, Germany, Greece, Italy, Latvia, Norway, Poland, Portugal, Spain, Sweden.

2.1.2 PLEDGER: "Performance optimization and edge computing orchestration for enhanced experience and Quality of Service"

URL/Reference:

http://www.pledger-project.eu/

https://cordis.europa.eu/project/id/871536

Abstract:

Next-generation edge computing infrastructures should confront the new challenges faced today with the power offered by cloud infrastructures. The EU-funded Pledger project aims to provide a new architectural model as well as a set of software tools that will prepare the future development of the next generation of edge computing. The project will allow edge computing providers to secure the stability and effective performance of the edge infrastructures. It will also allow edge computing users to understand the nature of their applications, research understandable quality of service metrics and optimise the competitiveness of their infrastructures. The project intends to introduce the set of tools in the application fields of manufacturing, mixed reality and smart cities.

Starting and (target) end time of project:

01/12/2019 – 30/11/2022

IoT and/or Edge Computing research challenges:

Edge computing allows data produced by Internet of Things (IoT) devices to be processed closer to where they are created instead of sending them across long routes to data centres or clouds. Doing this computing closer to the edge of the network enables organizations to run near real-time analysis of important data – a need of organizations across many domains, including manufacturing, healthcare, telecommunications and finance. The disruptive potential of edge computing is fuelled by the unprecedented growth of data, the imminent impact of 5th Generation (5G) networks and the growing importance of latency in modern applications. When specialized and expensive solutions are preferred over generic edge computing or cloud infrastructures, it creates additional costs or excludes a wide set of SMEs from being competitive or even operational.

It becomes clear that current approaches on edge computing are not sufficient to address this forthcoming massive usage of edge computing, especially in the frame of large IoT deployments in smart cities and industrial applications. The massive data generated by new modalities (e.g. Augmented Reality, Mixed Reality, real-time video processing for removing privacy-sensitive data etc.) are soon expected to account for an increasing portion of edge computing processing. The main goal in such scenarios is to ensure that the overall offered Quality of Service (QoS) fits the application needs over the edge or edge/cloud deployment. Speed and latency issues have been identified as the top barrier in this domain, while cost and reliability (meeting the provider Service Level Agreements - SLAs) are the top and second most important factors for evaluating edge and cloud services. Furthermore, achieving trust in such large scale IoT deployments is another crucial area of interest.

With the recent introduction of blockchains as an enabling technology for distributed and peer-to-peer systems, it comes as a challenge to check whether modern edge computing approaches are suitable for being coupled with emerging decentralized applications built on blockchains. A distributed trust technology, ensuring scalability, privacy, and reliability, is a cornerstone for the growth of IoT and edge computing environments.

Expected activities on "Dissemination and Impact on Standards":

Standardization activities results are:

- The "High Priority Edge Computing Standardisation Gaps and Relevant SDOs" AIOTI report43.
- The "Landscape of Internet of Things (IoT) Standards" StandICT report44 and the corresponding
- "Landscape of Edge-Computing" (to be published in December 2022).
- The "ETSI Technology Radar (ETR) 2022" report45 (to be updated at the end of 2022).
- The "Service Level Agreements Self-Assessment with Hyperledger Fabric" Hyperledger
- whitepaper46.
- A new NGSI "smart data model"47 in the context of FIWARE.

Pledger has produced contributions related to three standardisation landscape reports, one Open Source Framework whitepaper, and one Open Source guideline, by being active in WGs of SDOs (ETSI), Alliances (AIOTI, StandICT), and OSCs (Hyperledger, FIWARE). Moreover, the project has managed to exploit results from all of its technical WPs, with WP2 "Requirements Analysis and Architecture" input being used for the standardisation landscape reports to SDOs and Alliances, and WP3 "Performance, QoS and orchestration mechanisms" and WP4 "Trust, Smart Contracts and Decision Support mechanisms" outcomes being used for Frameworks and Guidelines to OSCs.

To sum up, Pledger has successfully met its standardisation goal of contributing to at least 2 standards with relation to SLA metrics and orchestration languages and has successfully established the baseline for future related activities extending beyond the official lifecycle of the project.

2.1.3 ARtwin: "An AR cloud and digital twins solution for industry and construction 4.0"

URL/Reference:

https://class-project.eu/

https://cordis.europa.eu/project/id/780622

Abstract:

EU-funded ARtwin aims at developing an Augmented Reality (AR) cloud platform for improving productivity and product quality of the European industry and construction 4.0. Based on 5G connectivity, the AR cloud platform will enable collaborative AR experiences adapted to factory and construction site environments. AR experience will operate on a large scale by using 3D mapping and vision-based localisation services. A remote rendering service will enable the display of complex 3D content on low-resources AR devices. Finally, dedicated tools will allow for service deployment and orchestration on any cloud infrastructure. Three pilot use cases will be used for validation, while contribution to **standardization** will aim at fostering the emergence of a sustainable and sovereign AR ecosystem in Europe.

Starting and (target) end time of project:

01/12/2017 – 30/11/2020

IoT and/or Edge Computing research challenges:

- To introduce an easily deployable platform that enables the design and maintenance of highly accurate real-time digital representations of large-scale real environments.
- To develop and deploy high quality interactive services set on improving business performance and well-tailored to the requirements of professional and industrial contexts.
- To demonstrate and validate the benefits of the ARCloud in major factories and construction sites, by deploying three demonstrators that will prove the quality and productivity gains.
- To contribute to **standardization** activities, by providing specifications of unified APIs and data representations, fostering in this way a growing and sustainable AR ecosystem in Europe.

Expected activities on "Dissemination and Impact on Standards":

Developed platform is formally defined if:

- It exposes easy-to-use APIs: standardizing APIs (e.g., TM Forum Open APIs) is a critical success factor for realizing the full value of Platform Business Models. **Standard APIs** lower the cost of participating in Platform businesses to customers (write once, integrate everywhere), and the investment required by Platform Owners themselves in leveraging legacy internal capabilities.
- It exposes searchable capabilities as coherent and compose-able blocks of business functionalities and operational patterns, exposed or published in a catalogue accessible through one of the Catalogue APIs (e.g., compliant with **TM Forum Catalogue API**). Capabilities editors may be business actors like organizations, governments, industry groups, and so on.
- It is modelled as structural hierarchies and layers, associated usage rules, capabilities and APIs. Modelling is managed through a Management API (e.g., TM Forum DSM-API).

Alongside, ARtwin partners, and mainly BCM and SIE, will seek to actively contribute to the activity Standardisation Bodies, with a view to fostering a growing and sustainable AR ecosystem across Europe, all while enhancing the brand of the ARtwin project and its solutions.

2.1.4 ELASTIC: "A Software Architecture for Extreme-ScaLe Big-Data AnalyticS in Fog CompuTIng ECosystems"

URL/Reference:

https://elastic-project.eu/

https://cordis.europa.eu/project/id/825473

Abstract:

Big data is nowadays being integrated in systems requiring to process a vast amount of information from (geographically) distributed data sources, while fulfilling the non-functional properties (real-time, energy-efficiency, communication quality and security) inherited from the domain in which analytics are applied. Examples include smart cities or smart manufacturing domains.

ELASTIC will develop a novel software architecture (SA) to help system designers to address this challenge. The SA will incorporate a novel elasticity concept to distribute and orchestrate the resources across the compute continuum (from edge to cloud) in an innovative fog computing environment. The new elasticity concept will enable to match analytics workload demands and fulfilling non-functional properties. The fog computing architecture will incorporate energy-efficient parallel architectures, combined with innovative distributed storage, secure communications and advanced cloud solutions.

Overall, the SA will enable the combination of reactive data-in-motion and latent data-at-rest analytics into a single extreme-scale analytics solution, in which the analytics workloads will be

efficiently distributed across the compute continuum based on their suitability and data processing needs.

The capabilities of ELASTIC will be demonstrated on a real smart-mobility use case, featuring a heavy sensor infrastructure to collect data across the Florence tramway network, equipped with advanced embedded architectures, heterogeneous sensors, V2I connectivity and access to cloud resources. Representative applications for advanced driving assistant systems, predictive maintenance and public/private transport interaction, have been selected to efficiently process very large heterogeneous data streams from distributed sensors.

ELASTIC technology will enable the development of innovative mobility services while preparing the technological background for the advent of full autonomous mobility systems.

Starting and (target) end time of project:

01/12/2018 – 31/05/2022

IoT and/or Edge Computing research challenges:

- ELASTIC develops a software architecture incorporating a new elasticity concept, that will enable smart systems to satisfy the performance requirements of extreme-scale analytics workloads. The new elasticity concept will efficiently distribute the workloads across the compute continuum, whilst guaranteeing real-time, energy, communication quality and security non-function properties inherited from the system domain.
- The vision of ELASTIC is that by extending the elasticity concept across the compute continuum in a fog computing environment, combined with the usage of advanced hardware architectures at the edge side, can significantly increase the capabilities of the extreme-scale analytics integrating both responsive data-in-motion and latent data-at-rest analytics into a single solution.
- ELASTIC considers a realistic yet visionary smart mobility use-case, which considers huge amounts of data coming from a large set of IoT sensors distributed along the Florence tramway network. ELASTIC adopts a very innovative federated/distributed fog architecture, supporting elasticity across the compute continuum whilst fulfilling real-time, energy, communication and secure properties.

Expected activities on "Dissemination and Impact on Standards":

ELASTIC is a member of BDVA, and participates in the BDVA newsletter and in events and conferences organized by the Association.

Different teams plan to publish the project results in open communities and public environments, as follows:

- OpenFog: OpenFog Reference Architecture (RA),
- Distributed Management Task Force (DMTF): cloud management standard called CIMI, that specifies a systematic and consistent way to define web service interfaces (REST),
- FIWARE: open and royalty-free API specification to interface among users and system developers,
- Linux Foundation EDGE: an umbrella organisation that aims to establish an open, interoperable framework for edge computing,
- OASIS: a non-profit open-standards body,
- Open Edge Computing Initiative: a collective effort driving the business opportunities and technologies surrounding edge computing.

2.1.5 CLASS: "Edge and CLoud Computation: A Highly Distributed Software Architecture for Big Data AnalyticS"

URL/Reference:

https://class-project.eu/

https://cordis.europa.eu/project/id/780622

Abstract:

Big data applications processing extreme amounts of complex data are nowadays being integrated with even more challenging requirements such as the need of continuously processing vast amount of information in real-time.

Current data analytics systems are usually designed following two conflicting priorities to provide (i) a quick and reactive response (referred to as data-in-motion analysis), possibly in real-time based on continuous data flows; or (ii) a thorough and more computationally intensive feedback (referred to as data-at-rest analysis), which typically implies aggregating more information into larger models. Given the apparently incompatible requirements, these approaches have been tackled separately although they provide complementary capabilities.

Starting and (target) end time of project:

01/01/2018 – 30/06/2021

IoT and/or Edge Computing research challenges:

1. Big data analytics are being applied to a wide range of applications domains, including those in charge of controlling critical real-time systems, challenging the need not only to efficiently processing extreme amounts of complex data, but also processing it in real-time.
2. CLASS developed a novel software architecture framework to help big data developers to efficiently distributing data analytics workloads along the compute continuum (from edge to cloud) in a complete and transparent way, while providing sound real-time guarantees. This ability opens the door to the use of big data into critical real-time systems, providing to them superior data analytics capabilities to implement more intelligent and autonomous control applications.
3. The capabilities of the CLASS framework have been demonstrated on a real smart-city use case in the City of Modena, featuring a heavy sensor infrastructure to collect real-time data across a wide urban area, and three connected vehicles equipped with heterogeneous sensors/actuators and V2X connectivity to enhance the driving experience.

Expected activities on "Dissemination and Impact on Standards":

CLASS is a member of the Big Data Value Association (BDVA) and participates regularly in the BDVA newsletter and in the network's events and conferences, such as the BDVAPPP Summit 2019 and the BDVA webinar series. The project has been added to the BDVA Landscape, an online map of big data projects, institutions, and use cases, while an extended description of the CLASS pilot use case has been published on the BDVA list of pilot studies. In addition, the CLASS partners have participated with a chapter in BDVA's open access book "Technologies and Applications for Big Data Value" to be launched by Springer. BDVA has also disseminated the CLASS final event to their mailing lists and networks encouraging their members to attend.

CLASS is actively involved with open communities. One major route of this is involvement with open-source projects, by consuming, adapting and contributing back to a project's code base. More specifically, WP5 (Analytics Layer) employs OpenWhisk as a foundation for CLASS' event-driven and inclusive programming model.

Moreover, sequence of contributions has been made by CLASS to the open-source project of Lithops (also used by CLASS).

2.1.6 LEGaTO: "Low Energy Toolset for Heterogeneous Computing"

URL/Reference:

https://class-project.eu/

https://cordis.europa.eu/project/id/780622

Abstract:

Recently system integrators have dramatically increased their efforts in heterogeneous computing by integrating heterogeneous cores on die (ARM), utilizing general purpose GPUs (NVIDIA), combining CPUs and GPUs on same die (Intel, AMD), leveraging FPGAs (Altera, Xilinx), integrating CPUs with FPGAs (Xilinx), and coupling FPGAs and CPUs in the same package (IBM-Altera, Intel-Altera). Heterogeneity aims to solve the problems associated with the end of Moore´s Law by incorporating more specialized compute units in the system hardware and by utilizing the most efficient compute unit. However, while software-stack support for heterogeneity is relatively well developed for performance, software stack support for power- and energy-efficient computing it is severely lacking. Given that the ICT sector is responsible for 5% of global electricity consumption, software stack-support for energy-efficient heterogeneous computing is critical to the future growth of the ICT industry. The primary ambition of the LEGaTO project is to address this challenge by starting with a Made-in-Europe mature software stack, and by optimizing this stack to support energy-efficient computing on a commercial cutting-edge European-developed CPU-GPU-FPGA heterogeneous hardware substrate, which will lead to an order of magnitude increase in energy efficiency.

Starting and (target) end time of project:

01/12/2017 – 30/11/2020

IoT and/or Edge Computing research challenges:

1. One order of magnitude improvement in energy-efficiency for heterogeneous hardware through the use of the energy-optimized programming model and runtime.
2. 5× improvement in Mean Time to Failure through energy-efficient software-based fault tolerance.
3. Size reduction of the trusted computing base by at least an order of magnitude.
4. 5× increase in FPGA designer productivity through the design of novel features for hardware design using dataflow languages.

Expected activities on "Dissemination and Impact on Standards":

While it has a major research focus, the work performed in the LEGaTO project also strongly affects new industry trends and standards. As an active member of the PCI Industrial Computer Manufacturers Group (PICMG), LEGaTO partner Bielefeld University, together with companies like congatec, Kontron, Intel, or Adlink Technology, is involved in the standardization of the new computer-on-module form factor COM-HPC. The new specification will allow easy, modular integration of new microserver technology into edge and IoT applications by defining common interfaces, mechanical dimensions and cooling.

2.1.7 SYNERGY: Big Energy Data Platform and AI Analytics Marketplace for new viable solutions

URL/Reference:

https://cordis.europa.eu/project/id/872734

https://www.synergyh2020.eu/

Abstract:

The European electricity sector is undergoing a major fundamental change with the increasing digitalization and roll-out of smart meters.

This advent of the electricity sector modernization comes together with the fact that the power system is becoming more thoroughly monitored and controlled from "end to end" and through the whole value chain of stakeholders involved in the electricity system operation. This is a huge shift away from traditional monitoring and control approaches that have been applied exclusively over the transmission and distribution networks, since the smart electricity grid era is pushing sensing, control and data collection at the edge of electricity networks, which needs to be further re-defined due to the wide penetration of Distributed Energy Resources (DERs), such as renewable energy sources (RES), smart home devices and appliances (IoT-enabled), distributed storage, smart meters and electric vehicles (EVs). In response to this need for "end-to-end" coordination between the electricity sector stakeholders – not only in business terms but also in exchanging information between them – SYNERGY introduces a novel framework and references big data architecture that leverages data, primary or secondarily related to the electricity domain, coming from diverse sources (data APIs, historical data, statistics, sensor / IoT data, weather data, energy market data, and various other open data sources) to help the electricity value chain stakeholders to simultaneously enhance their data reach, improve their internal intelligence on electricity-related optimization functions while getting involved in novel sharing/trading models of data sources and intelligence, in order to gain better insights and shift individual decision-making at a collective intelligence level. SYNERGY addresses and takes the best of breed from a number of technologies, such as IoT for timely ingesting real-time data at the edge and performing in-situ analytics. On the other hand, big data analytics are performed in a secure experimentation playground in the SYNERGY cloud infrastructure, to extract as much information as possible from data assets.

Starting and (target) end time of project

01/01/2022 – 30/06/2023

IoT and/or Edge Computing research challenges:

- Interoperability: Common Information Model definition based on a number of standards (such as: IEC 61850 – 61968 – 61970 – 62056 – 62325 – 62361, OpenADR, USEF, SAREF – SAREF4ENER – SAREF4BLDG, IFC, SSN) for full IoT functionalities of the SYNERGY Big Data Platform and AI Marketplace.
- Research, development and testing of distributed architecture for edge on-premise deployment of the SYENRGY Big Data Platform and AI Marketplace

Expected activities on "Dissemination and Impact on Standards":

- Cooperation with BDVA and BRIDGE Initiative. Additional collaboration with ETIP-SNET for more related energy R&I strategies and OPENDEI for platform and digital knowledge share.
- Exchanging experiences and best practices, sharing the state -of-the-art, common C&D events with "sister" projects within the framework of the aforementioned organizations.
- Availability until June 2023

2.1.8 ACCORDION: Adaptive edge/cloud compute and network continuum over a heterogeneous sparse edge infrastructure to support NextGen applications

URL/Reference:

Project website: https://www.accordion-project.eu

Project website on CORDIS https://cordis.europa.eu/project/id/871793

Abstract:

There is an increasing number of signs that the edge computing concept is going to play a dominant role in the forthcoming technology developments, disrupting economies at a large scale. The big cloud providers promptly jumped in to get the lion's share, but edge computing is intrinsically more "democratic" than cloud computing. In fact, its distributed and localized nature can be an antibody for big trusts, if properly exploited.

Synergistically employing edge computing with upcoming technologies such as 5G provides an opportunity for EU to capitalize on its local resource and infrastructure and its SME-dominated application development landscape and achieve an edge-computing-driven disruption with a local business scope. To this end, ACCORDION establishes an opportunistic approach in bringing together edge resource/infrastructures (public clouds, on-premises infrastructures, telco resources, even end-devices) in pools defined in terms of latency, that can support NextGen application requirements. To mitigate the expectation that these pools will be "sparse", providing low availability guarantees, ACCORDION will intelligently orchestrate the compute & network continuum formed between edge and public clouds, using the latter as a capacitor. Deployment decisions will be taken also based on privacy, security, cost, time and resource type criteria. The slow adoption rate of novel technological concepts from the EU SMEs will be tackled though an application framework, that will leverage DevOps and SecOps to facilitate the transition to the ACCORDION system. With a strong emphasis on European edge computing efforts (MEC, OSM) and 3 highly anticipated NextGen applications on collaborative VR, multiplayer mobile- and cloud-gaming, brought by the involved end users, ACCORDION is working to radically impact the application development and deployment landscape, also directing part of the related revenue from non-EU vendors to EU-local infrastructure and application providers.

Starting and (target) end time of project:

01/01/2020 – 30/04/2023

IoT and/or Edge Computing research challenges:

- ACCORDION project is facing a quite wide spectrum of challenges in Edge computing. In fact, it has the objective to deliver a comprehensive platform for easing the task of supporting the management of resources as well as the tailoring and optimization of applications on edge-based infrastructures. This goal is targeted by means of the development of three different frameworks, each devoted to a specific goal: resource indexing and pooling, application orchestration, application design and DevOps.
- Overall, the three main challenges faced are concerned with: (i) Intelligent resource brokering as well as efficient and secure application placement, (ii) efficient decentralised edge resource indexing, (iii) high-level representation of edge applications.

Expected activities on "Dissemination and Impact on Standards":

ACCORDION project interacts mainly with two Standard Organizations: ITU-T and ETSI. ACCORDION is contributing to the ETSI MEC standard via one of the consortium partners (NEC Europe). ACCORDION is promoting its vision of Edge Computing, in terms of application and resource management. The ACCORDION contribution to ITU-T is focused on the SG12, concerning the dynamic QoE assessment through its consortium partner Technische Universitat Berlin. ACCORDION expects that most of its contributions to standards will be materialised after the end of the project.

2.1.9 BRAINE: Big data pRocessing and Artificial Intelligence at the Network Edge

URL/Reference:

https://www.braine-project.eu/

Abstract:

BRAINE provides a new vision for utilizing edge resources by providing novel network-edge workload distribution schemes. Predicting resource availability and workload demand, identifying trends, and taking proactive actions are all aspects of the novel workload distribution. The workload distribution technology developed in the context of BRAINE can be transferred to many other edge/fog computing environments to achieve different goals. Last but not least, BRAINE will have an important positive impact on the environment.

Through BRAINE, edge computing can reduce this projected energy consumption by offloading many of the AI functions next to the end-users. BRAINE demonstrates edge computing enabling

AI through four use cases: healthcare assisted living (case 1), hyperconnected smart city (case 2), robotics in Factory 4.0 (case 3) and supply chain Industry 4.0 (case 4); the use cases are supported by organizations with specific domain expertise. Inside the UC1, the focus is given to IoT health sensors and actuators that are used by patients.

Starting and (target) end time of project:

01/05/2020 – 30/04/2023

IoT and/or Edge Computing research challenges:

Devising an EC infrastructure that offers control, computing, acceleration, storage, and 5G networking at the Edge and excels in scalability, agility, security, data privacy, and data sovereignty in Big Data and AI for low latency and mission-critical applications.

- Developing a future-proof Edge security framework and associated infrastructure based on 5G. With the latest software and hardware security technologies.
- Developing a distributed and partly-autonomous system that takes data privacy and sovereignty into account on each and every decision regarding workload placement, data transfer, and computation, while guaranteeing interoperability with the environment.
- Developing a heterogeneous, energy efficient Edge MicroDataCenter, suitable for stationed, mobile, and embedded autonomous applications, that goes beyond the current hardware and software architectures and offers Big Data processing and AI capabilities at the Edge.
- Testing and demonstrating the effectiveness and generality of the BRAINE approach by evaluating multiple real-world use cases and scenarios that exhibit the required scalability, security, efficiency, agility, and flexibility concerns.

Expected activities on "Dissemination and Impact on Standards":

- members of the BRAINE project follow the AIOTI activities in various areas (edge and 5G, standardization, energy)
- members of the project also follow the 6G IA (SNS JU) in the aspects of edge developments for beyond-5G and 6G
- BRAINE is following the 3GPP and ETSI specs related to workload placement in combination with network (and network slice) scaling and life-cycle management for the edge environments
- BRAINE also follows closely the recommendations related to the post-quantum protection protocols for the security keys distribution and protecting the links between edge data centres
  - Post-quantum cryptography emerging standards (NIST, ETSI)
  - Security evaluation methods (ISO 17825 / WG3 N2290 / WG3 N2291)
  - Edge related standardization (ETSI, AIOTI)
  - Ontologies (Digital Reference) (W3 org)
  - Open-source implementation of cryptographic standard (OpenSSL)
- IoT standards related to security are also followed from perspective of combining distributed ledger technologies and security challenges of IoT devices interacting with edge (EMDC)

2.1.10 MORPHEMIC: Modelling and Orchestrating heterogeneous Resources and Polymorphic applications for Holistic Execution and adaptation of Models In the Cloud

URL/Reference:

https://cordis.europa.eu/project/id/871643

https://www.morphemic.cloud/

Abstract:

MORPHEMIC proposes a unique way of adapting and optimizing Cloud computing applications by introducing the novel concepts of polymorph architecture and proactive adaptation. The former is when a component can run in different technical forms, i.e. in a Virtual Machine (VM), in a container, as a big data job, or as serverless components, etc. The technical form of deployment is chosen during the optimization process to fulfil the user's requirements and needs. The quality of the deployment is measured by a user defined and application specific utility. Depending on the application's requirements and its current workload, its components could be deployed in various forms in different environments to maximize the utility of the application deployment and the satisfaction of the user. Proactive adaptation is not only based on the current execution context and conditions but aims to forecast future resource needs and possible deployment configurations. This ensures that adaptation can be done effectively and seamlessly for the users of the application. The MORPHEMIC deployment platform will therefore be very beneficial for heterogeneous deployment in distributed environments combining various Cloud levels including Cloud data centres, edge Clouds, 5G base stations, and fog devices. Advanced forecasting methods, including the ES-Hybrid method recently winning the M4 forecasting competition, will be used to achieve the most accurate predictions. The outcome of the project will be implemented in the form of the complete solution, starting from modelling, through profiling, optimization, runtime reconfiguration and monitoring. Then the MORPHEMIC implementation will be integrated as a pre-processor for the existing MELODIC platform extending its deployment and adaptation capabilities beyond the multi-cloud and cross-cloud to the edge, 5G, and fog. This approach allows for a path to early demonstrations and commercial exploitation of the project results.

Starting and (target) end time of project:

01/01/2020 – 30/06/2023

IoT and/or Edge Computing research challenges:

MORPHEMIC is a multi-cloud management system that orchestrates the execution of applications while ensuring the meet of the application owner objectives. These objectives can be expressed in terms of computing performance or/and cost.

Morphemic provides transparent management allowing not only the cloud but also the edge applications which often perform in very limited environment computational power and must satisfy availability and response time requirements. The cloud/edge computing domain offers approaches to attain business requirements that edge applications must meet. Dynamic adaptation, meaning, the real-time modification of the resources allocated to the application is an effective solution to ensure the performance of these applications knowing that the workload which is the main factor influencing the performance is not stable, therefore the resources assigned to an application must be adapted in accordance with the evolution of the managed workload. Although dynamic resource provisioning is a technique applied in cloud/edge computing, workload prediction enabling proactive adaptation is a feature implemented in Morphemic project to ensure the proper functioning of applications in an edge infrastructure.

We should be noted that an edge application can have several forms (script, container, serverless) and can run on different processing unit (CPU, GPU, FPGA, etc.). The latter influences the performance of the application.

As illustration, an application can present a specific performance on a hardware in accordance with the internal structure of the application (algorithm, workflow, etc ...). Morphemic brings a

mixed analysis of the performance model of the application which consists of static analysis (analysis of the source code) and dynamic with the correlation of performance indicators after several executions to allow polymorphic adaptation (change of the form and hardware executing the code) of the edge or cloud application.

In particular, MORPHEMIC proposal in Section 1.4 Ambition Challenge 2 states: Self-healing federated event processing management system at the edge.

Expected activities on "Dissemination and Impact on Standards":

MORPHEMIC aims to collaborate with the AIOTI Alliance research and innovation, standardisation and ecosystem building.

A first case study description has been provided and the interaction will be followed up with further case study evolutions including potential standardization activities.

MORPHEMIC aims to Collaborate with projects RAINBOW & PLEDGER, a joint session will be presented at EBDVF 2022 on 22nd/23rd November 2022. With the rapidly exploding number of smart and connected devices today and the abundance of data constantly generated by new and emerging technologies such as **smart cities**, **5G/6G**, **IoT**, **autonomous mobility**, **smart manufacturing**, **extended reality**, etc. are putting higher demands on the cloud infrastructures, cloud services and cloud developers especially for real time and mission critical applications. This session will aim to highlight opportunities for **boosting data-driven digital transformation** of the EU innovation landscape and strengthening its competitiveness by leveraging on the next-generation Cloud Continuum platforms developed by three EU-funded Cloud Computing projects: **RAINBOW**, **PLEDGER** and **MORPHEMIC.**

A follow up group of interested partners will be created during the session and common potential standardization activities will be discussed.

MORPHEMIC collaborate with the open-source ecosystem of OW2, a project booth within the OW2 space, will be present at the Open Source Experience November 8-9, 2022 Venue: Paris Palais des Congrès Porte Maillot. The event will be an occasion to interact with the open source ecosystem and with the open source developers involved or wishing to be involved in the MORPHEMIC OW2 code base. The interactions will be followed up after the event by the team.

A follow up group of interested partners will be created during the event and common potential standardization activities will be discussed.

2.1.11 5G COMPLETE: A unified network, computational and storage resource management framework targeting end-to-end performance optimization for secure 5G multi-technology and multi-tenancy environments

URL/Reference:

https://5gcomplete.eu/

Abstract:

5G-COMPLETE aims to revolutionize the 5G architecture, by efficiently combining compute and storage resource functionality over a unified ultra-high capacity converged digital/analog Fiber-Wireless (FiWi) Radio Access Network (RAN). By employing the recent advances in Ethernet fronthauling introduced by the eCPRI standard as a launching point, 5G-COMPLETE introduces and combines a series of key technologies under a unique architectural proposition that brings together i) the high capacity of fiber and high-frequency radio, ii) the audacity of converged FiWi fronthauling, iii) the spectral efficiency of analog modulation and coding schemes, iv) the flexibility of mesh self-organized networks, v) the efficiency of high-speed and time-sensitive packet-switched transport, vi) the rapid and cost-efficient service deployment through unikernel technology and finally vii) an enhanced security framework based on post-Quantum cryptosystems.

5G-COMPLETE's proposed converged Computing/Storage/RAN infrastructure effectively merges the 5G New Radio fronthaul/midhaul/backhaul faculties into one common Ethernet-based platform and transforms the RAN into a low-power distributed computer that shapes new

network concepts. 5G-COMPLETE's results will be validated in a range of scalable lab- and field-trial demonstrators in Athens (Greece), Lannion (France) and Bristol (UK). Upon completion, 5G-COMPLETE will have introduced new business models and novel research opportunities that will be streamlined into tangible results by its 13 consortium partners that expand along the complete 5G research and market chain.

Starting and (target) end time of project:

29/10/2019 – 31/10/2023

IoT and/**or Edge Computing research challenges**:

Below information is copied from "Deliverable D2.2: Report on Use Cases, System requirements, KPIs and Network Architecture", 5G-COMPLETE, 2021.

- 5G network architectures introduce the placement and integration of compute resources in various segments of the network deployments in order to co-locate parts of end-user applications and services together with the required softwarized network functions.
- Mobile edge computing, Network Function Virtualization (NFV) and various RAN disaggregation approaches practically aim to materialise these principles, and at the same time drive joint compute/storage and network service provisioning.
- At the same time, resource allocation optimisation comes hand by hand with exploiting the spatio temporal character of demand for compute or network services and resources.
- To this end, 5G network systems are moving towards supporting complete service lifecycles, i.e., various service types, at specific locations and time periods; thus, emphasis is placed on service orchestration in various service terms.
- At the business level, taking these into account, in accordance to the vertical services and stakeholders' interest, services level requirements and agreements are shifting from simple connectivity QoS guarantees (for retail or wholesale purposes) to complex service descriptions, including and possibly combining aspects, such as:
  - Versatile Connectivity (both data rate and latency, and in some cases jitter) QoS guarantees over multiple links
  - Compute resource requests and performance
  - Specific reliability/availability/security thresholds • Specific time constraints and allowances, even requested ad-hoc
  - Scaling capabilities in terms of resources/ number of links etc.
  - Operational aspects and additional functionalities

Expected activities on "Dissemination and Impact on Standards":

The architectural approach of 5G-COMPLETE is inspired by state-of-the-art standardisation activities pursued by ETSI, 3GPP, IEEE and the Open-RAN (O-RAN) alliance. The 5G-COMPLETE solution aims to efficiently integrate a variety of advanced wireless technologies with optical networking to support the required network connectivity for 5G. The project proposes full integration of network with compute and storage resources in support of the very demanding 5G and B5G services. The architectural principles of 5GCOMPLETE exploit the benefits of softwareisation and RAN disaggregation. This document provides a short summary of the business level requirements on service management that emerge from the service provisioning models adopted at various layers in accordance with the 3GPP TS 28 series standards.

2.1.12 5G INDUCE: Open cooperative 5G experimentation platforms for the industrial sector Network Applications

URL/Reference:

https://www.5g-induce.eu/

Abstract:

5G-INDUCE targets the development of an open, ETSI NFV compatible, 5G orchestration platform for the deployment of advanced 5G Network Applications. The platform's unique features provide the capability to the Network Application developers to define and modify the application requirements, while the underlay intelligent OSS can expose the network capabilities to the end users on the application level without revealing any infrastructure related information. This process enables an application-oriented network management and optimization approach that is in line with the operator's role as manager of its own facilities, while it offers the development framework environment to any developer and service provider through which tailored made applications can be designed and deployed, for the benefit of vertical industries and without any indirect dependency through a cloud provider.

Starting and (target) end time of project:

01/01/2021 – 30/06/2024

IoT and/or Edge Computing research challenges:

Network Application Management Platform: The development and integration of a full-stack Network Applications Management Platform including state-of-the-art control and data plane solutions based on intelligent OSS layer, scalable microservices-based cloud orchestration platform, and advance user interfaces for the porting of Network Applications and the monitoring of their attributes.

Transfer Learning-Enabled IoT System for Continuous Prediction of Vehicle CO2 Concentration: We present the design, implementation, and deployment of an IoT-based system for machine learning (ML)-based real-time prediction of CO 2 exhaust concentrations in road vehicles, by means of transfer learning. The system offers a scalable and cost-effective solution for monitoring and predicting CO 2 exhaust concentrations from a vehicle fleet. Moreover, the system is specifically designed to be installed in a low-powered microcontroller unit (MCU) to collect and process data from a CO2 sensor, as well as to perform ML-based emission prediction without a sensor. To accomplish this, we have developed an artificial neural network (ANN) model able to generate training labels to further train subsequent ANN models via transfer learning mechanisms. The resulting models are sent to the IoT devices installed in the vehicle to perform the on-board predictions. Empirical experiments show very promising results in terms of high prediction accuracy and satisfactory transfer learning loop execution time.

Flow Assignment and Processing on a Distributed Edge Computing Platform: The evolution of telecommunication networks toward the fifth generation of mobile services (5G), along with the increasing presence of cloud-native applications, and the development of Cloud and Mobile Edge Computing (MEC) paradigms, have opened up new opportunities for the monitoring and management of logistics and transportation. We address the case of distributed streaming platforms with multiple message brokers to develop an optimisation model for the real-time assignment and load balancing of event streaming generated data traffic among Edge Computing facilities. The performance indicator function to be optimised is derived by adopting queuing models with different granularity (packet- and flow-level) that are suitably combined. A specific use case concerning a logistics application is considered and numerical results are provided to show the effectiveness of the optimisation procedure, also in comparison to a "static" assignment proportional to the processing speed of the brokers.

Expected activities on "Dissemination and Impact on Standards":

The below Input is copied from Deliverable "D7.5 Dissemination, communication and standardization activities - Version c", 5G-INDUCE, 2024

Along the second half of 5G-INDUCE project execution the technology concepts considered and implemented for achieving the actual establishment and formal validation of the trials have been selected, their dependencies have become clear and their status of maturity vs that of previous releases of the 3GPP standards have been assessed. In an Innovation Action project like 5G-INDUCE, the daily tasks of the project i) first of all leverage stable technology developments as a safe baseline to rely upon (this was mostly 3GPP Rel15 and Rel16), ii) integrate extensions beyond commercially available solutions for incorporating evolving concepts and architectures from the immediately previously released standards (this was Rel16 and then Rel17), and iii) identify beyond the state of the art concepts and solutions that address gaps identified at industry solutions and latest or even still developing standards (this has been the case for, firstly, Rel17 and then Rel18). Thus, in the first half of 5G-INDUCE project focus on 3GPP standardization was on Rel17 whilst for the second half of the project the addressed release of 3GPP has been Rel18.

The below listed contributions towards 3GPP address identified gaps, and propose generic technological solutions that could also be applied to other domains, now or in the future, so hopefully creating a higher impact in the technology development, over time.

It is the case of:

- 23.502 CR 3953 - AIMLsys - QoS filtering criteria corrections – 2023-04-06 (Ericsson)
- 23.501 CR 4191- Translation of Internal-External Information for Assisting Application Layer AI/ML Operations – 2023-04-07 (Ericsson)

Both referenced contributions were approved and are now part of the 3GPP Rel18 standard.

2.1.13 5GMED: sustainable 5G deployment model for future mobility in the Mediterranean Cross-Border Corridor

URL/Reference:

https://5gmed.eu/

Abstract:

The 5GMED Project aims to bring a **sustainable 5G deployment model for future mobility** in the Mediterranean Cross-Border Corridor. **5GMED** demonstrates advanced Cooperative Connected, and Automated Mobility (CCAM) for the automotive sector and railway communication services along the Mediterranean cross-border corridor between Figures, Spain and Perpignan, France, enabled by a multi-stakeholder compute and network infrastructure deployed by MNOs, neutral hosts, and road and rail operators, based on 5G (3GPP Release 16).

Starting and (target) end time of project:

01/09/2020 – 31/08/2024

IoT and/or Edge Computing research challenges:

Edge Computing

5GMED, an H2020 5GPPP Phase III European Project, intends to demonstrate advanced Cooperative Connected and Automated Mobility (CCAM) and Future Railway Mobile Communications System services (FRMCS) along the cross-border between Spain and France. This initiative is enabled by a consortium that includes 21 partners, coordinated by Cellnex Telecom.

One of the key technologies in this project is **Edge Computing**. Edge Computing is similar to cloud computing, however the storage and compute capabilities are extended at the network's edge by deploying servers in the edge sites **closer to the end-users**. Data transmission to and from the cloud won't be necessary, enabling faster data transmission and processing and better service performance.

5G mobile technology enables Edge Computing's potential: The Edge Computing's potential is further enabled by the 5G mobile technology, which is able to support demanding new service types, such as Ultra-Reliable Low-Latency communications (**uRLLC**), enhanced mobile broadband (**eMBB**), and Massive Machine Type Communications (**mMTC**). The deployment of Edge Computing requires an edge orchestrator to achieve automated management of the lifecycle of the infrastructure, the network functions, and the applications associated with it. The edge orchestrator provides a mechanism to orchestrate these network layers in a unified approach.

Edge Computing to digitalize the road infrastructure, intelligently manage traffic and more: In the context of 5GMED, Edge Computing is facilitated by deploying a 5G network to provide connectivity and coverage at both sides of the border. In this cross-border 5G infrastructure, several innovative use cases require Edge Computing capabilities:

- by **digitalizing the road infrastructure** with the help of Edge Computing and 5G, automated driving on highways with safety is made possible. This is achieved by placing the intelligence at the network's edge, i.e., close to the vehicles;
- **intelligent traffic management** results in safe and efficient mobility by quickly detecting and anticipating possible dangerous situations and events such as traffic jams and providing warnings in a rapid manner;
- the **follow-me concept**, where infotainment content should be delivered in a timely manner to the moving user (both in automotive and train scenarios).

The applications and services in 5GMED are managed by the **NearbyOne orchestrator**, which is a multi-domain orchestration platform, federated between borders to ensure seamless operations by coordinating and orchestrating resources and services across the compute continuum.

Expected activities on "Dissemination and Impact on Standards":

The main relations between 5GMED and the standardisation ecosystem was identified within the following working groups:

- 3GPP: working groups for defining the global specification for 5G. This includes everything from the air interface to network architecture and protocols
- ETSI: 5G dedicated working groups
- SAE: 5G dedicated working groups
- 5GAA: working groups dedicated to development standards for 5G-enabled mobility services
- SSIG: the working groups created for the satellite industry interested to promote the satellite into different standardization bodies, mainly the 3GPP. This group is in charge of coordinating the 3GPP standardisation contributions
- GSOA: is the CEO-driven association representing the satellite industry, GSOA provides a platform for collaboration between companies involved in the satellite ecosystem globally and a unified voice for the sector.

2.1.14 5GMETA

URL/Reference:

https://5gmeta-project.eu/

Abstract:

The 5GMETA open platform aims to leverage car-captured data to stimulate, facilitate and feed innovative products and services. Cars capture and generate huge volumes of real-time data about the driving dynamics, the environment and the driver and passengers' activities. With connected and automated mobility applications expanding at fast pace, the value of data from vehicles is vital not only for the automotive industry, but also for new players such as SMEs and high-tech start-ups. By expanding 5G network functions, 5GMETA will stimulate and facilitate innovative products and services whilst ensuring data.

Starting and (target) end time of project:

01/09/2020 – 29/02/2024

IoT and/or Edge Computing research challenges:

The key challenges and features of the 5GMETA platform are:

- 5G features-ready: leverages 5G connectivity to enable instantaneous data sharing, crucial for time-sensitive applications like autonomous driving and smart city services. 5GMETA envisions
- the use of 5G New Radio (NR) for low-latency messaging, as well as edge computing to deploy low-latency CCAM services.
- Open-source: the platform's source code is publicly available under European Union Public License v1.2. Its dependencies (Open Source Mano, Kubernetes, Kafka, etc) are all available under open-source software licenses.
- Layered architecture: the 5GMETA platform has a hierarchical architecture, using the cloud layer to centralise the production and consumption, and the edge to gain the capillarity of the distributed edge infrastructure to perform data anonymization and sampling as closer to the producing sensor and device as possible
- Scalable: designed to grow with the needs of the CCAM industry, supporting large-scale data transactions and a growing number of users.
- Monetization: each dataflow is associated with a concrete license that establishes the legal terms and conditions under which users can access, use, modify, and distribute the data. Only the data samples satisfying the license conditions are transferred and received by consumers. In addition, the data consumption and computing resources are metered. The latter might for example support a pay-as-you-go approach for pricing.
- Efficient edge processing: reducing operational expenditure as the consumers scale up, by means of cost-performance schemas on data scalability reusing the required processing to common pricing plans and data queries.
- Geo-filtering: regions of interest can be defined for geo-pinned data filtering when querying data.
- Support of data producers' mobility: vehicles are moving nodes that pose a great challenge for a multi-edge scenario. The platform includes edge discovery and handover mechanisms to
- seamlessly move from one serving edge to another.
- Security: the API access is secured with authentication, communication is encrypted and containers are signed to ensure trust.

Expected activities on "Dissemination and Impact on Standards":

5G-META is relevant for CCAM on the topic of **IoT data access standardisation**. 5G-META is developing and integrating platform to ingest and deliver car data, and its objectives include CCAM use cases.

The relevance for standards is in the data shared by OEM on the cloud/edge. This project is collaborating to ETSI-MEC standards, e.g. the interfaces for applications to access vehicle data on MEC (ETSI MEC.030 V2X API), and to retrieve information nodes in a certain area (MEC Location API ETSI GS MEC 013).

Findings of 5G-META are expected to continue the work on IoT but also to contributed to standardization of *Vehicle-to-Network (V2N) data sharing*, addressed in AUTOPILOT (ETSI-M2M) and C-ROADS Task Force 4 ("Hybrid Communication") but not standardized, yet. This is a remarkable gap, considering the **increasing role of V2N in the future**, also thanks to 5G.

5GMETA contribution to ISO standardisation work

ISO Technical Committee 204 on "Intelligent Transport Systems" has recognised that Artificial Intelligence and Big Data standardisation is gaining momentum in all different domains of standardisation.

ISO Technical Committee 204's scope is to frame and provide standardisation of information, communication and control systems in the field of urban and rural surface transportation, including its intermodal and multimodal aspects. The Committee also deals with traveller information, traffic management, public and commercial transport, emergency services and commercial services in the intelligent transport systems (ITS) field.

The Technical Committee has established the new Working Group 20 (WG20). WG20 will focus on "Big Data and Artificial Intelligence supporting ITS" and will work on Intelligent Transport Systems specific use cases. To that end, ISO TC204 WG20 has launched a call for contribution to obtain appropriate ITS specific and AI and/or Big Data relevant input(s) for this standardisation work. Collected inputs will be published in the ISO technical report TR 12786 titled "Intelligent transport systems — Big data and artificial intelligence supporting intelligent transport systems — Use cases".

5GMETA is proud to contribute to this effort by proposing a use case named "Crowd-sourced AI dataset generation and model update". The use case contributes by describing the project results' on crowd-sourced dataset generation and Machine Learning model update through connected vehicles in the field of Advanced Driver Assistance Systems (ADAS) and Autonomous Driving (AD).

2.1.15 5G-VICTORI

URL/Reference:

https://www.5g-victori-project.eu/

Abstract:

5G solutions for verticals is a well-defined European objective. This requires developing 5G infrastructures to address a wide range of applications adopting flexible architectures, offering converged services across heterogeneous technology domains with unified software control. However, vertical industries today can only verify use cases in small scales in commercial environments, before investing in large scale deployments. Through ICT-17 projects 5G infrastructures become available to verticals to test their applications, however large-scale trials are still not possible. 5G-VICTORI will conduct large scale trials for advanced vertical use case verification focusing on Transportation, Energy, Media and Factories of the Future and cross-vertical use cases. It leverages 5G network technologies developed in 5G-PPP Phase-1 and Phase-2 projects 5G-XHaul and 5G-PICTURE and exploits extensively existing facilities interconnecting main sites of all ICT-17 infrastructures i.e. 5G-VINNI, 5GENESIS and 5G-EVE and the 5G UK test-bed in a Pan-European Infrastructure.

The project will provide enhancements of existing infrastructures towards integration of a large variety of vertical and cross-vertical use cases. 5G-VICTORI's platform aims to transform current closed, purposely developed and dedicated infrastructures into open environments where resources and functions are exposed to ICT and vertical industries through common vertical and non-vertical specific repositories. These functions can be accessed shared on demand and deployed to compose very diverse set of services in a large variety of ecosystems. 5G-VICTORI's uniquely strong consortium brings together major players form ICT including operators, equipment vendors academic and research organisation and SMEs as well as main players from vertical industries including nationwide rail and electricity operators, rail technology vendors, media content delivery players and a number of SMEs focusing on advanced vertical services.

Starting and (target) end time of project:

01/06/2019 – 30/06/2023

IoT and/or Edge Computing research challenges:

Zero-Touch Network Orchestration At The Edge: to autonomously provide an end-to-end orchestration platform to orchestrate, monitor, and profile network services. Subsequently, we describe a new method to autonomously generate performance profiles of these network services and compute optimum resources required to meet the given KPIs and performance targets.

Transforming a legacy facility to a Smart Factory: A typical factory consists of several low functionality sensors. This work presents an architecture that can enhance the day-to-day operation of the site by combining modern IoT and legacy equipment and transforming the site for the 5G era. Operation and security of the site will benefit from the low latency the proposed Mobile Edge Computing architecture offers. Constant and uninterrupted monitoring makes preventive maintenance decisions even more accurate. Multitier architecture allows monitoring of each site to be performed locally without delays, while overall monitoring and control of remote sites is feasible as well.

Expected activities on "Dissemination and Impact on Standards":

The standardisation activities within 5GVICTORI are initially focused on the following topics/domains:

5G Networks technology-specific:

- IEEE Wireless technologies.
- 3GPP network technologies RAN (Radio Access Network), CN (Core Network).
  - 3GPP RAN1/RAN2, ORAN forum: monitoring of activities and possible contribution to RAN API.
  - 3GPP RAN/SA: monitoring of activities and possible contribution focusing on interfacing further evolved multimedia broadcast multicast service (FeMBMS) with 5G Core Contribution on native 5G Broadcast support.
- MANO technologies, in particular OSM (Open Source Management and Orchestration). Open Source MANO (OSM): participation in the OSM community to actively promote the activities of 5G-VICTORI, particularly in relation to cross-domain orchestration.
- Software-Defined Networking (SDN).
- ETSI NFV Information modelling, ETSI Multi-access Edge Computing (MEC).

5G Networks operation/deployment-related:

- NGMN (Next Generation Mobile Network): monitoring of groups' activities, and possible contribution.
- Vertical Industries and Services – specific domains such as:
  - Transportation (Rail),
  - Factories of the Future,

- Media,
- Energy.

2.1.16 AI@EDGE: A Secure and Reusable Artificial Intelligence Platform for Edge Computing in Beyond 5G Networks

URL/Reference:

https://aiatedge.eu/

Abstract:

Our vision is that Artificial Intelligent Systems are irreversibly set on the evolutionary path of every future vertical as well as of every object and service we humans will interact with in the near future. This trend is motivated by the need to support elastic and demanding real-world use cases such as automated and cooperative mobility, e-health, gaming, entertainment, etc. For this reason, in AI@EDGE we leveraged the concept of **reusable, secure, and trustworthy AI for network automation** to achieve an EU-wide impact on industry-relevant aspects in multi-stakeholders' environments. AI@EDGE approach to answer the above-mentioned challenges has two lines of action. First, we designed, prototyped, and validated a network and service automation platform capable of supporting flexible and programmable pipelines for the creation, utilization, and adaptation of secure and privacy-aware AI/ML models. Second, we used this network and service automation platform to orchestrate AI-enabled end-to-end applications. Here, we introduced the novel concept of Artificial Intelligence Functions (AIFs) to refer to the AI-enabled end-to-end applications sub-components that can be deployed across the AI@EDGE platform.

Starting and (target) end time of project:

01/01/2021 – 31/12/2023

IoT and/or Edge Computing research challenges:

- **Edge AI assisted monitoring of linear infrastructures using drones in BVLOS operation**: by incorporating AI and Edge Computing functionalities for automated monitoring of road infrastructures in BVLOS (Beyond Visual Line of Sight) mode.
- **Enabling Intelligence Inclusiveness in Edge to Cloud Continuum: Challenges and Opportunities:** Edge to Cloud Continuum is a concept that integrates cloud computing and cellular networks that has been gaining popularity due to its potential to provide a seamless user experience and address the challenges of managing complex multi-domain networks involving massive IoT devices. Enabling intelligence in the Edge to Cloud Continuum can further enhance its capabilities, offering benefits such as reduced latency, improved scalability, enhanced resource utilization, and increased context awareness.

Expected activities on "Dissemination and Impact on Standards":

To maximise the impact of AI@EDGE regarding standardisation, a three-step strategy has been established from the beginning of the project:

- Identification of relevant standards AI@EDGE can rely on.
- Identification of gaps. The project will analyse relevant standards and identify gaps in current state of standards development to fulfil the project objectives and so refine technical and scientific contributions.
- Contributions to standards in different forms. Not all the project's developments necessarily have to be included into standard documents.

ITU-T FG autonomous networking: The ITU-T Focus Group on Autonomous Networks has as main objective to define an exploratory road on the requirements of future networks, real-time responsive experimentations and draft technical reports and specifications of autonomous future networks. Moreover, as a results of these specifications, the focus group aims to provide an open platform for experimentation where to perform pre-standards activities related to the topics of the groups.

ETSI Plugtests: For more than two decades, ETSI Plugtests have proved to be a valuable tool in the development of global standards. Plugtests events serve two main purposes:

They provide essential feedback to ETSI technical committees to help improve standards and to accelerate the standards-making process.

They enable engineers to get together to test the interoperability of their implementations – which can reduce a product's time-to-market. The benefits of such events include:

- improving the interoperability of products and services
- supporting the deployment of new technologies
- enabling networking between partners, competitors and other experts validating ETSI standards. Plugtests are organized by ETSI's Centre for Testing and Interoperability (CTI). The CTI offers a wide range of services for testing and interoperability and organizes an average of 12 Plugtests events every year, covering diverse technologies and offering a program of events that responds to market demand.

2.1.17 Evolved 5G: Experimentation and Validation Openness for Long-term evolution of VErtical inDustries in 5G era and beyond

URL/Reference:

https://evolved-5g.eu/

Abstract:

Upgrading the 5G experimentation and openness potential in Europe: As 5G is gearing up for market deployment to incorporate realistic business cases, Europe is taking steps to lead global developments. The materialisation of the fifth generation of telecommunications systems, which will provide ultra-high bandwidth, massive machine to machine communications and low latency connectivity, hinges on the development of network applications (NetApps). The EU-funded EVOLVED-5G project will upgrade the 5G experimentation potential in Europe and materialise the openness of 5G to vertical industries by creating a NetApp development and verification environment. It will also enable the digital market around NetApp designing. Quantifying the performance and flexibility that 5G provides to verticals is also planned, as is maximisation of the business potential from the integration of 5G in manufacturing.

Starting and (target) end time of project:

01/01/2021 – 31/12/2023

IoT and/or Edge Computing research challenges:

The intense research work on 5G experimentation in Europe has reached the point where the evolved 5G capabilities, provided through the Service-Based Architecture (SBA), are to be exploited by third party innovators.

- Oenness is the realisation of network programmability through standard APIs. An endeavor that is expected to shape a new and dynamic ecosystem in mobile networks from both the technology and marketing perspectives.
- Compose services by consuming 3GPP APIs (native APIs) as well as other telco assets (referring to business support system – BSS APIs, e.g. service orchestration APIs).
  - For example, a Network App could consume APIs that provide monitoring events and network slice configuration analysis to compose a service that guarantees quality of experience for latency-sensitive applications

Expected activities on "Dissemination and Impact on Standards":

The standardization of EVOLVED-5G results has focused on relevant standards development organizations (SDOs) pertinent to the areas of Mobile System Standards and 5G Software Networks orchestration. The EVOLVED-5G team, through an initial analysis performed

The project focused on participating and contributing in 3GPP SA2 & SA6 WGs (LNV & TID), 5G-PPP Architecture (FOG, NCSRD, LNV) and Pre-standardization WGs (LNV), GSMA (TID), ETSI OpenCAPIF SDG (FOG, NCSRD, TID, UMA, LNV), ETSI-OSM (ATOS), ETSI-MEC ISG (LNV), TM FORUM (MAG), IEEE TSN (UMA), and other SDOs related to Industry 4.0 and FoF bodies, such as the AIOTI (INTRA & UPV), BDVA/DAIRO (INTRA), EFFRA (INTRA), and 5G-ACIA (LNV).

2.1.18 BD4NRG: Big Data for Next Generation Energy

URL/Reference:

www.bd4nrg.eu

https://cordis.europa.eu/project/id/872613

Abstract:

The rising decentralization of the energy system is unveiling an enormous opportunity for energy stakeholders to leverage on big data & AI technologies to improve decision making. There are however some barriers hampering the exploitation of this potential, such as the lack of standardized big data architectures for smart grids and regulatory frameworks not enabling data sharing. In that respect BD4NRG is:

- Delivering a reference architecture for Smart Energy, which aligns BDVA SRIA, IDSA and FIWARE architectures, SAREF standard and extend COSMAG specification to enable B2B multi-party data exchange, while providing full interoperability of leading-edge big data technologies with smart grid standards and operational frameworks.
- Evolving and upscaling a number of technology enablers (such as scalable sovereignty-preserving hybrid DLT/off-chain data governance, big data elastic pipeline orchestration, IoT/edge-cloud AI-based federated learning and multi-resource sharing tokenized marketplace), loosely integrate and deploy them within the BD4NRG framework.
- Delivering an open modular big data analytic toolbox as front-end for one-stop-shop analytics services development by orchestrating legacy and/or third-party assets.
- Validating such framework through the delivery of predictive and prescriptive edge AI-based big data analytics on 12 large scale pilots, deployed by different energy stakeholders (TSOs and DSOs power network operators, aggregators, storage/renewable assets operators, local energy communities, ESCOs, power market operators, municipalities, financial institutions and ENTSO-E), fully covering the energy value chain.
- Setup a vibrant data-driven ecosystem, which will federate new energy data providers, attract SMEs for novel energy services provisioning through cascading funding.

Starting and (target) end time of project:

01/01/2021 – 31/12/2023

IoT and/or Edge Computing research challenges:

- Edge-based Big Data Analytics for smart energy grids
- Development of IoT/edge big data management enablers
- IoT/edge-cloud AI-based federated learning allowing sharing and learning across multiple organizations and stakeholders without sensitive data opening

Expected activities on "Dissemination and Impact on Standards"

AIOTI: The project partners have (and are building new) different relationships with EU initiatives on the topics relevant to the project results for contributing on standardisation activities, but in the IoT and Edge computing the more relevant is the AIOTI where BD4NRG is represented and

usually provides contributions according to the opportunities and if relevant, in the WG Energy, WG Standardization, WG Digital for Green.

2.1.19 An Open Ecosystem for European strategic autonomy and interoperability across the computing continuum industry (OpenContinuum)

URL/Reference:

https://cordis.europa.eu/project/id/101070030

Abstract:

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.

Starting and (target) end time of project:

01/09/2022 – 31/08/2024

IoT and/or Edge Computing research challenges:

The project has just been initiated. The following challenges are mentioned:

- baseline common open architecture for computing continuum research projects, reinforced collaboration between European public and private initiatives from Cloud to edge to IoT
- increased awareness on the importance of Open Source and standards for EU digital autonomy.

2.1.20 Unlocking the Cloud Edge IoT demand potential in Europe (Unlock-CEI)

URL/Reference:

https://cordis.europa.eu/project/id/101070571

Abstract:

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 cloud-edge-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.

Starting and (target) end time of project:

01/06/2022 – 30/11/2024

IoT and/or Edge Computing research challenges:

The project pays specific attention to data governance issues, leveraging the relationship with industry-driven initiatives such as Gaia-X and CCAM (Connected, Co-operative & Automated Mobility) partnership. UNLOCK carries out a systematic assessment of the state of the open European CEI ecosystem and develop future market scenarios and related market pathways for the development of the open European CEI ecosystem. It will engage with industry stakeholders representing the most relevant industry value chains in Europe for CEI potential demand and develops a productive and effective interface between the demand constituency and the supply side, including the coordination of HE projects resulting from CL4-2021-DATA-01-05, CL4-2022-DATA-01-02, and CL4-2022-DATA-01-03 and Cluster 3 cybersecurity projects. It finally designs and implement a coordinated communication and dissemination strategy running throughout the lifetime of the project to create awareness about the whole of the European demand-side landscape.

2.1.21 Visualization of the Edge Computing EU funded completed projects landscape

This section provides a landscape visualization of the completed Edge Computing projects funded by the EU, that are introduced in this report.

The "Edge Computing EU funded completed projects landscape (Technology and Marketing Dimensions)", shown in **Figure 9**, is a graphical representation that highlights the main activity (up to the day of generating this representation) of the ongoing projects in the area of Edge Computing, according to the Business to Consumer (B2C) vs. Business to Business (B2B) (horizontal axis) and the Connectivity vs. Service & App (vertical axis) classifications.

The projection of these edge computing completed projects into vertical industry domains is shown in **Figure 10** and for standardisation activities in different SDO's and initiatives is shown in **Figure 11**.

The dimensions, the vertical/horizontal domains and standardisation organisations and initiatives of the landscapes and the method used to visualize completed projects into these landscapes shown in **Figure 9**, **Figure 10** and **Figure 11** respectively, are the same ones as defined in Section 1.1.26.

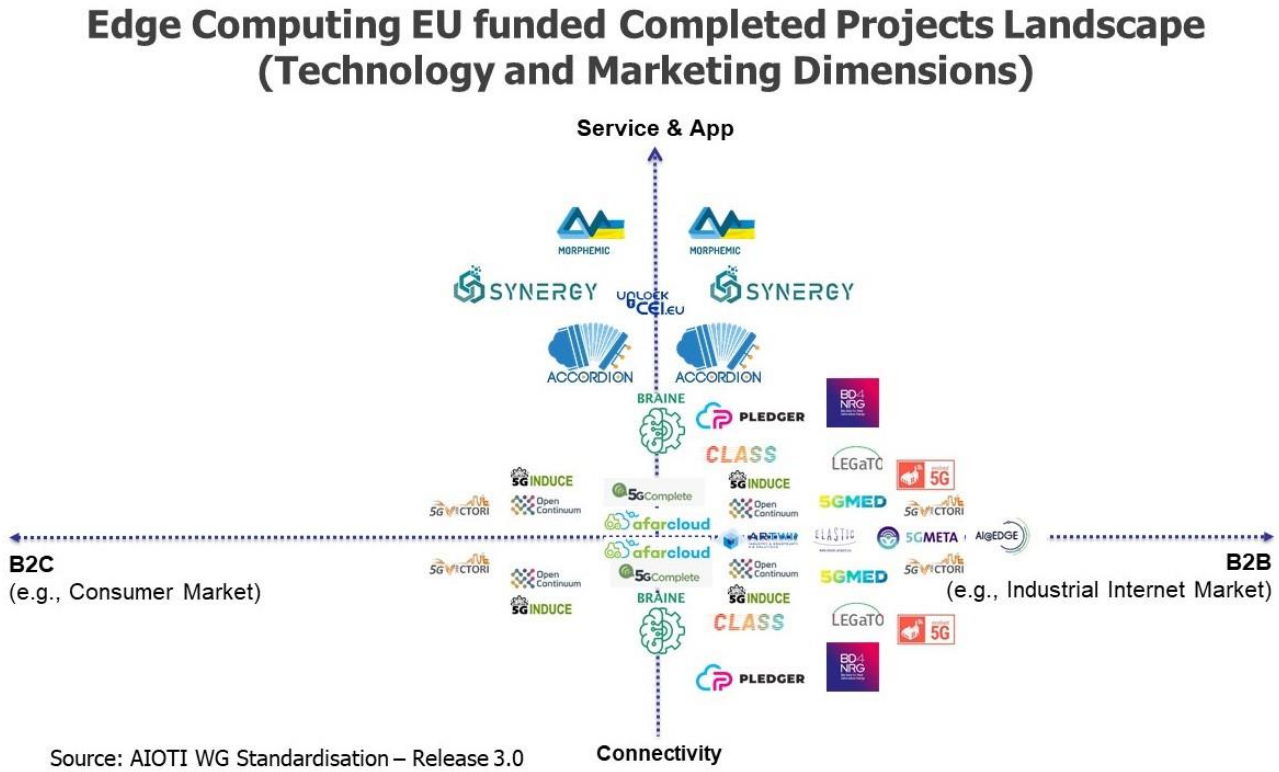


Figure 9: Edge Computing EU funded Completed Projects Landscape, when Technology and Marketing Dimensions are used

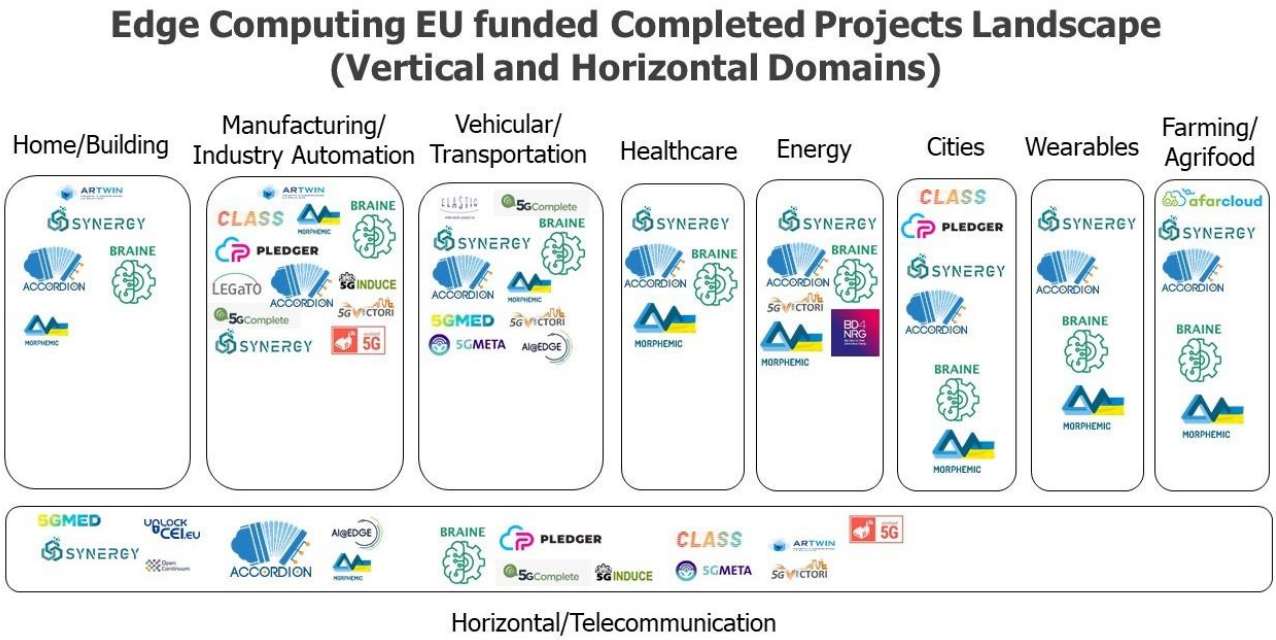


Figure 10: Edge Computing EU funded Completed Projects Projection on Vertical and Horizontal Domains

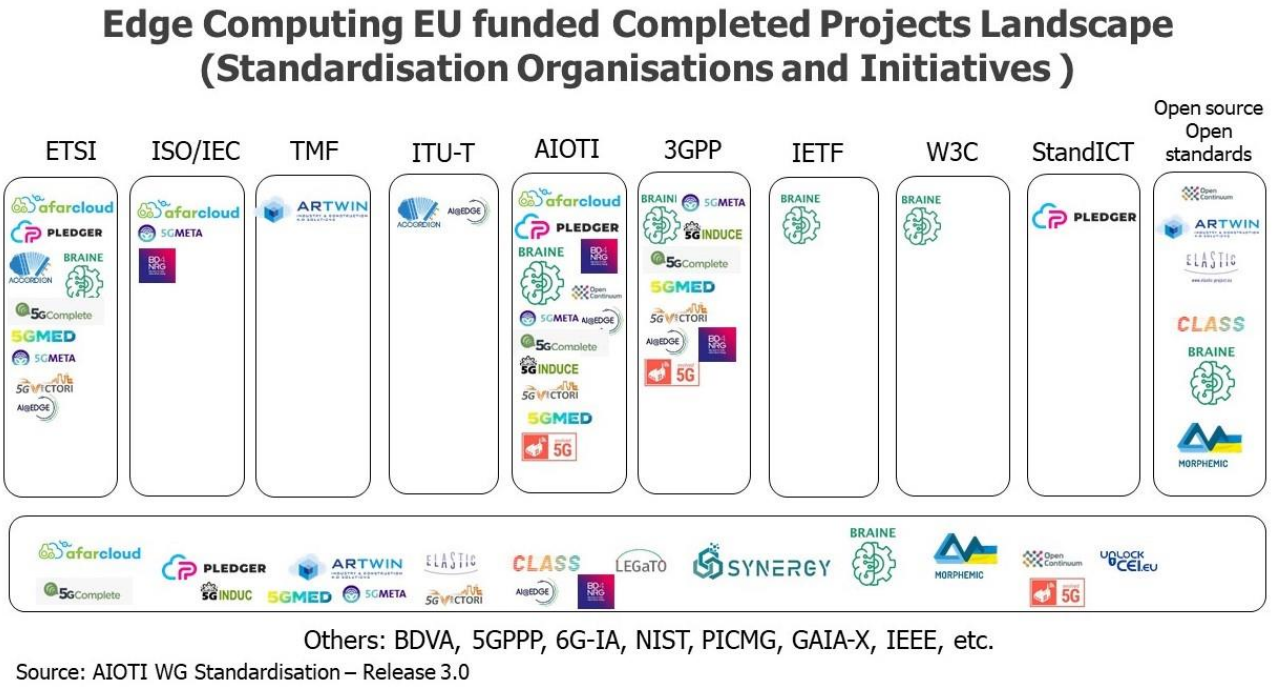


Figure 11: Edge Computing EU funded Completed Projects Projection on Standardisation Organisation and Initiatives

2.2 Ongoing Projects

This section provides description of Edge Computing EU funded ongoing projects.

2.2.1 AI4CSM: Automotive Intelligence for Connected Shared Mobility

URL/Reference:

https://ai4csm.eu/

https://cordis.europa.eu/project/id/101007326

Abstract:

The AI4CSM project will develop advanced electronic components, systems and architectures for future mass-market Electric, Connected, Automated and Shared (ECAS) vehicles for the digital transformation in the automotive sector to support the mobility trends and accelerate the transition towards a sustainable ecosystem based on the "Green Deal" principles. The EC is taking initiatives to ensure that digital technologies such as AI, 5G, IoT and cloud/edge computing can accelerate the transition of the automotive industry to electrical, autonomous, connected, and shared vehicles. AI4CSM will deliver key innovations in technical areas including sensor fusion and perception platforms; efficient propulsion and energy modules; advanced connectivity for cooperative mobility applications; vehicle/edge/cloud computing integration concepts; new digital platforms for efficient and federated computing; and intelligent components based on trustworthy AI techniques and methods. AI4CSM will design scalable and embedded intelligence for edge and edge/cloud computing. AI4CSM consists of 8 collaborative R&D clusters, gathering 41 partners from 10 countries. AI4CSM will reinforce user acceptance and affordability by convenience and services for the major transition to a diverse mobility. AI4CSM addresses the increasing demand of mobility, supporting future traffic concepts and strengthen the European automotive manufacturing base as a global industry leader.

Starting and (target) end time of project:

01/05/2021 – 28/02/2025

IoT and/or Edge Computing research challenges:

In the eight collaborative R&D clusters will be worked on the following IoT and Edge research challenges and innovations (only these innovations are referenced, of course there are others to meet too):

- Development of smart edge- and cloud-based building bricks for autonomous mobility interconnected with secure communication architectures and systems, particularly on secure edge/cloud data utilization
- Architectures and platforms (semiconductors, software, systems) on in-car, edge and cloud level
- C-ITS and cloud connectivity
- Driver's health monitoring
- Natively integrated telematics
- Cloud fusion of edge perception results into the digital twin
- Low-latency vehicle/edge/cloud connectivity
- Sensor-network fusion and AI-based perception
- Automated cloud-based learning and scenario generation
- Standardized data exchange for digital twins (via edge-cloud)

- Collaborating with standardization organizations on IoT, cloud, AI and automotive standardization for advanced and highly automated vehicles and intelligent transport systems.

Expected activities on "Dissemination and Impact on Standards":

One of the eight collaborative R&D clusters is dedicated to "Impact on Green Deal, Standardization, Certification, Ethical Aspects" in collaboration with the other seven R&D clusters.

- Evaluate the results of technology development and the experiences achieved in the demonstrators (use cases, in context of edge- and cloud computing, like robot taxi, virtual City routing, lessons from critical scenarios, trustworthy and secure AI in combination with cloud-based learning and scenario generation, C-ITS and cloud computing for multimodal connectivity, health monitoring supported by intelligent cloud data to achieve preventive maintenance, etc.),
- Raise awareness of existing and evolving standards in the addressed areas of interest (including IoT, Edge/cloud computing, connectivity, and others) and their application,
- Collaborate with/join relevant standardization groups in ISO, IEC, ETSI, and ISO/IEC JTC1 SC41 (IoT), SC 38 (Cloud computing and distributed platforms) and SC42 (AI) and related automotive standardization groups in ISO TC22 SC32 (road vehicles, e.g., automated driving systems, connected vehicles end-to-end safety), ISO TTC22 SC31 (Extended Vehicles) and others to contribute to standards and influence evolving standards based on AI4CSM experiences and results.
- Dissemination of the results among stakeholders, including standardization committees and authorities, and the industrial and scientific communities on fares, exhibitions and conferences
- Align stakeholders and relevant groups in the semiconductor industry and the automotive industry to support the green-deal initiative.

Acknowledgement:

AI4CSM project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 101007326. The JU receives support from the European Union's Horizon 2020 research and innovation programme. It is co-funded by the consortium members and grants from Germany, Netherlands, Czech Republic, Austria and Norway, Belgium, Italy, Latvia, India.

2.2.2 AURORAL: Architecture for Unified Regional and Open digital ecosystems for Smart Communities and Rural Areas Large scale application

URL/Reference:

https://www.auroral.eu/#/

https://cordis.europa.eu/project/id/101016854

Abstract:

AURORAL focuses on delivering interoperable, open and integrated digital platforms that serve rural regions and contribute to a European, globally competitive, ecosystem of digital services and businesses to empower Smart Communities. AURORAL aims to deliver a dense network of Smart Communities under a common multi-interoperability framework aimed at succeeding the just, fair and open digital transformation.

AURORAL pilot regions implement the concept throughout Europe, targeting an investment platform of innovative services, primary focusing Smart Communities onto rural areas. **AURORAL digital environment** is demonstrated by cost-efficient and flexible cross-domain applications through large-scale pilots in eight European regions: **Alentejo (PT), Southern Burgenland (AT), Penedès (ES), Piemont (IT), Lapland (FI), Hålogaland (NO) – Tourism, Hålogaland (NO) – Health, Västerbotten (SE). AURORAL is expected to be a driver** of the emergence of a widespread network of Smart Communities in Europe and ultimately it is expected to contribute to balance urban and rural opportunities for all Europeans.

Starting and (target) end time of project:

01/01/2021 – 31/12/2024

Challenges:

In situations where life is at risk, technology and operators need to be efficient and well-coordinated. Technology for managing and navigating unstructured data need to in place and well-maintained. Knowledge of topography, available resources, previous experience and planning skills will be used to assist UAS (Unmanned Aerial System) in training, planning, tactical and operational missions.

The architecture of the AURORAL platform allow for sharing of horizontal services through agents. Data management is handled through VICINITY which offer a privacy-by-design approach. Thus, satellite data from ESA through the Copernicus network and situational alerts received from public databases can support local awareness. Furthermore, UAV planning tools from the aerial authorities provide information on no-fly zones and assist in relocating resources. Maps and GIS data with information on topography and infrastructure at land and at sea can further be used to identify areas of interest or concern. Other resources are based on public base maps, weather information and prognosis to further support local preparedness and contingency plans.

Collecting and processing data can be handled by service providers that offer the relevant subsets through the AURORAL platform. Thus, services can be replicated and scaled up based on need and location.

The health use case benefits from this approach. Scenarios such as search-and-alert along trails, search-and-rescue for lost persons in predefined geo-zones, assistance in on-site activities or observation along a predefined path can be built on shared resources.

In particular drones (UAV) hosting LiDAR, video and IR-camera supporting various filters, sensors measuring particles, humidity, temperature, geomagnetic changes are a source for up-to-date information relevant in assisting ongoing missions.

- Registering geolocations using coordinates alongside metadata, and identify points of interest based on dynamic geo-zones, i.e., interchangeable based on existing plans or to support planned or ongoing missions
- Local assignment of predefined settings based on priority and frequency, i.e., emergency, alert, regular services
- Automatic (in-situ) configuration of equipment based on task, i.e., transport of commodity vs. biological material, observation of area for changes in sediments, unauthorized entrance etc.
- Prognosis on scheduled actions based on machine-learning trained on rulesets for events such as entering no-fly zones, monitoring animal well-fare and tourists being caught in natural disasters (such as landslides, flooding, avalanches) at land or at sea.
- Automatic planning and strategy development and assisting in tactical and operational missions
- Establishing digital twin operating on dataspace with topographic data using content from UAV and previous missions
- Identify sources through open data, proprietary data and automatic registration
- Plan for flight and areas to traverse based on 5G coverage map and deploy equipment to alleviate poor reception in areas with ongoing rescue operations
- Integrate IoT devices from field personnel – volunteers, rescue dogs and mobile equipment
- Offering methodologies to reduce complexity in navigating static data and dynamic data from sensors.

Expected activities on "Dissemination and Impact on Standards":

Participation in ISO/IEC JTC 1/SC41:

- Further active participation in ISO/IEC work as mirror group leader.
- Follow up for new Task Forces and new work items.
- Participation in Working Groups for forthcoming standard actions.
- Cooperation using AIOTI for contribution to ISO/IEC TR and evaluation of the AIOTI reports and standards.

Participation in AIOTI:

- Participation in the AIOTI Board that will take place in IoT Week 2022 (Dublin, Ireland).
- Enrolled in WG Standardisation to participate in the SDOs exploration and alignment.
- Enrolled in WG Standardisation to actively contribute to the next release of HLA.
- Contribution to white papers in data spaces subject.
- Enrolled in AIOTI WG Energy, WG Mobility, WG Agriculture.

2.2.3 Autonomous, scalablE, tRustworthy, intelligent European meta Operating System for the IoT edge-cloud continuum (aeROS)

URL/Reference:

https://aeros-project.eu/

Abstract:

The project will deliver common virtualised services to enable orchestration, virtual communication (network-related programmable functions), and efficient support for frugal, explainable AI and creation of distributed data-driven applications. aerOS will be based on continuum infrastructure elements like smart devices, tiny/far/near edge computing nodes, and public/private clouds (including virtual services and NetApps), providing scalable and secure access to applications and services while keeping its data autonomy. The solution will be generic and directly applicable to any vertical, cross-vertical business process, and several different physical or virtual platforms.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

The project has just been initiated. The following challenges are mentioned:

- Optimal orchestration
- Definition and implementation of distributed AI components with explain ability
- Definition and implementation of decentralised security, privacy and trust
- Specification and implementation of a data autonomy strategy for the IoT edge cloud continuum
- Intelligent realisation of Smart Network Functions
- Global ecosystem creation, maximisation of impact and open call conduction
- Definition, Deployment and Evaluation of real-life use cases

2.2.4 Flexible, scaLable, secUre, and decentralIseD Operating System (FluiDOS)

URL/Reference:

https://www.fluidos.eu/

Abstract:

This project will deliver a fluid, dynamic, scalable, and trustworthy computing continuum, spanning across devices and unifying edge and cloud in an energy-efficient manner. FluiDOS will build on consolidated operating systems and orchestration solutions, resource sharing in the computing continuum, AI-based optimisation for cost and energy, and a zero-trust paradigm to enable an open, collaborative ecosystem that will support European digital autonomy. Stakeholders will be involved through pilots and demonstrators in the fields of agriculture, energy, and logistics, challenging the project's ability to adapt to different environments and operating conditions, showcasing its true innovation potential

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

The project has just been initiated. The following challenges are mentioned:

- OPTIMAL ORCHESTRATION Fluidify the edge and unify it with the cloud through a borderless, decentralised continuum leveraging automatic, autonomous resource discovery and integration.
- Move the gravity outside the data centre, creating a cross-provider, community-based computing and service fabric leveraging open-source software.
- Orchestrate services and hyper-distributed applications in a continuous, automated fashion over multiple devices and domains, leveraging energy-efficient AI learning algorithms and training for mobility/behaviour prediction and traffic forecasting.
- Introduce a Zero Trust paradigm aimed at securing the access of geographically scattered resources in an authenticated, authorised manner.
- Enable the emergence of a multi-stakeholder market of edge services and apps, independent from cloud providers and crucial to ensuring European digital autonomy.

2.2.5 Towards a functional continuum operating system (ICOS)

URL/Reference:

https://www.icos-project.eu/

Abstract:

This project will cover challenges of the IoT-edge-cloud paradigm, proposing an approach to embed a set of functionalities, defining an IoT-Cloud Operating System (ICOS). Its aim is to design, develop and validate a meta-operating system by addressing the challenges of device volatility and heterogeneity, continuum infrastructure virtualisation and diverse network connectivity, optimised and scalable service execution and performance, as well as resources consumptions. It will also cover security, privacy, and trust, and reduce integration costs and effective mitigation of cloud provider lock-in effects, in a data-driven system built on openness, adaptability, data sharing and a future edge market scenario for services and data.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

The project has just been initiated. The following challenges are mentioned:

- Design of an intelligent meta OS for the continuum
- Exploiting novel intelligent data and resource utilization methods
- Enforce trustworthy yet open operation
- Demonstrate the project outcomes in key relevant scenarios
- Building an open innovation environment and fostering the creation of new applications in the continuum as well as the science and engineering community

2.2.6 A META operating system for brokering hyper-distributed applications on cloud computing continuums (NebulOus)

URL/Reference:

https://cordis.europa.eu/project/id/101070516

Abstract:

NebulOus will contribute to research in cloud and fog computing brokerage, by introducing advanced methods to enable secure and optimal application provisioning, resource adaptation and reconfiguration. It will contribute to the cloud computing continuum through the development of a meta-operating system and platform to exploit edge and fog nodes, in conjunction with multi-cloud resources, to cope with requirements posed by low latency applications.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

IoT and/or Edge Computing research challenges:

The project has just been initiated. The following challenges are mentioned:

- Development of appropriate modelling methods and tools for describing the cloud computing continuum, application requirements, and data streams; these methods and tools will be used for assuring the QoS of the provisioned brokered services. Efficient comparison of available offerings, using appropriate multi-criteria decision-making methods that are able to consider all dimensions of consumer requirements.
- Intelligent applications, workflows and data streams management in the cloud computing continuum. Addressing in a unified manner the security aspects emerging in of transient cloud computing continuums (e.g. access control, secure network overlay etc.). Conducting and monitoring smart contracts-based service level agreements.

2.2.7 Next Generation Meta Operating System (NEMO)

URL/Reference:

https://meta-os.eu

https://cordis.europa.eu/project/id/101070118

Abstract:

Artificial Intelligence of Things (AIoT) is one of the next big concepts to support societal changes and economic growth, being one of the fastest growing ICT segments. A specific challenge is to leverage existing technology strengths to develop solutions that sustain the European industry and values.

NEMO establishes itself as the gamechanger of the AIoT-edge-cloud continuum by introducing an open source, modular and cybersecure meta-operating system, leveraging on existing technologies and introducing novel concepts, methods, tools, testing and engagement campaigns. NEMO will bring intelligence closer to the data and make AI-as-a-Service an integral part of network self-organisation and micro-services execution orchestration.

Its widespread penetration and massive acceptance will be achieved via new technology, pre-commercial exploitation components and liaison with open-source communities.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

The detailed description of the NEMO project can be found in Section 1.2.2 of this report.

2.2.8 A lightweight software stack and synergetic meta-orchestration framework for the next generation compute continuum (NEPHELE)

URL/Reference:

https://nephele-project.eu/

https://cordis.europa.eu/project/id/101070487

Abstract:

The next generation IoT and Edge Computing technologies are evolving at a rapid pace. This evolution moves in parallel with the increase in the heterogeneity of the IoT technologies. To efficiently manage hyper-distributed applications across heterogeneous infrastructure in the Cloud-to-Edge-to-IoT continuum, convergence of IoT technologies and development of synergetic orchestration mechanisms has to take place. NEPHELE aims to tackle these challenges and enable the efficient, reliable and secure end-to-end orchestration of hyper-distributed applications over programmable infrastructure across the compute continuum, considering the integration of IoT devices with the rest part of the infrastructure. NEPHELE aims to introduce two core innovations, namely: (i) an IoT and edge computing software stack for leveraging virtualization of IoT devices at the edge part of the infrastructure and supporting openness and interoperability aspects in a device-independent way; and (ii) a synergetic meta-orchestration framework for managing the coordination between cloud and edge computing orchestration platforms, through high-level scheduling supervision and definition, based on the adoption of a "system of systems" approach. A set of use cases across various vertical industries are considered, including disaster management, logistic operations in ports, energy management in smart buildings and remote healthcare services.

Starting and (target) end time of project:

01/09/2022 – 31/08/2025

The detailed description of the NEPHELE project can be found in Section 1.2.4 of this report.

2.2.9 High Performance, Edge And Cloud computing (HiPEAC)

URL/Reference:

https://cordis.europa.eu/project/id/101069836

Abstract:

HiPEAC will reinforce the development of Europe's computing ecosystem to support our digitalisation by guiding the research and innovation (R&I) of key emerging technologies, sectors, and value chains. Its goal is to strengthen European leadership in the global data economy and accelerate the digital and green transitions through human-centred innovation. This will be achieved by mobilising partnerships and stakeholders to provide roadmaps on the creation of next-generation computing technologies, infrastructures, and platforms. The aim is to contribute to the technological development and market uptake of advanced applications across the value chain. This next generation of computing will increase European autonomy in the data economy, which is required to support future hyper-distributed applications and provide opportunities for the digital transformation of our economy and society, new business models, economic growth, and job creation.

Starting and (target) end time of project:

01/12/2022 – 31/05/2025

IoT and/or Edge Computing research challenges:

The key aim is to support and contribute to rapid technological development, market uptake and digital autonomy for Europe in advanced digital technology (hardware and software) and applications across the whole European digital value chain. HiPEAC will do this by connecting and upscaling existing initiatives and efforts, by involving the key stakeholders, and by improving the conditions for large-scale market deployment. The next-generation computing and systems technologies and applications developed will increase European autonomy in the data economy. This is required to support future hyper-distributed applications and provide new opportunities for further disruptive digital transformation of the economy and society, new business models, economic growth, and job creation.

2.2.10 CloudSkin: Adaptive virtualization for AI-enabled Cloud-edge Continuum

URL/Reference:

https://cloudskin.eu/

https://cordis.europa.eu/project/id/101092646

Abstract:

As of today, 80% of the data processing and analysis occurs in cloud data centres, and only 20% of processing occurs at the edge. CloudSkin aims to design a cognitive cloud continuum platform to fully exploit the available Cloud-edge heterogeneous resources, finding the "sweet spot" between the cloud and the edge, and smartly adapting to changes in application behaviour via AI.

CloudSkin's three main innovations are the following:

1. The CloudSkin platform will leverage AI/ML to optimize workloads, resources, energy, and network traffic for a rapid adaptation to changes in application behavior and data variability, re-configuring the "sweet spot" between the cloud and the edge in the face of the rapid varying conditions;
2. The CloudSkin platform will also help users to achieve "stack identicality" across the Cloud-edge continuum, whereby the same (legacy) software stacks (e.g., MPI programs) running in data centres can seamlessly run at remote edges. The development of a new lightweight, portable virtualization abstraction will be paired with the development of new confidential abstractions to protect data while it is in use; and
3. CloudSkin will also contribute to prepare the needed infrastructure to integrate the new virtualized execution abstractions into the virtual resource continuum, particularly, for those Cloud-edge applications composed of small tasks with fast data access and sharing requirements.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

CloudSkin aims to design a cognitive cloud continuum platform to fully exploit the available Cloud-edge heterogeneous resources, finding the "sweet spot" between the cloud and the edge, and smartly adapting to changes in application behavior via AI. To facilitate automatic deployment, mobility and security of services, CloudSkin will build an innovative universal container-like execution abstraction based on WebAssembly that allows the seamless and trustworthy execution of (legacy) applications across the Cloud-edge continuum.

The goals of CloudSkin are the following:

- Smart management for the Cloud-edge continuum: The overall objective is to leverage the generated knowledge from state-of-art AI methods to transparently orchestrate Cloud-edge resources. The key goal is to build a "Learning Plane" that, in cooperation with the application execution framework and continuum infrastructure, can enhance the overall orchestration of Cloud-edge resources. Such plane is the materialization of the cognitive cloud, where decisions on the cloud and the edge are driven by the continuously obtained knowledge and awareness of the computing environment through AI, and particularly, neural networks and statistical learning, taking the challenge of enabling these methods into low-power edge devices.
- Virtual execution for the Cloud-edge continuum: This goal focuses on a new universal and flexible execution abstraction, we called it "Cloud-edge cells", that will enable the execution of legacy and highly granular applications in the cloud continuum. The new container-like execution abstraction will be based on WebAssembly technology. It will enable the execution of the same computation on a wide range of cloud and embedded devices and make task execution "migratable" across different servers and devices in the continuum infrastructure. We will integrate our WebAssembly executor with Kubernetes. More specifically, we will contribute new features to Kubernetes that will support the efficient migration of WebAssembly containers between different levels of the continuum, exploiting WebAssembly's capability for state serialization.
- Infrastructure support for the Cloud-edge continuum: This objective is to prepare the infrastructure to turn it into a virtual resource continuum, where the large set of Cloud-edge cells composing applications can be allocated flexible resources, according to their dynamically changing needs. One of the major challenges here is to design an infrastructure to support extremely short-lived Cloud-edge cells and tasks (of 1 to 10ms, or less) and extremely intense bursts with fast data access requirements. This requires delivering bare metal resource performance to storage, despite virtualization and dynamic reallocation, which today is not possible in the cloud continuum. CloudSkin will achieve this by leveraging high-performance I/O (RDMA networking) and near-storage CPU compute capacity (GPUs, FPGAs) to the fine-grained application tasks.

CloudSkin technology will be demonstrated with four use cases, from four different domains:

- **5G automotive** - Orchestration of edge apps with matching cloud performance and the creation of AI video-analytics.
- **Metabolomics** - Edge/on-premises batch analytics and reduction of cloud offloading for Hybrid Metaspace.
- **Surgery** - Real-time edge video analytics with dynamic resource allocation and Private Deep & Federated Learning at the edge.
- **Agriculture IoT** - Dynamic cloud offloading to match detail level and creation of an IoT-based agriculture data space.

Expected activities on "Dissemination and Impact on Standards":

The project will exchange information with the other RIA projects of the topic HORIZON-CL4-2022-DATA-01-02 in order to exploit results, synergies and maximize impacts and coordinate dissemination activities of the swarms project portfolio. As a facilitator to carry out this duty, the CloudSkin project has already joined the EUCloudEdgeIoT.eu community as a member of the Cognitive Cloud working projects. In the next months, the project is expected to enrol in some of the six individual task forces, offered by the EUCloudEdgeIoT.eu initiative, such as the task force in communication, namely, TF6 Communication.

Since we are in the first year, the dissemination activities will be mainly carried out through the participation of the project in specific venues to share the vision and objectives of the project with other related EU-funded projects.

In this sense, we are organizing the Cloud-Edge Continuum (CEC) workshop (on October 10, 2023, in Reykjavik, Iceland), which will be co-located with IEEE ICNP'23. A key point of the

workshop will be exploiting shared interests among multiple European projects on similar topics. In the workshop, there will be a specific poster walk session where representatives of several projects will be able to interact with each other to find synergies:

- NearData: Extreme Near-Data Processing Platform
- INTEND: Intent-Based Data Operation In The Computing Continuum
- CLEVER: Collaborative edge-cLoud continuum and Embedded AI for a Visionary industry of thE futuRe
- GLACIATION: Green responsibLe privACy preservIng dAta operaTIONs
- CloudSkin: Adaptive virtualization for AI-enabled Cloud-edge Continuum
- SmartEdge: Semantic Low-code Programming Tools for Edge Intelligence
- CAMEO: Creating an Architecture for Manipulating Earth Observation data
- AI for Edge: The Future of Orchestration in the Computing Continuum

The workshop topics of interest clearly align with CloudSkin objectives (e.g., network optimizations, novel system architectures, security/privacy, AI-enabled resource allocation, for the Cloud-Edge Continuum). Of course, we will continue contacting other projects to encourage them to participate. This will be an effective approach to gather researchers from multiple projects related to cloud-edge environments to share insights and foster collaboration.

Moreover, we will also take advantage of conferences and workshops where partners of the project will present their contributions to actively disseminate the project, such as ACM/IFIP Middleware'23 and WoSC9.

By now, they are not planned standardization activities in the project. But several companies in the consortium are expected to actively contribute to standards by the third year of the project (e.g., Gaia-X, or dataspaces).

2.2.11 CODECO: COgnitive Decentralised Edge-Cloud Orchestration

URL/References:

https://he-codeco.eu

https://cordis.europa.eu/project/id/101092696

Abstract:

The overall aim of CODECO is to contribute to a smoother and more flexible support of services across the Edge-Cloud continuum via the creation of a novel, cognitive Edge-Cloud management framework. To achieve this aim, CODECO proposes a unique, smart, and cross-layer orchestration between the decentralised data flow, computation, and networking services, to address Edge-Cloud challenges derived from the rising Internet and IoT service decentralisation. CODECO is developing an ecosystem consisting of open-source toolkits, large-scale experimentation, training tools and events, use-cases across 4 vertical domains (Smart Cities, Energy, Manufacturing, Smart Buildings), multiple events integrated into a unique Innovation and Research Community Engagement Programme.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

- Automated configuration and cognitive Edge-Cloud management, considering a cross-layer behaviour (application to the network), data and meta-data management, and policy enforcement. Privacy and security automation are aspects also addressed in this first layer of automation.
- Privacy preserving decentralised learning and context-awareness, addressed in a cross-layer manner, and focusing on beyond federated learning approaches that may better suit the orchestration of data workflow-computation-networking, addressing application requirements, node usage, prediction of mobility patterns, desired levels of privacy, security, among others.
- Dynamic scheduling and workload migration. Addresses challenges derived from the higher degree of automation due to container and workload mobility between nodes in a single cluster and across different clusters, e.g., optimal placement of workloads according to application requirements; status synchronisation; which information to exchange and to disclose; safe handover. Context-awareness and ML are applied in this context to assist in understanding the system conditions, triggering changes, and on the overall offloading process.
- Joint orchestration of computational and networking resources. On the one hand, the networking infrastructure needs to become more flexible, intent and context-driven, i.e., the network should be seen and worked upon as being a single system. On the other hand, joint computational and networking paradigms, that integrate, by design, aspects such as security/trustworthiness, mobility support, decentralised and flexible naming spaces are key to build a smart, decentralized Edge ecosystem.
- Global view of data in the IoT-Edge-Cloud continuum. Where are datasets stored, what are their characteristics, and what constraints limit how data can be processed and replicated? To achieve this, CODECO collects and manages metadata ("data that provides information about other data") and makes this metadata available to the orchestration and other system components.

CODECO proposes the following assets:

A1: Open, cognitive toolkits and smart Apps, integrating the elastic and advanced concepts to manage, in a smart and flexible way, containerized applications across Edge and Cloud (dynamic cluster and multi-cluster environment

A2: A developer-oriented open-source software repository, to be available in an early stage of the project, thus allowing for early exploitation of initial, advanced results and a better adaptation throughout the project lifetime

A3: Training tools, to support the development of services based on the CODECO framework;

A4: Use-cases across 4 domains (Smart Cities, Energy, Manufacturing, Smar Buildings), as the basis for experimentation and demonstrations

A5: a Research and Innovation community engagement program, based on the different use-cases and including the different CODECO stakeholders

A6: CODECO integration into the large-scale EdgeNet, experimental infrastructure, to assist in the building of experimentation and novel concepts by the research community

Expected activities on "Dissemination and Impact on Standards":

The CODECO consortium and the nature of the CODECO software brings in the possibility to explore liaisons towards different standardisation bodies, pre-normative entities, and standardisation alliances/consortia.

The standardisation work in CODECO is supported by Task 6.3. (October 2023 until December 2025). To best explain the initial points of contributions, Table 3 summarises the standardisation

efforts that partners are already planning, where strong contributions to Gaia-X, AIOTI, ETSI, IETF and BDVA are expected. The contributions shall be developed in a consolidated way, coordinated via the T6.3 leader (IBM), where each industrial partner shall have a representative to support an adequate development of standardisation contributions.

Table 3: Initial planned standardisation liaisons

Entity	Group	Partners	CODECO Contributions	Verification Measures
EUCloudEdgeIoT	**Multiple**	**FOR, ATOS, ECL**	**Architecture, taxonomy, contributions to specific standards, white papers**	
Gaia-X	OWP Data Exchange	FOR, IBM	Contributions to the Gaia-X reference architecture on CODECO data management models; *NetMA; MDM; SWM; ACM*.	Gaia-X white papers: WP3 deliverables; WP6 deliverables.
Gaia-X	Sub-WG Interconnection and networking	FOR	Contributions to network service composition models, based on the CODECO learnings; *NetMA; MDM*.	Gaia-X reference architectures and catalogue; Gaia-X white papers.
AIOTI	WG Standardisation	ICOM, FOR	Raise awareness to the role of CODECO in the context of Smart Cities; integrate the cross-layer CODECO perspective on data management, computation and networking. *All components*.	WG03 reporting; joint standardization meetings organized in CODECO
AIOTI	WG Testing and Experimentation Environments	FOR	CODECO use-cases and EdgeNet interconnections as a reference testbed, aligned with the AIOTI testbed methodology. *All components, use-case customization.*	IG Testbeds events in 2022 and 2023; white papers.
ETSI	CSC[9]	ICOM	Contributions in the context of Cloud/Edge application of CODECO. *ACM, NetMA*	White papers and testbeds.
IETF	ALTO[10]	TID	CODECO application-network integration contributions to existing RFCs. *NetMA*	IETF ALTO draft and RFCs; WP6 reports.
IETF	RAW[11]	FOR	CODECO extensions and support for decentralized Edge computing services. *NetMA; use-case requirements*.	IETF draft; contributions to existing drafts and RFCs.
IRTF	DINRG[12]	FOR, ATH	Integrate the CODECO findings about fields such as networking management; IoT; decentralised Internet services. *All components.*	IETF draft; joint events.
5GPPP	Experts Group	FOR, I2CAT, ATOS	Integrate the CODECO ideas and the role of an automated management of containers in 5G interoperability support for Edge computing. *ACM*	Smart networks vision white papers.
BDVA		IBM, UPRC, ATOS	Contributions to CODECO on AI engineering and trustworthiness aspects in data spaces.	White paper contributions.

9 http://csc.etsi.org/

10 https://datatracker.ietf.org/wg/alto/about/

11 https://datatracker.ietf.org/wg/raw/documents/

12 Decentralised Internet Infrastructure Research Group. https://datatracker.ietf.org/rg/dinrg/about/

Entity	Group	Partners	CODECO Contributions	Verification Measures
EUCloudEdgeIoT	**Multiple**	**FOR, ATOS, ECL**	**Architecture, taxonomy, contributions to specific standards, white papers**	
		INTRA, I2CAT	Contributions are also envisioned to CEN-CENELEC JTC 21 on AI[13] *PDLC*	
ETSI	ENI[14]	ICOM, TID	Contributions in intent-based Edge Service Management for resource and energy efficiency. *PDLC, NetMA*	Proof of Concept (PoC).

2.2.12 VERGE - AI-powered eVolution towards opEn and secuRe edGe architEctures

URL/Reference:

https://www.verge-project.eu

Abstract:

Edge computing involves a connected and distributed ecosystem of highly heterogeneous computing elements, located anywhere across the path between end-devices, access and core network, also sharing boundaries with central cloud infrastructures [VEREGE1] – [VERGE4]. Edge computing can facilitate the implementation of several key innovations in the optimization of Beyond 5G (B5G) networks, such as dynamic network slicing, flexible functional splits or adaptive virtual network functions (VNFs) placement and scaling. Furthermore, the introduction of artificial intelligence (AI) and machine learning (ML) in resource orchestration solutions is enabling a completely new level of closed-loop programmability and automation, especially when near real-time decisions need to be made while handling massive amounts of data, close to the end users. In addition to empowering B5G network optimization and automation, edge computing is a key vertical service enabler across multiple sectors [VERGE5]. Such vertical applications pose significant and diverse challenges on existing network and computing infrastructures. Current edge-enabled 5G architectures lack the required level of flexibility, openness and automation, and the mechanisms to support distributed and disaggregated application and network designs that are needed by such next generation services. Besides, even though edge computing has been widely considered within 5G networks, the adopted approaches have been mainly driven by specific use case requirements leading to a fragmented architectural landscape with respect to the edge deployments and performance aspects [VERGE6][VERGE7]. Hence, further evolution and closer synergy between the B5G and the edge computing paradigms are needed to ensure the real-time responsiveness and fast computation capacity needed to ensure enhanced and dynamic user experience [VERGE8]. To address the above-mentioned gaps and to fully exploit the potential of edge computing, the EU-funded collaborative research project VERGE [VERGE9] [VERGE10] proposes an evolved edge computing architecture integrated with the B5G network fabric. The proposed design aims to enable the seamless execution of cloud-native services, including disaggregated Radio Access Network (RAN) and core network functions, distributed AI and big data workflows, while leveraging data-driven, AI/ML-based solutions for edge and network optimization. Simultaneously, it ensures that the AI-based solutions are secure and trustworthy.

The proposed architecture is modular and scalable, powered through secure data-driven and AI-based solutions that enable its adaptability to the requirements of B5G and forthcoming 6G applications.

In particular, the proposed design aims to enable the seamless execution of cloud-native services, including disaggregated Radio Access Network (RAN) and core network functions,

13 https://www.bdva.eu/node/1814

14 https://www.etsi.org/technologies/experiential-networked-intelligence

distributed AI and big data workflows, while leveraging data-driven, AI/ML-based solutions for edge and network optimization. Simultaneously, it ensures that the AI-based solutions are secure and trustworthy. The proposed architecture is modular and scalable, powered through secure data-driven and AI-based solutions that enable its adaptability to the requirements of B5G and forthcoming 6G applications.

Starting and (target) end time of project:

01/01/2023 – 30/06/2025

IoT and/or Edge Computing research challenges:

The main goal of VERGE is to provide an integrated approach on how to tackle the challenges of edge computing evolution, described around three main pillars:

- "Edge for AI", namely a flexible, modular and converged edge platform design, unifying the lifecycle management and closed-loop automation for cloud-native applications, Multi-access Edge Computing (MEC) and network services across the edge-cloud compute continuum for ultra-high computational performance.
- "AI for edge", namely an AI-powered portfolio of solutions leveraging the multitude of collected metrics for intelligent management and orchestration.
- "Security, Privacy and Trustworthiness of AI-based models at the edge", providing a suite of methods to protect AI models against adversarial attacks, increase their explainability and reliability, and ensure data privacy.

VERGE has devised two use cases to showcase its innovations: i) "An XR-driven edge-enabled industrial B5G applications" and ii) "Autonomous tram services for safety and entertainment in a smart city environment". The latter was described in [VERGE11], together with the expected VERGE innovations and improvement areas that each of the innovations is expected to contribute in the context of B5G and edge computing scenarios. The elaboration of the use cases and associated service requirements led to the initial version of the VERGE system architecture [VERGE12], depicted in **Figure 12**, as well as the initial versions of the three architectural pillars, namely Edge4AI [VERGE13], AI4Edge [VERGE14] and SPT4AI [VEREGE15]that form the proposed architecture for B5G edge evolution. The work is continuing and is expected to help in overcoming the following barriers:

Barrier #1 Data intensive processing at the Edge continuum: dealing with highly distributed and heterogeneous compute resources

Unlike cloud computing where the processing is spread over homogeneous computing and memory resource clusters, edge computing needs to contemplate a heterogeneous panoply of highly distributed processing elements, with different performance and power consumption budgets, memory solutions and interconnectivity standards. These processing elements range from micro-controllers, micro-processors, Graphics Processing Units (GPUs) and Field Programmable Gate Arrays (FPGA) accelerators, to complex multi-processor System on a Chip (SoC) devices, Application-Specific Integrated Circuits (ASICs) and AI-optimized processors. There is a need for targeted solutions that fully leverage the massive parallelism capabilities of the HW-accelerated platforms for intensive and ultra-low latency processing. On the other hand, the complexity of parallel programming techniques for such heterogeneous scenarios can be daunting, stressing the need for programming models capable of providing the right level and granularity of abstraction to express the performance capabilities of the underlying HW platforms, with the lowest possible overhead.

Barrier #2 Learning at the edge: the scarce resources challenge

Edge intelligence, defined as the application of AI and ML at the network edge, has been identified as a key element in 6G, leveraging the multitude of data generated by the network and applications to learn and predict the runtime conditions and service requirements, thus enabling the proactive solutions for reduced latency and overall better performance and automation. However, the constraints on the training of such complex AI models over limited edge resources, the absence of sufficient local context information or data interpretation and the privacy concerns regarding the transfer of sensitive user datasets to the cloud, stress the need for decentralized leaning solutions.

Barrier #3 Lack of a unified e2e AIOps framework and AI conflict management

AI at the edge has been used for proactive network management, such as channel modelling and prediction, traffic and mobility forecasting, network resource allocation, task offloading, etc. However, while most AI solutions have been designed addressing stand-alone problems, the development of unified frameworks capable of overseeing end-to-end operations are not well investigated. In this direction, efficient collision-free AI solutions will be needed, able to work in a harmonized way when dealing with closely related problems, such end-to-end slicing, optimally splitting DU and CU functions across the edge-cloud compute continuum, or resource allocation of network and computation resources under edge constraints. Besides, AI techniques are expected to exploit the huge amount of data collected at the edge for achieving an optimized operation.

Barrier #4 Orchestrating the orchestrators

One of the most radical changes brought by 5G is the high network programmability, driven by Network Function Virtualization (NFV) and Software Defined Networking (SDN). The current trend for RAN disaggregation enables the flexible and dynamic placement of VNFs across the network infrastructure to meet specific performance requirements. At the same time, applications are adopting cloud-native design principles, breaking computation into microservices or even serverless functions, and enabling novel split and distributed computation execution models. Hence, it becomes evident that as we move towards 6G, there is a need to create an integrated communication and computation environment where network and application services can be seamlessly deployed, executed and orchestrated. This makes the management and orchestration of services and resources very challenging, further aggravated by the heterogeneous, multi-tenant and multi-site edge-enabled topologies. Moreover, the existence of different orchestration solutions in the compute continuum spanning from coarse grain multi-site orchestration to single site intend driven orchestration, all the way down to fine grain distributed task-level orchestration reaching even at System-on-Chip (SoC) device level, makes the cognitive coordination of the different orchestrators a new challenge to consider.

Barrier #5 Understanding the adversaries: Trustworthiness and explainability

Trustworthy AI covers a wide range of concerns such as robustness, safety, security, privacy, explainability, fairness and reliability that are being increasingly mandated. Despite the distributed nature of the communication domain and the network heterogeneity, we still have the risk of adversarial attacks in a telco environment, targeting the robustness of AI models by compromising the decision-making process (evasion attacks) or undermining the training data, thus leading to performance deterioration (poisoning attacks). Because of their small footprints, adversarial ML-based attacks are more covert and difficult to detect, calling for novel solutions to ensure that the AI models' decisions are robust in the face of minor changes to the input data.

On the other hand, understanding of how an AI model makes particular decisions and contributes to achieving the goals of the stakeholder is a key component of the trustworthiness of the AI system. Hence, the concept of explainable AI (XAI) has been gaining a lot of attention. However, many studies have considered XAI, scalability and feature dependence are still an open issue. For example, providing explanation for each task of the model is challenging when the number of task increases, stressing the need for task-aware XAI models.

Feature dependence also causes problems in explanation, especially when features are correlated, making it very difficult to attribute the importance of each feature in the output of the XAI model.

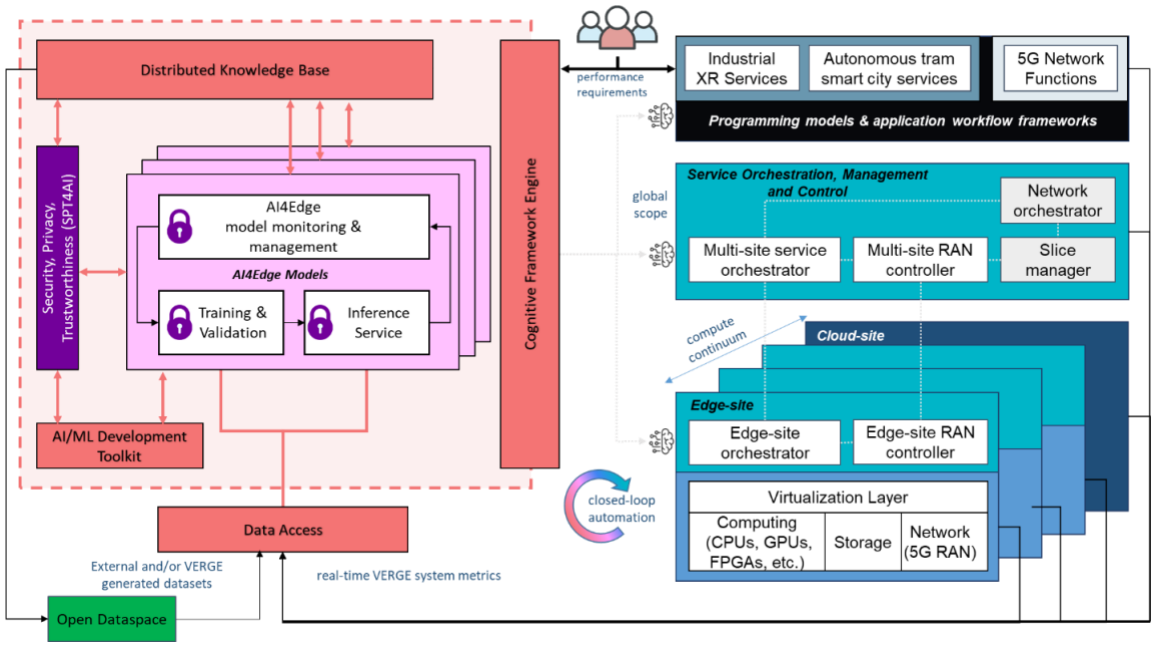


Figure 12: Overview of the VERGE initial system architecture.

Use Case: Autonomous tram services for safety and entertainment in a smart city environment

The concept of autonomous driving in Light Rail Transit (LRT) tram public transport systems heavily relies on multiple sensors, such as cameras, radars, light detection and ranging (LIDAR) systems, etc., which coupled with AI processes can provide the necessary level of perception and actuation in real-time. However, the implementation of such autonomous systems poses challenging requirements since these services are exposed to several critical uncontrollable events such as pedestrians, vehicles, and obstacles, demanding a much higher level of situational awareness and more dynamic interaction. Edge computing together with orchestration of tram autonomy functions, dedicated network slices for safety-related critical and non-critical data and B5G communication technologies can play a fundamental role towards addressing these challenges, by offering the necessary ultra-reliable low-latency connectivity, high computational capability closer to the data sources, mobility support and dynamic reconfigurability needed to implement different services of the autonomous tram of the future. At the same time, smart cities are adopting sensing, computing and communication technologies to provide innovative services for a more efficient, safe and sustainable city management and enhanced quality of life.

Fuelled by the wide IoT penetration, cities are collecting massive volumes of data, which, through AI and big data technologies, is transformed into valuable and actionable knowledge, able to automate and optimize several city aspects. In such highly distributed and heterogeneous environments, edge computing is a key enabling technology, making it possible to fuse together information coming from both the sensor-equipped trams and the city to better detect and anticipate hazards that may lie along the trajectory of the tram, beyond the visibility of the tram sensors. Furthermore, innovative XR entertainment services with demanding latency and processing requirements can be supported, e.g., providing immersive touristic information for people moving by tram or other means within specific areas of interest. Figure 13 illustrates the components of this use case, which involves applications (e.g., track occupation monitoring and obstacle/hazard detection) aimed at improving the safety and operational efficiency of the autonomous tram in a smart city environment, and at providing immersive entertainment services for passengers.

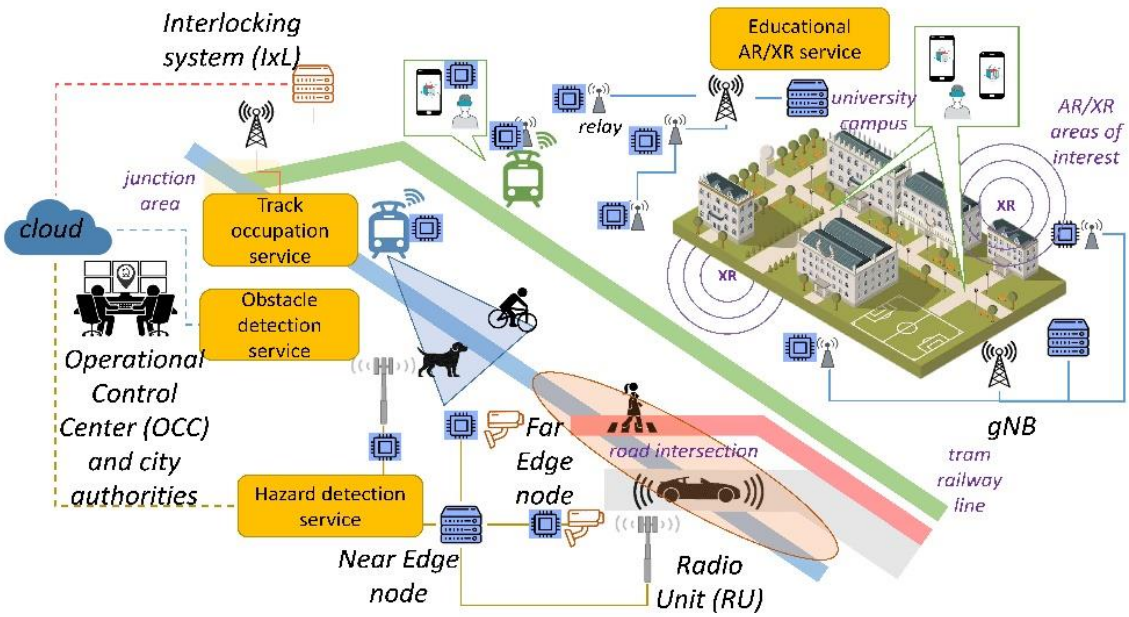


Figure 13: Autonomous tram services for safety and entertainment in a smart city environment use case scenario

VERGE created four user stories that present a number of services to enhance the operation and safety of the autonomous tram by implementing complex AI pipelines for sensor fusion and computer vision applications, while also providing AR/XR-enabled entertainment services to passengers. These services impose demanding Service Level Requirements (SLRs), motivating the need for novel edge-assisted solutions to handle the increasing amount of computation needed in near real-time conditions, coupled with efficient and dynamic network reconfiguration techniques to meet the service connectivity requirements especially in terms of latency, bandwidth and reliability. Furthermore, the use of AI brings new challenges with respect to the safety and trustworthiness of the employed methods, which must be highly accurate and robust against the variability of the operation conditions. The considered user stories are the following ones:

- User story 1, entitled "track occupation and speed monitoring", consisting of an onboard service that tracks the position and speed of the tram and an edge-enabled interlocking system, which coordinates the track occupation status of the tram junction areas.
- User story 2, entitled "obstacle detection and tracking (ODT)", consisting of an onboard service that fuses data from onboard tram sensors to identify and track obstacles that lie in the tram frontal area, alerting the driver accordingly.
- User story 3, entitled "edge-enabled hazard detection service", deployed at the infrastructure side across the tram railway lines, performing real-time detection of traffic hazards in an extended area and alerting both the tram, extending its situational awareness, and relevant city authorities.
- User story 4, entitled "provision of AR/XR entertainment and educational services along the tram route", intended for passengers onboard the tram and for students in an adjacent university campus area close to a tram stop.

In this context, VERGE has identified eight specific technical challenges which will be addressed by innovative technical solutions developed within the lifetime of the project and supported by the novel VERGE architecture and AI-enabled framework for the evolution of edge computing within the 5G/B5G ecosystem. The overview of this approach is illustrated in Table 4, linking the proposed innovations with the described user stories and the relevant validation methods. It should be noted that this is meant to be a starting point for the technical contributions of the project, which will be further refined and consolidated within the projects' lifetime.

reflects the improvement areas that each one of these VERGE innovations is expected to contribute to in the context of B5G and edge computing evolution scenarios.

Table 4: VERGE innovations and related user stories

VERGE innovations	Related user stories	TRL
Advanced orchestration of AI-enabled smart city services in distributed edge environments.	3	4-5
Dynamic computation splitting for real-time services.	2, 4	2-3
AI-driven network slicing for XR and for IoT-enabled autonomous tram services.	1, 2	3-4
Relays with edge computing capabilities for supporting XR services.	4	2-3
Smart micro-orchestration of disaggregated RAN elements over FPGA platforms.	3	2-3
AI model generalization for robustness to scenario changes.	2	2-3
Causal discovery and hazard prediction using structural causal models.	3	2-3
Secure edge intelligence empowered by advanced learning solutions.	3	2-3

Table 5: Improvement areas for the identified VERGE innovations in the use case

VERGE innovations	Reduced latency	Enhanced service availability	Enhanced service reliability	Efficient resource utilization	Energy efficiency	Flexibility/scalability	Enhanced computation	Efficient AI model training	AI safety	AI explainability
Advanced orchestration of AI-enabled smart city services in distributed edge environments.	✓			✓		✓	✓			
Dynamic computation splitting for real-time services.	✓		✓	✓	✓	✓				
AI-driven network slicing for XR and for IoT-enabled autonomous tram services.	✓	✓	✓	✓		✓		✓	✓	
Relays with edge computing capabilities for supporting XR services.	✓	✓	✓	✓	✓			✓		
Smart micro-orchestration of disaggregated RAN elements over FPGA platforms.	✓		✓	✓	✓	✓	✓			
AI model generalization for robustness to scenario changes.								✓	✓	✓
Causal discovery and hazard prediction using structural causal models.				✓					✓	
Secure edge intelligence empowered by advanced learning solutions.					✓			✓	✓	✓

Expected activities on "Dissemination and Impact on Standards":

VERGE has a plan to impact standardization bodies that are relevant for the project. At this stage of the project execution, the contributions have focused on ETSI MEC, as described in the following:

ETSI MEC #35 meeting

The document MEC(23)000403: "Joint communications and computing resources prioritization based on 5QI" was presented at MEC #35 Meeting, 18-22 September 2023. The contribution considered the possibility of enabling a harmonized management of the computing resources and communication resources in a 5G network with edge computing capabilities. For this purpose, a consistent prioritization of resources in the radio network and edge computing domains based on the 5G Quality of Service (QoS) Indicator (5QI) parameter standardized by 3rd Generation Partnership Project (3GPP) for the radio segment was proposed. In addition to introducing the concept, possible implementations for extracting the 5QI value from the 5G core network were discussed involving the use of the Network Exposure Function (NEF) of the 5G core and the Radio Network Information Service (RNIS).

ETSI MEC #36 meeting

The ETSI MEC #36 Meeting was held on 4-8 December 2023. In this meeting, the contributions of the project have been more focused towards the following work items (WI):

- Work item MEC-0043 on "Abstracted Radio Network Information for Industries", intended to study use cases, key issues and recommendations related to exposing abstracted radio network information for the industries. The aim for the abstraction is to provide a developer-friendly API that hides the complexity and requires only little technical skills or knowledge of the underlying Radio Network. Targeted industry segments and areas include e.g. Augmented reality and Virtual reality, Vehicle-to-everything, Logistics, Future Factories, Coordinated Robots and Drones.
- Work item MEC-0044 "Study on MEC Application Slices", which studies the potential requirements and enhancements to the MEC system needed to support MEC Application Slices, i.e., the slicing of the MEC applications. The WI also studies the necessary changes to align the MEC support for network slicing and the concept of MEC application slice, relationship and alignment with MEC system support for network slicing, as well as potential requirements and enhancements to the MEC system architecture and functions.

With the focus on these two WIs in mind, two contributions were presented.

- Document MEC(23)000535 "Addition of abstracted information for the V2X use case": The contribution provided a text proposal introducing the Service Priority as an abstracted radio network information for the V2X use case in the current draft document of the WI MEC-0043.
- Document MEC(23)000536 "Introducing a new key issue about the mapping of QoS requirements between MEC Application Slices and Network Slices". This contribution targeted the current draft document of the WI MEC-0044 and proposed a new key issue for the mapping of the QoS requirements between MEC application slices and network slices. The proposal considered the use of the 5QI for conducting this mapping and presented an example.

Furthermore, VERGE partners are active contributors in several pre-standardization Work Groups (WG) of European associations, e.g., the 5G-AA, the 6G-IA and the AIOTI WGs dedicated to standardization, as well as in standardization developing organizations (SDOs), also serving in key driving roles. For instance, INTEL personnel have just been appointed for the next four years 3GPP Service and System Aspects (SA) Chairman, which is one of the most influential and critical standards leadership roles in the global cellular industry. 3GPP is chartered to develop 5G Advanced/6G software-defined infrastructure for native AI applications and workload. Those are topics of strategic importance for VERGE, which is therefore in the best position to seize the opportunity to push its results into the 3GPP work. That will be in fact facilitated by the role of the SA Chairman, who will be responsible for overseeing the definition and specifications of the global cellular system overall architecture and service capabilities, including Services Requirements/Use case (SA1), System Architecture (SA2), Security and Privacy (SA3), Management, Orchestration and Charging (SA5), all areas where VERGE outcomes can have a tangible impact.

INTEL personnel also cover key roles in ETSI, e.g., board of directors member and the chair role of the Operational Co-ordination Group on Artificial Intelligence (OCG AI); OCG AI manages the information flow to CEN/CENELEC JTC21 in support of the AI Act [VERGE16]. ETSI has a number of Technical Committees and Industry Specification Groups (ISG) developing AI solutions, partly in support of the European AI Regulation as summarized in a recent ETSI White Paper [VERGE17]. ETSI is also important due to the several AI-related actions, like the Cyber Resilience Act (CRA) **Error! Reference source not found.**[VERGE18], issuing rules to ensure safer HW and SW, and the Radio Equipment directive (RED) [VERGE19], which establishes a regulatory framework for placing radio equipment on the market, assessing new market access requirements for all future products. Both CRA and RED are very relevant for VERGE use cases. Finally, INTEL has also the chairmanship of ISO/IEC JTC1, developing standards in the information technology domain.

Of course, having a VERGE consortium member in a driving role in an SDO does not per se imply an immediate impact of VERGE on that SDO. In order to impact an SDO, a project-wide team-work needs to be in place, and the partner or the set of partner, which can present a VERGE contribution to an SDO, needs to have that contribution aligned with the partner's overall SDO strategy.

In any case, before committing to any SDO contribution, there must be some results produced by the project, and those results are not supposed to appear before the end of the first year of VERGE (2023). Anyway, at the current status of the project schedule, the following SDOs are expected to be potentially impacted by VERGE contributions:

- ETSI (Zero-touch network and Service Management – ZSM, Multi-access Edge Computing – MEC)
- 3GPP (several WGs)
- GSMA Operator Platform Group
- ONF (Open Network Foundation)
- O-RAN (WG3, WG6)

- NGMN (WG on 6G Use Cases)
- NGMN (Network Automation and Autonomy based on AI Working Group)

Presented contribution:

A VERGE representative (Dr. Irene Vilà from Universitat Politècnica de Catalunya) presented to the ETSI MEC#35 meeting, hold in September 2023, the contribution "MEC(23)000403: Joint communications and computing resources prioritization based on 5QI". 5QI stands for 5G Quality of service Identifiers. The basic idea is to propose traffic prioritization based on the 5QI associated to each traffic flow. The contribution was very well received by the ETSI WG and follow ups have been asked for.

Next steps:

The following contributions are planned to happen in the next months:

- Ongoing work in SA3 related to VERGE focus areas will be monitored and if necessary, liaison statement(s) will be sent to inform the progress in the project and to inform requirement of studies in 3GPP to address the security and privacy issues in ML with possible solutions that require standardization because of interoperability issues.
- Contribution on a Reinforcement Learning solution that learns to obtain the optimal CU-DU functional split (based on the traffic dynamics, the SLAs, etc.) could have a potential impact to O-RAN Alliance WG3: The Near-Real-Time RIC and E2 Interface Work Group.
- Presentation to the AIOTI standardization WG a plan of action from several VERGE tasks work.
- Presentation to the 6G-IA Pre-Standardization WG a plan of action from several VERGE tasks work.
- Follow up on the presentation to ETSI MEC in Q1 2024.

Finally, on all the mentioned above SDOs and pre-standardization WGs, a constant monitoring activity will be performed by several VERGE partners, and when a decision is deemed affecting the ongoing discussions in VERGE, a report will be made to VERGE partners by the partner that identified the potential interlock between the SDO and VERGE work.

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[VERGE18] https://digital-strategy.ec.europa.eu/en/policies/cyber-resilience-act
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2.2.13 dAIEDGE - A network of excellence for distributed, trustworthy, efficient and scalable AI at the Edge

URL/Reference:

https://daiedge.eu

Abstract:

The vision of dAIEDGE Network of Excellence (NoE) is to strengthen and support the development of the dynamic European edge and distributed Artificial Intelligence (AI) ecosystem as an essential ingredient in the growth and competitiveness of European industrial sectors. The dAIEDGE Network aims to reinforce the research and innovation value chains to accelerate the digital and green transitions through advanced edge AI technologies, applications, and innovations, building on Europe's existing assets and industrial strengths. In parallel, it will fortify the edge AI research and industrial communities through technological developments beyond state of the art and become a dependable and strategic pillar for the European AI Lighthouse. This will be achieved by mobilising and connecting the European AI and edge AI constituency, the relevant stakeholders, European partnerships, and projects, to provide roadmaps, guidelines and trends supporting the next-generation edge AI technologies. The key aim is to support and ensure rapid development, market uptake and open strategic sovereignty for Europe in the critical technologies for distributed edge AI (hardware, software, frameworks, tools). The dAIEDGE NoE will play a catalyst role in building a solid edge AI virtual network of research facilities and laboratories to benefit the European research and industrial community. The NoE multidisciplinary concept provide an arena for matchmaking, exchanging ideas, tools, and services, by bringing together the leading research centres, AI-on-demand platforms, digital innovation hubs, AI projects and initiatives. The ultimate goal for the dAIEDGE NoE is to support Europe to become a global centre of excellence with unique human-centred edge AI competence addressing the social and economic challenges and the needs of the citizens and society.

Starting and (target) end time of project:

01/09/2-23 – 31/08/2026

IoT and/or Edge Computing research challenges:

1. Edge AI Methodology and software
   - Robustness and specialization
   - On-device learning
   - On-device communication
2. Edge AI hardware and infrastructure:
   - Creation and assimilation of new hardware
   - Integration in AI continuum
   - Code generation, tuning, deployment
3. Ease of deployment and reuse
   - Benchmarks
   - Sharing and optimization of AI resources

- Marketplace

4. Edge AI security, privacy, fairness and reliability
   - Security aspects
   - Privacy and ethical aspects
5. Establishing edge AI capability
   - Use cases in multiple domains
   - Demonstrator deployment
6. Edge AI interoperability (SW/HW)
   - Context challenge
   - Spatial challenge
   - Operational challenge
   - Legislative challenge

These challenges encompass various aspects of edge computing, including infrastructure management, virtual lab design, scheduling optimization, model deployment, and integration into a broader ecosystem. The project aims to address these challenges to advance the state of edge computing research and development.

Expected activities on "Dissemination and Impact on Standards":

The project employs a dedicated strategy to expedite the transition from research to exploitation in Europe. This involves leveraging the participation of major European industry leaders, including ST, THALES, SED, SYNOPSYS, VERSES, and expanding the network to include a wider range of stakeholders in AI at the edge. This network includes high-potential start-ups and scale-ups, facilitating the dissemination of dAIEDGE enabling technologies to the enterprise world. A specific task is dedicated to proactively identifying innovative solutions with potential for exploitation. Each innovation undergoes systematic analysis and assessment, considering three main axes:

- Industrial exploitation (identifying industry potential for new products and services).
- Standardization (assessing potential for global standardization).
- Sustainable Development Goals (evaluating potential contribution to the UN's 17 SDGs)

The project will engage with the following AI networks related to edge computing:

1. **AI-on-Demand Platform (ICT-49):**
   - Strategic alignment with representatives from AI-on-Demand platform.
2. **Bonseyes AI Marketplace:**
   - Integration with the Bonseyes AI Marketplace for collaborative tools and services.
3. **AI4EU:**
   - Integration and merging with the AI on-demand platform developed by AI4EU.

Moreover, three Open Calls (OCs) (task starts at month 8) will be defined and managed as exchange programmes (1 OC) and collaborative projects (2 OCs) following EC procedures and rules.

2.2.14 AIMS5.0: Artificial Intelligence in Manufacturing leading to Sustainability and Industry5.0

URL/Reference:

https://www.aims50.eu/

https://cordis.europa.eu/project/id/101112089

Abstract:

AIMS5.0, a collaborative Innovation Action, aims at strengthening European digital sovereignty in comprehensively sustainable production. The project and its well-balanced consortium with 53 ambitious academic and industry partners intends to boost the economy by adopting, extending and implementing AI-enabled hardware and software components and systems across the whole industrial value chain.

New technologies from IoT and based on Semantic Web ontologies, enhanced Digital Twin, ML (Machine Learning) and AI (Artificial Intelligence) will help European manufacturers to shift from Industry4.0 to Industry5.0, creating human-centric workplace conditions and a climate-friendly production. Above all, sustainability and resilience will be improved.

We will see AI enabled fabs way more productive and eco-efficient. This will go hand in hand with shorter supply chains, a better resilience, a higher sustainability and global competitiveness keeping the main production in Europe.

AIMS5.0 a collaborative Innovation Action aims at strengthening European digital sovereignty in comprehensively sustainable production, by adopting, extending and implementing AI-enabled hardware and software components and systems across the whole industrial value chain to further increase the overall efficiency.

Vulnerability of existing supply chains in crisis shows the need for shorter supply chains and for keeping production in Europe. AI enabled fabs will be given more output and higher sustainability, which makes them more competitive on a global scale.

20 use cases in 9 industrial domains will validate the project's findings in an interdisciplinary manner. A professional dissemination, communication, exploitation and standardization will ensure the highest impact possible.

Fields of Science (EU Cordis assignment): Internet of things, AI, semantic web, ontology

More details related to this project are provided in Section 1.2.6 of this report.

2.2.15 ODEON – federated data and intelligence Orchestration & sharing for the Digital Energy transition

URL/Reference:

https://odeonproject.eu/

https://cordis.europa.eu/project/id/101136128

Abstract:

Even if significant progress has been made towards the Twin Transition, the recent energy crisis revealed the EU energy system's vulnerability and dependence on external energy sources and highlighted the need for intensifying the integration of RES in electricity, transport and building (heating) sectors. To achieve on this, the energy system shall transform from a centralised/fossil-fuel-based to an energy efficient, RES-based and interdependent system, operating with a high degree of flexibility offered by distributed assets. ODEON is conceived under the principle that this can only be realized through the creation of an inclusive ecosystem of stakeholders characterized a mesh of Data, Intelligence, Service and Market flows, jointly enabling the resilient operation of the energy system under increased RES integration and distributed flexibility. ODEON introduces a sound, reliable, scalable and openly accessible federated technological framework (i.e. ODEON Cloud-Edge Data and Intelligence Service Platform and corresponding Federated Energy Data Spaces. AI Containers, Smart Data/AIOps orchestrators) for the delivery of a wealth of services addressing the complete life-cycle of Data/AIOps and their smart spawn in federated environments and infrastructures across the continuum. It will integrate highly reliable and secure federated data management, processing, sharing and intelligence services, enabling the energy value chain actors and 3rd parties to engage in

data/intelligence sharing, towards the delivery of innovative data-driven and intelligence-powered energy services in accordance to the objectives set by the Digitalisation of Energy Action Plan. ODEON results will be extensively validated in 5 large-scale demonstration sites in Greece, Spain, France, Denmark and Ireland involving all required value chain actors, diverse assets, heterogeneous grid and market contexts, and multi-variate climatic and socio-economic characteristics to support its successful replication and market uptake.

More details are provided in Section 1.2.8.

2.2.16 P2CODE - Programming Platform for Intelligent Collaborative Deployments

URL/Reference:

https://p2code-project.eu/consortium/

Abstract:

The P2CODE project aims at innovating and creating a wide-open, secure and trusted IoT-to-edge- to-cloud compute continuum that will realize the true potentials of edge intelligence. To this aim, the P2CODE 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. The platform will do so by implementing innovative design approaches and will constitute a fully-integrated infrastructure under the cloud–managed P2CODE architecture. P2CODE will contribute to the wider scope of reinforcing Europe's position in the market of next generation smart systems (sensors and devices) integrated in an evolving Internet of Things and cyber-physical ecosystems with strong capacities at the edge.

More details are provided in Section 1.2.9.

2.2.17 OASEES - Open Autonomous programmable cloud appS & smart EdgE Sensors

URL/Reference:

https://oasees-project.eu/

Abstract:

The IoT, connected smart devices interacting with each other and people and collecting all kinds of data, is exploding. The massive amount of data created is processed centrally at the cloud, which helps scalability by providing on-demand access to computing resources. Centralised processing and cloud hosting bring data governance and identity management issues to the user. Similarly, existing edge device authentication solutions require a centralised entity to authenticate data. The EU-funded OASEES project aims to create an open, decentralised, intelligent, programmable edge framework for swarm architectures and applications. The framework will leverage the decentralised autonomous organisation paradigm and integrate human-in-the-loop processes for efficient decision-making.

More details are provided in Section 1.2.10.

2.2.18 OpenSwarm - Orchestration and Programming ENergy-aware and collaborative Swarms With AI-powered Reliable Methods

URL/Reference:

https://openswarm.eu/

Abstract:

Low-power wireless technology tends to be used today for simple monitoring applications, in which raw sensor data is reported periodically to a server for analysis. The ambition of the Horizon Europe OpenSwarm project is to trigger the next revolution in these data-driven systems by developing true collaborative and distributed smart nodes, through groundbreaking R&I in three technological pillars:

- Efficient networking and management of smart nodes
- Collaborative energy-aware Artificial Intelligence (AI)
- Energy-aware swarm programming.

The EU-funded OpenSwarm project aims to take the technology further by developing collaborative and distributed smart nodes. To do so, it will explore efficient networking and management of smart nodes, collaborative energy-aware AI and energy-aware swarm programming. The energy-aware, collaborative swarms will be demonstrated in labs equipped with two 1 000-node test beds. They will then be validated in five real-world use cases in application domains such as industrial, health, environmental and mobility.

More details are provided in Section 1.2.11.

2.2.19 TaRDIS - Trustworthy and Resilient Decentralised Intelligence for Edge Systems

URL/Reference:

https://www.project-tardis.eu/about-tardis/

Abstract:

Developing and managing distributed systems is a complex task requiring expertise across multiple domains. This complexity considerably increases in swarm systems, which are highly dynamic and heterogeneous and require decentralised solutions that adapt to highly dynamic system conditions. The project 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. TaRDIS proposes a language-independent event-driven programming paradigm that exposes, through an event-based interface, distribution abstractions and powerful decentralised machine learning primitives. The programming environment will assist in building correct systems by taking advantage of behavioural types to automatically analyse the component's interactions to ensure correctness-by-design of their applications, taking into account application invariants and the properties of the target execution environment. TaRDIS underlying distributed middleware will provide essential services, including data management and decentralised machine learning components. The middleware will hide the heterogeneity and address the dynamicity of the distributed execution environment by orchestrating and adapting the execution of different application components across devices in an autonomic and intelligent way. TaRDIS results will be integrated in a development environment, and also as standalone tools, both of which can be used for developing applications for swarm systems. The project results will be validated in the context of four different use cases provided by high impact industrial partners that range from swarms of satellites, decentralised dynamic marketplaces, decentralised machine learning solutions for personal-assistant applications, and the distributed control process of a smart factory.

More details are provided in Section 1.2.12.

2.2.20 SmartEdge

URL/Reference:

https://www.smart-edge.eu

https://cordis.europa.eu/project/id/101092908

Abstract:

Swarm intelligence consists of a network of endpoint devices that are able to generate and process data at source. An entire network becomes more intelligent and flexible when individual edge devices can identify and share vital information with peers. From healthcare systems to self-driving vehicles, sharing this information must be done without compromising reliability, security, privacy and scalability. The EU-funded SMARTEDGE project will provide a solution in a low-code programming environment using three tools: continuous semantic integration, a dynamic swarm network and a low-code toolchain for edge intelligence. The solution will be demonstrated in the automotive and health sectors, among others.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

The objective of the SMARTEDGE project is to enable the dynamic integration of decentralised edge intelligence at runtime while ensuring reliability, security, privacy and scalability. We will achieve this by enabling a semantic-based interplay of the edge devices of such systems via a cross-layer toolchain that facilitates the seamless and real-time discoverability and composability of autonomous intelligence swarm. Hence, an application can be freely built by distributing the processing, data fusion and control across heterogeneous sensors, devices and edges with ubiquitous low-latency connectivity. The goal of this project is to develop a SMARTEDGE solution with a low-code tool programming environment with various tools: (1) Continuous Semantic Integration (CSI); (2) Dynamic Swarm Network (DSW); and (3) Low-code Toolchain for Edge Intelligence. CSI allows the SMARTEDGE solution to interact with devices according to a (i) standardized semantic interface, via a (ii) continuous conversion process based on declarative mappings and scalable from edge to cloud, and (iii) providing a declarative approach for the creation and orchestration of apps based on swarm intelligence. DSW provides (i) automatic discovery and dynamic network swarm formation in near real time, (ii) hardware-accelerated in-network operations for context-aware swarm networking, and (iii) embedded network security. The low-code tool chain provides (i) semantic-driven multimodal stream fusion for Edge devices; (ii) swarm elasticity via Edge-Cloud Interplay; (iii) adaptive coordination and optimization; (iv) cross-layer toolchain for Device-Edge-Cloud Continuum. The SMARTEDGE solution will be comprehensively demonstrated over four application areas: automotive, city, factory and heath via the strong collaboration of eight industrial partners, Dell, Siemens, Bosch, IMC, Conveq, Cefiel and NVIDIA with eight research institutes.

Expected activities on "Dissemination and Impact on Standards":

SmartEdge enables seamless integration of SmartEdge devices via standardized semantic interfaces. Standardized semantic interfaces provide a common way to access the devices' data from the application level. For the different use-cases covered by the project, there is a need for seamless communication across diverse protocols, such as OPC UA, MQTT, and DDS. Ensuring interoperability at the protocol level is essential to make use of these interconnected systems.

Table 6 provides a list of technologies and as well some of the used standards.

Table 6: Technologies applied in SmartEdge Various Use Cases

UC	Communication protocol	Serialization format	Semantics
1	W3C WoT (different protocols)	RDF Turtle, JSON/JSON-LD	(Use-case specific ontologies)
2	C-V2X/ETSI-G5, MQTT/NATS	JSON/JSON-LD	Smart Traffic Ontology
3	DDS, Zenoh	ROS2 Binary, JSON-LD	Robotics Ontology
4	OPC UA	XML	OPC UA FX and OPC UA companion specifications
5	BLE, DDS, MQTT	JSON	Healthcare Ontology

Standardization: W3C Web of Things advancements

During 2023, noteworthy milestones were reached within the W3C Web of Things (WoT) and its related activities, with participation from SmarEdge's partners.

- The WoT 1.1 normative specifications have been officially published as W3C Web standards. Concurrently, efforts have commenced on the development of the 2.0 specifications.
- The W3C WoT Community Group (WoTCG) hosts monthly online meetups, resulting in over 50 hours of video content showcasing how organizations worldwide leverage WoT.
- The WoTCG Discord server boasts over 110 participants actively discussing recent WoT developments and assisting one another.

In traditional Internet of Things (IoT) projects, developers grapple with the complexity of diverse systems and services from different vendors, hindering flexibility and interoperability. Customers want to be able to choose devices from multiple vendors without redesign.

The W3C Web of Things (WoT) simplifies IoT application development by offering standardized building blocks. The WoT uses web technology to harmonize access to diverse IoT devices and breaks silo walls. This allows WoT applications to be written on top of a single, portable interaction abstraction.

Many sectors benefit from WoT standards, e.g. smart homes, smart cities, smart industry, smart agriculture, smart healthcare and many more.

2.2.21 DECICE - DEVICE - EDGE – CLOUD Intelligent Collaboration framEwork

URL/Reference:

https://www.decice.eu/

Abstract:

DECICE is a Horizon Europe project that is developing an AI-enabled open and portable management framework for automatic and adaptive optimization and deployment of applications in computing continuum encompassing from IoT sensors on the Edge to large-scale Cloud / HPC computing infrastructures.

Starting and (target) end time of project:

01/2023 – 12/2025

IoT and/or Edge Computing research challenges:

1. A cloud management framework that can seamlessly connect and deploy applications to devices across the HPC, Cloud and Edge continuum
2. A digital twin that models the compute, memory, storage and network resources and the application tasks using simulation and real time monitoring at the Edge and Cloud
3. AI-scheduler that produces scheduling decisions on placement of job and data as well as conducting rescheduling to adjust to system changes in Cloud and Edge

Expected activities on "Dissemination and Impact on Standards":

Standardization bodies and entities focused on the development of interoperable IoT solutions and services, such as ETSI, IEEE, CNCF, the OPC Foundation, the Industrial Internet Consortium, IETF, W3C, and 3GPP; pre-normative bodies such as IRTF, specific study groups and task-forces of ETSI, 3GPP, IEEE; open-source initiatives such as FOSDEM, IOTA, OpenStack, FIWARE, Linux Foundation, Apache, Eclipse Foundation

Please note there is no effort at the moment in standardizing at the moment as it is in active development phase

2.2.22 Hexa-X-II: A holistic flagship towards the 6G network platform and system, to inspire digital transformation, for the world to act together in meeting needs in society and ecosystems with novel 6G services

URL/Reference:

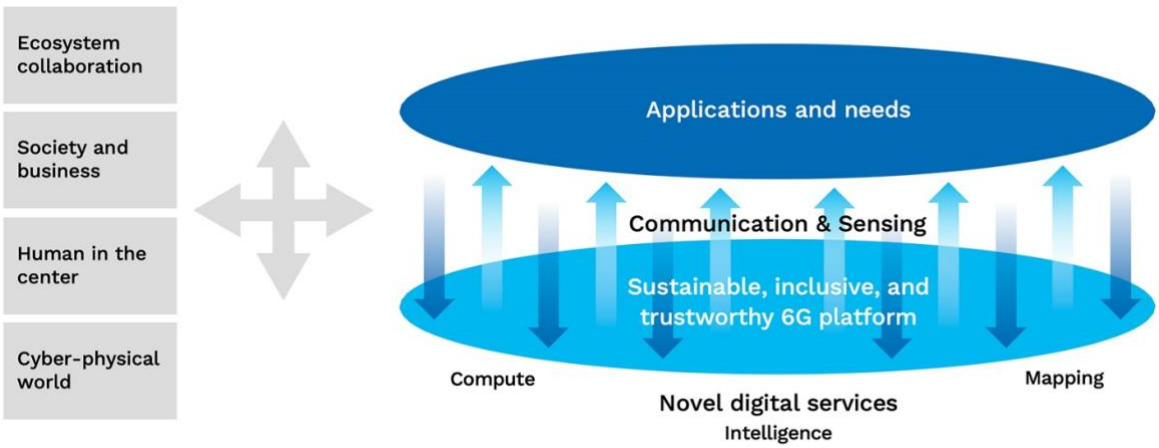
https://hexa-x-ii.eu/

Abstract:

The Smart Networks and Services Joint Undertaking (SNS JU) 6G Flagship project Hexa-X-II leads the way to the end-to-end (E2E) system design (based on integrated and interacting technology enablers) and the enabling platform delivering novel services for the next generation (6G) of wireless networks. The project will continue on the tracks of the Horizon Europe project ***Hexa-X***, which has laid the foundation for the global communication network of the 2030s by developing the 6G vision and basic concepts, including candidate key technology enablers. The work in Hexa-X-II expands from research to systemization analysis, early validation, and proof of concept. It progresses from the 6G key enablers that connect the human, physical, and digital worlds to advanced technology readiness – validated technology – including key aspects of modules, protocols and interfaces, and data. Hexa-X-II will design a system blueprint aiming at the sustainable, inclusive, and trustworthy 6G platform that should meet the future needs of serving and transforming society and business, as is illustrated in Figure below.

Hexa-X-II will also address implementation aspects of the 6G platform and encompass a full scope consisting of:

- Defining use cases, services, and requirements, ensuring the value for society
- Designing the platform and system, ensuring global impact on 6G development
- Assuring technology readiness in critical areas, ensuring EU strategic autonomy.



Starting and (target) end time of project:

01/01/2023 – 30/06/2025

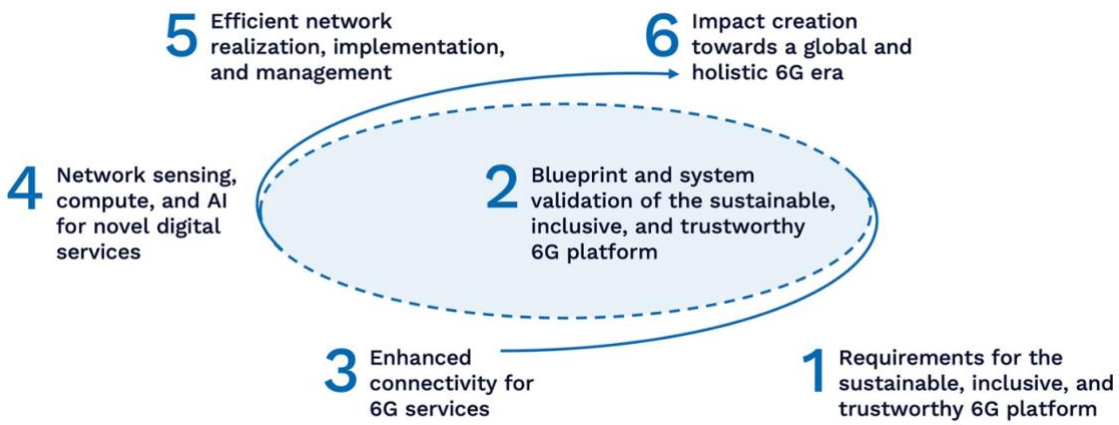
IoT and/or Edge Computing research challenges:

Hexa-X-II will address implementation aspects of the 6G platform and encompass a full scope consisting of:

- Defining use cases, services, and requirements, ensuring the value for society
- Designing the platform and system, ensuring global impact on 6G development
- Assuring technology readiness in critical areas, ensuring EU strategic autonomy.

Hexa-X-II will move ahead of the current state of the art of 6G research and add on to the technical substance by building advanced technology readiness demonstrated with Proof of-Concepts (PoCs), by further integrating towards a 6G platform for the delivery of services, and by fostering international harmonisation of 6G development. In order to achieve this, Hexa-X-II has defined six main objectives.

- As the foundation, the project will analyse needs and develop a consolidated set of requirements in terms of Key Performance Indicators (KPIs) and KVIs for the future 6G platform, considering the key values of sustainability, inclusion, and trustworthiness (Ob. 1).
- The 6G platform will be systemized and integrated into a blueprint considering the key values, involving an evaluation of KPIs, which in turn will provide a validation of the project's developed design and content (Ob. 2).
- The 6G system will enable breakthrough technologies and interfaces for connectivity services (Ob. 3), building on the progress of 5G-Advanced and meeting the demands of the 2030s.
- Expanding the scope of networks, the project will develop enabling technologies and interfaces for novel digital services building on new network capabilities of sensing, compute, and AI (Ob. 4).
- The project will further ensure that the 6G system is realizable, implementable, and manageable in a resource-efficient manner (Ob. 5).
- Finally, Hexa-X-II will contribute to a holistic European 6G view and will be a leading voice in the globally aligned roadmap towards 6G by impacting standardisation activities (Ob. 6).



Expected activities on "Dissemination and Impact on Standards":

In Deliverable D7.5 Impact to industry activities, standardisation and regulation – intermediate release the following planned contributions to various SDOs and industry groups are included:

- 3GPP SA1, Use cases, corresponding requirements and key performance/value indicators.

- 3GPP SA2, Develop the overall 3GPP system architecture and services including access network, core network, architecture modularisation, AI/ML usage, RAN-CN interface, UE-CN and CN-Application (e.g., network exposure) interfaces.
- 3GPP SA3, Security and privacy threats, and their impact on system resilience, and the techniques to address them. Distributed and trustworthy AI, Quantum-safe crypto Distributed ledgers, Remote attestation, Context-awareness, etc.
- 3GPP SA5, Intent reporting Intent conflict administration, 3rd party services. Trustworthy AI/ML-based control ML training and analysis. Trustworthy management, zero-touch multiple closed loop coordination.
- 3GPP RAN, Radio interface architecture and protocols (e.g., MAC, RLC, PDCP, SDAP), the specification of the radio resource control protocol and the radio resource management procedures. Intelligent radio air interface design, flexible spectrum access solutions, Non-Terrestrial Networks solutions, joint communication and sensing Evolution of cellular IoT, enhancement of RedCap devices (eRedCap), Ambient IoT (potential future topic).
- ITU-R SG1, Spectrum management
- ITU-R SG5, Terrestrial services
- ITU-R WP 5D, 6G vision and requirements.
- ITU-T SG5, Environment, climate action, sustainable digitalisation and circular economy.EMF D-MIMO.
- ETSI ZSM, Security and privacy threats Intent based management, digital twins, service management automation, smart contract based closed loop governance, closed loop governance. Programmability, zero-touch automation, AI-based network management and orchestration, trustworthy management and integration fabric, interdomain network and service management. Integration fabric (reference implementation), smart contract based closed loop governance.
- ETSI MEC, Security and privacy threats, the techniques to address them, and the use of NDT techniques to evaluate threats and mitigation strategies Edge computing, extreme edge computing
- ETSI THz ISG, Channel modelling, sub-THz radio RF impairment modeling / sub-THz radio aspects
- ETSI NFV, Security and privacy threats. Cloud evolution e.g., dynamic discovery and monitoring different extreme edge nodes, resource allocation
- ETSI ISG SAI, Understanding of the risks associated to widespread use and support to AI by networks, including the realisation of relevant proofs of concept
- ETSI ENI, Integration fabric (reference implementation), smart contract based closed loop governance.
- ETSI OSM, Management and orchestration
- ETSI RIS, RIS
- NGMN, Use cases and requirements
- O-RAN nGRG, Use case and requirements. Architectural aspects
- GSMA, Use cases and requirements
- IETF DetNet, Deterministic network (data plane) and orchestration (control plane)
- IETF RAW, Deterministic network (data plane) and orchestration (control plane)
- IETF dmm, Mobility management
- IETF Security Area, On the application of attestation techniques, quantum-safe technologies, and automated certificate and key management procedures to improve security and privacy in next-generation networks.

- IRTF NMRG, AI-based orchestration
- BEREC, Environmental sustainability

Beside planned contributions there are many contributions already submitted to all above mentioned SDO and standardization initiatives – included in Deliverable D7.2.

2.2.23 6G-Cloud: Service-oriented 6G Network Architecture for Distributed, Intelligent, and Sustainable Cloud-native Communication Systems

URL/Reference:

https://www.6g-cloud.eu/

Abstract:

One key innovation in the 6G era will be the new design of the system architecture to support the extreme cloud continuum, where network functions from different 6G network segments can be composited flexibly and dynamically based on service needs in diverse cloud environments. With this in mind, 6G-Cloud aims to go far beyond the current 5G architecture design with disruptive and innovative approaches and solutions. It will research, develop, and validate key technologies to realize an artificial intelligence (AI)-native and cloud-friendly system architecture atop the cloud continuum. It will integrate cloud resources offered by multiple stakeholders and allow network functions from different 6G network segments to be composed flexibly and dynamically based on service needs in hybrid cloud environments using orchestration.

Starting and (target) end time of project:

01/01/2024 – 30/06/2026

IoT and/or Edge Computing research challenges:

- Define the overall AI-native and cloud-friendly 6G system architecture able to realize an end-to-end service-oriented 6G network atop multi-stakeholder cloud environment.
- Develop Cloud Continuum Framework for resource management and exposure with relevant business interfaces to allow flexible network composition of RAN-Core-Edge-Extreme-Edge networks in a dynamic multi-tenant environment.
- Bring service-oriented design and realize an end-to-end 6G service-based solution composed of smoothly integrated RAN and core, with the ability to act in the network-of-networks scenario.
- Develop a distributed management and orchestrated framework capable of scalable management and orchestration of network services atop the cloud continuum.
- Develop a native and network digital twin-enabled AI/ML framework to serve as an overarching cognitive plane of the 6G-Cloud architecture.
- Develop a unifying and open programable control framework for fine-grain network function coordination, resource allocation, and third-party control app integration in service-oriented 6G networks.
- Study energy efficiency, security, reliability, and sustainability aspects of the service-oriented system architecture and develop disruptive solutions for high-value applications.
- Develop proof-of-concepts to validate the architecture design and demonstrate the overall 6G-Cloud concept.
- Bring significant contributions to support early architectural standardization work.

Expected activities on "Dissemination and Impact on Standards":

- 3GPP: As it is known, 3GPP is organised in Working Groups (WG). The WGs of the radio access part (i.e. RAN2, RAN3, RAN4) are the ones most relevant for the project together with the SA5 WG that is dealing with management and orchestration aspects of RAN. In

addition, SA1 and SA2 are standardization targets for new use cases and topics related to System Architecture.

- ETSI Technical Committees (TC) and Industry Specification Group (ISG) relevant for the project are ISGs: NFV, MEC, ZSM and Management & Orchestration (MANO).
- O-RAN Alliance: Its main focus is to define open interface specifications in the RAN segment. Another target of the O-RAN group is to support a full automation in the RAN domain with benefits for the operators in terms of OPEX; in fact O-RAN considers in its architecture the presence of an orchestration framework and a radio controllers enabling AI/ML algorithms that support the automation of several aspects.
- Open Network Automation Platform (ONAP) project: Linux Foundation networking launched ONAP project in February of 2017, and it is the largest open source networking project that exists today in the industry and it provides an open-source network automation platform for real-time, policy-driven orchestration and automation of physical and virtual network functions that enables software, network, IT and cloud providers and developers to rapidly automate new services and support complete lifecycle management.
- ETSI Open-Source MANO (OSM) Community: OSM is a community-based project under the umbrella of ETSI created with the intention to provide an open-source reference implementation of a Management and Orchestration solution aligned with ETSI NFV standards. This project helps improve ETSI NFV standards by proposing changes to ISG NFV based on its implementation experiences.
- ETSI MEC Industry Specification Group (ISG): MEC offers application developers and content providers cloud computing capabilities and an IT service environment at the edge of the network. This environment is characterized by ultra-low latency and high bandwidth, as well as real-time access to radio network information that can be leveraged by applications. NCSRD is an active member of ETSI MEC focused on activities related to the security of edge telco environments.
- ITU-T SG13, Q20/21. ITUT-SG13 is working on many aspects of future networks, including network virtualization, cloud technologies, SDN, business models, network slicing, and AI/ML technologies applied to network management. OPL has been an active contributor in SG13 for many years. Please note that the NoN concept, due to the need for integration of different networking solutions, including the legacy ones, requires standardization that at present is beyond the 3GPP scope.

2.2.24 6G-BRICKS: Building reusable testbed infrastructures for validating cloud-to-device breakthrough technologies

URL/Reference:

https://6g-bricks.eu

https://cordis.europa.eu/project/id/101096954

Abstract:

Sixth generation (6G) wireless technology, which currently only exists as a concept, will create seamless connectivity between the physical and cyber worlds. The technology will use higher frequencies than 5G networks and provide substantially higher capacity and lower latency. Academia and industry are investigating a new generation of smart networks with enhanced capacity (by at least one order of magnitude) and new infrastructures to deploy these very dense networks. The EU-funded 6G-BRICKS aims to establish an experimental research facility to evaluate two key 6G candidate technologies: reconfigurable intelligent surfaces and cell-free massive multiple input multiple output. Novel unified control paradigms based on explainable AI and machine reasoning will also be explored.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

6G networks, currently only existing as concepts, are envisioned as portals to a fully digitized society, where the physical and virtual world are blended via boundless Extended Reality (XR), and also as an enabler for the Digital and Green transformation of the European Industries. To support this vision, the network capacity must be increased at least by an order of magnitude, while infrastructures must be transformed into a very dense continuum. Thus, academia and industry have shifted their attention to the investigation of a new generation of Smart Networks and infrastructures.
It is clear that to win this race towards shaping the next-generation communication ecosystem, a new generation of testbed infrastructures and breakthrough research and technology development is needed needed, as well as a new generation of testbeds to support future research initiative. To this end, 6G-BRICKS aims to deliver a new 6G facility, building on the baseline of mature ICT-52 platforms, that bring breakthrough cell-free and RIS technologies that have shown promise for beyond 5G networks. Moreover, novel unified control paradigms based on Explainable AI and Machine Reasoning are explored. All enablers will be delivered in the form of reusable components with open APIs, termed "bricks ". Finally, initial integrations with O-RAN are performed, aiming for the future-proofing and interoperability of 6G-BRICKS outcomes.

Expected activities on "Dissemination and Impact on Standards":

Standards body/forum	Working Group (WG)	6G-BRICKS contribution
3GPP	WG: RAN1	Monitor standardization activities in RAN1 and give input to the project consortium on standardization roadmap decisions. Potential opportunities for active participation in RAN1 for example through liaison statements and white papers will also be monitored and leveraged if appropriate.
3GPP	WG: S4	Monitor standardization activities in RAN4 and give input on interfaces and test requirements to the project consortium to adapt logging and monitoring interfaces that may comply with test solutions and can be utilized by experimenters.
ETSI	ISG: RIS	Proactive engagement and dissemination of the results of 6G-BRICKS into ISG RIS through technical contributions, proof-of-concepts, and potential new work item proposals. Partner in the project (IDE) is the chair of this ISG.
ETSI	ISG: ENI	Contribute to ISG's PoC activities by proposing and implementing a PoC on intent-based multi-domain cloud-native management of Edge and Deep Edge resources, which will showcase mechanisms developed within the 6G-BRICKS PaaS-based resource management and abstraction framework and the XAI-driven DMO mechanisms
O-RAN	WG2 WG3	**WG2** - Monitoring work on non-real-time RIC enhancements; Reporting to project consortium to prepare architecture for future ORAN incorporation of new APIs and interfaces.
O-RAN	WG4	Monitoring 5G and 6G advancements of open fronthaul to report towards project consortium on possible changes and adaptions
O-RAN	WG1 WG4	Include **RIS** as part of the **O-RAN** architecture, and target standardization of 6G-BRICKS components for distributed cell-free synchronization, Fronthauling, and RIS integration
AIOTI	WG Standardisation	Raise awareness to the role of 6G-BRICKS in interoperability between Edge, Deep Edge and IoT domains.
ISO/IEC JTCI SC29	MPEG	Monitoring relevant activities at **MPEG** (Media coding and delivery (MPEG Systems, JVET, MIV), with contributions relevant to Metaverse.

2.2.25 SUNRISE-6G: Sustainable federation of research infrastructures for scaling-up experimentation in 6G

URL/Reference:

https://sunrise6g.eu

https://cordis.europa.eu/project/id/101139257

Abstract:

6G represents the future of technology, promising exceptional performance through innovative access technologies. It is poised to prompt a complete re-evaluation of network architecture design, with new stakeholders entering the value chain of future networks. The EU-funded SUNRISE-6G project aims to develop a massively scalable internet-like architecture for all public and private infrastructures. Additionally, it seeks to establish a pan-European facility to support converged workflows and tools, offering a unified catalogue of 6G enablers and facilitating cross-domain vertical application onboarding through a Tenant Web Portal. The project will focus on four pillars: implementing new 6G enablers, a compliant Federation solution, a Federated AI plane, and a commonly adopted Experimentation Plane.

Starting and (target) end time of project:

01/01/2024 – 31/12/2026

IoT and/or Edge Computing research challenges:

The 6G is expected to emerge as key enabler for the intelligent digital society of 2030 and beyond, providing superior performance via groundbreaking access technologies, such as joint communication and sensing, cell-free, Radio Intelligent Surfaces, and ubiquitous wireless intelligence. Most importantly, 6G is expected to trigger a total rethink of network architecture design, which builds on a key idea of new stakeholders entering into a value chain of future networks. The SUNRISE-6G approach is inspired by the "network of networks" concept of 6G Networks, aiming to integrate all private and public infrastructures under a massively scalable internet-like architecture.

SUNRISE-6G similarly aspires to create a federation of 6G test infrastructures in a pan-European facility that will support converged Testing as a Service (TaaS) workflows and tools, a unified catalogue of 6G enablers publicly accessible by experimenters, and cross-domain vertical application onboarding. Experimentation and vertical application onboarding are offered via a Tenant Web Portal, that acts as a single-entry point to the facility, serving end users (e.g. experimenters) and tenants (e.g. vertical developers, infrastructure owners, 6G component manufactures).

The project execution is based on 4 pillars, delivering:

a) Implementation of new 6G enablers, complementary to existing ones being developed in SNS Phase 1 projects

b) A truly scalable and 3GPP compliant Federation solution that provides access to heterogeneous resources and devices from all Europe

c) Federated AI plane aligned with AIaaS and MLOPS paradigms, which promotes a collaborative approach to AI research which benefits immensely from scaling-up datasets and models

d) Commonly adopted Experimentation Plane, which offers common workflows to experimenters.

Expected activities on "Dissemination and Impact on Standards":

SDO	Working Group	Expected Contribution
ITU-T	ITU-T Q.4068	Contribute to Common Interfaces and APIs, Data Models and Formats, Reference Architectures (e.g., ITU-T Q.4068). Path towards impacting IMT 2030 developments.

SDO	Working Group	Expected Contribution
ITU-T	WP 5D	To follow activities of ITU-R WP 5D on 6G definition (IMT-2030). UOULU's 6G Flagship representative is nominated as Finnish national representative to WP5D work which offers a clear pathway for SUNRISE-6G to affect the development of IMT-2030.
ETSI	RIS	To contribute by including the creation of technical reports and studies that explore the potential benefits, applications, and challenges of RIS in the context of future communication networks, such as 6G systems, as well as potential new requirements.
ETSI	NFV	To provide use cases and requirements for incorporating NFV technologies into 6G networks. This includes exploring new service models, network architectures, and management and orchestration (MANO) approaches that leverage the benefits of virtualization in 6G systems.
ETSI	MEC	To allow containerized MEC apps to be disaggregated at any MEC host with the extension of the Mobile Edge platform at the system and host level.
ETSI	ZSM	To contribute with the development of proof-of-concept implementations and demonstrators showcasing the integration of ZSM technologies in 6G systems, providing valuable insights into the practical challenges and opportunities of deploying automated network management functions in next generation networks.
ETSI	ENI	To follow and contribute with technical reports and studies to ETSI ENI and its system architecture aspects on intent LCM, closed loops automation, Federated Administrative Domains and knowledge management. Moreover, ICOM will lead the start of an ETSI Software Development Group (SDG) on a Federation Framework that will devise, in collaboration with consortium partners who are ETSI members, an open Federator SDK.
ETSI	OpenCAPIF (OCF) SDG	CAPIF open-source framework will be integrated as part of the Exposure Gateway to ensure secure and trustworthy exposure of resources especially when they belong to different trust domains. Under discussion how CAPIF can be applied in the project. OCF was recently created and is not included in DoA.
3GPP	RAN1	Monitor standardization activities in RAN1 and give input to the project consortium on standardization roadmap decisions. Potential opportunities for active participation in RAN1 for example through liaison statements and white papers will also be monitored and leveraged if appropriate.
3GPP	SA1	To contribute with the outcome of the NTN communication in SA1 for use cases and requirements
3GPP	SA2	**SA2** for integration into architectures of existing mobile communication networks
3GPP	SA5	**SA5** for operations and management of NTN and NTCS in 6G
CAMARA	Edge Cloud API QoS on Demand	Monitor and align API requirements, publish API definitions and advancing current APIs, enabling seamless access to Telco network capabilities (5G and 6G). Aiming to extend the Camara Initiative APIs, offering unified developer APIs towards SUNRISE-6G use-cases and components (e.g. Open-source implementation of exposing NTN emulator components, aligned with CAMARA APIs).
O-RAN	Next-Gen Research Group (nGRG)	SUNRISE-6G will follow and contribute to the discussions in the O-RAN's next Generation Research Group, which specifically focuses on the O-RAN development needs towards 6G. The most relevant nGRG research streams for the SUNRISE-6G topics will be: • **RS02**: Architecture • **RS05**: Management • **RS06**: Cross Domain • **RS08**: nG Research Platforms
O-RAN	WG1, WG2, WG3	**WG1** - Include RIS as part of the O-RAN architecture, and target standardization of SUNRISE-6G components for distributed cell-free

SDO	Working Group	Expected Contribution
		synchronization, and RIS integration. Moreover, include the Cell-free and JCS as a part of the overall O-RAN architecture. **WG2** - Monitoring work on non-RT RIC enhancements; Reporting to project consortium to prepare architecture for future ORAN incorporation of new APIs and interfaces.
CNCF	DevOps	Share paradigm, protocols, and implementations of declarative APIs target end-to-end automations of infrastructures and services.
TM-FORUM	Open API DG	Application of TMF Open APIs for the SUNRISE-6G capability exposure, feasibility checks, tests across testbeds.
AIOTI	WG Standardisation	Raise awareness to the role of SUNRISE-6G in interoperability between Edge, Deep Edge and IoT domains

2.2.26 Experiment driven and user experience oriented analytics for extremely precise outcomes and decisions (HORIZON-CL4-2022-DATA-01 "ExtremeXP")

URL/Reference:

https://extremexp.eu

https://cordis.europa.eu/project/id/101093164

Abstract:

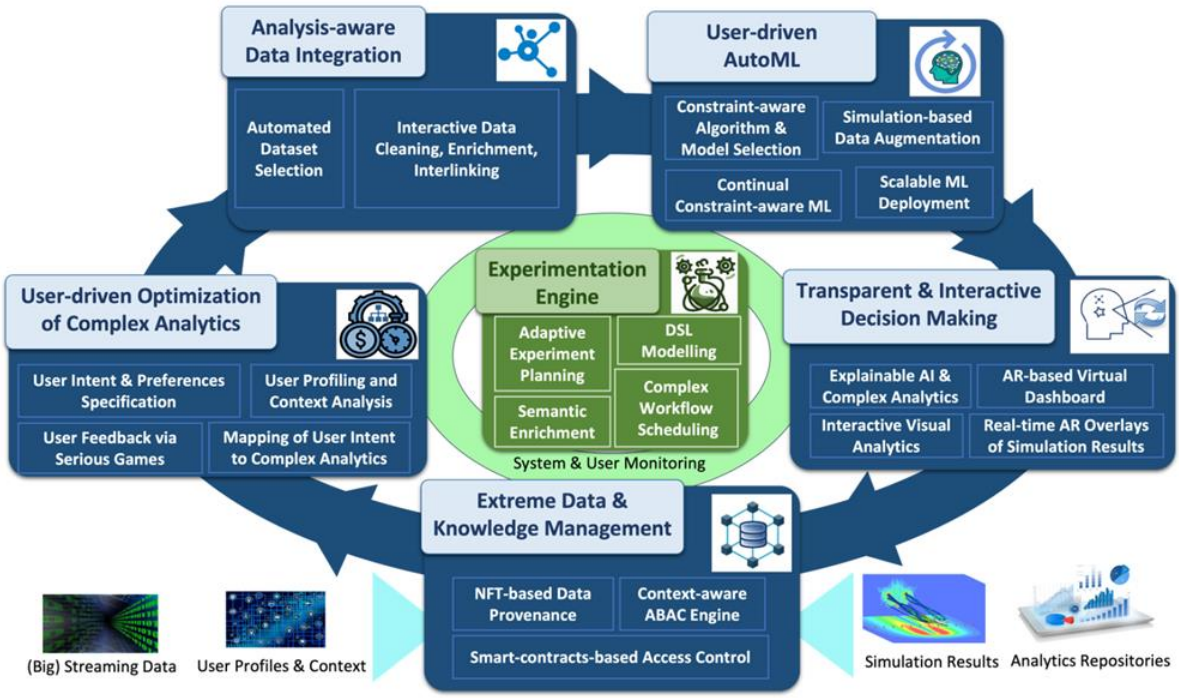
Extreme data characteristics represent a challenge for advanced data-driven analytics and decision-making in critical domains such as crisis management, predictive maintenance, mobility, public safety and cyber-security. Data-driven insights must be timely, accurate, precise, fit-for-purpose and reliable, considering and learning from user intents and preferences. The EU-funded ExtremeXP project will create a next-generation decision support framework that integrates novel research from big data management, machine learning, visual analytics, explainable AI, decentralised trust, and knowledge engineering. The framework will aim at optimising the properties of complex analytics processes (e.g. accuracy, time-to-answer, specificity, recall, precision, resource consumption) by associating different user profiles with computation variants, promoting a human-centred, experimentation-based approach to AI and complex analytics. The project will perform five pilot demonstrations.

Starting and (target) end time of project:

01/01/2023 – 31/12/2025

IoT and/or Edge Computing research challenges:

Decisions based on data-driven insights can be vital and have a phenomenal impact on the environment, society, and business. Many critical domains such as crisis management, predictive maintenance, mobility, public safety, and cyber-security become increasingly disrupted by new means to harness the extreme proliferation of data for effective decision making. Generating data-driven insights that can be used and trusted by decision-makers is, however, still far from trivial. On the one hand, (big) data analytics solutions need to cope with data of extreme (exabyte) scale, low quality (sparse/missing/insufficient values), different modalities (raw data, text, images), and different owners. On the other hand, complex data analytics comprising machine learning (ML) and simulation tasks need to provide outcomes (i.e., predictions, visualizations) that are both accurate, precise, and fit for purpose. While accuracy refers to outcomes that are close to reality and precision to being focused and not dispersed, fit-for-purpose refers to their actual usefulness in decision making. On top of these needs, insights are not used in decisions if they cannot be trusted; therefore, increased trustworthiness in data-driven insights is pivotal in the adoption of data-driven decision making, in life-critical domains.



Existing R&D efforts typically target only one of the aspects of the data analytics conundrum: they focus either on resource efficiency and scalability, data management, ML performance, AI explainability, or data visualization. Several existing big data frameworks and architectures (Lambda, Data Lakes, etc.) provide support of processing, analytics, ML, simulations, and visualizations for large data volumes, given the proper infrastructure; however, they mainly focus on efficiency and scalability in pre-designed data analytic workflows. Automated ML (AutoML) streamlines the whole process of providing optimised ML models from data ingestion and pre-processing to model selection and training, to model execution and result visualization; however, it does not involve end (business) users in the loop. Explainable AI aims at ML models that can explain their generated results, increasing the understanding and ultimately the trust of end users in data-driven insights; It typically focuses on individual ML models and does not consider the user intents and preferences. Current visualization techniques mostly focus on visually representing the outcomes of analytics processes in one direction, from data processing outputs to graphs, charts etc., neglecting interaction with end users, which can further expose user requirements in an incremental manner and hint towards the data processing that fits their needs. Overall, past work contributes to data quality, without sufficient attention to the user intent. We need to embed the user in data production and management; and ways to detect (and correct) when the data (and ML-driven systems) diverge from such intent.

In response to this dire need for decision making based on accurate, precise, fit-for-purpose, and trustworthy data-driven insights, ExtremeXP proposes a new paradigm for data analytics, which we call experimentation-driven analytics. The main contribution is that it puts the end user, i.e., requirements, preferences, constraints, interpretation, explanations, feedback, and decision making, at the centre of complex analytics processes (from data discovery to novel interactions), proposing a human-in-the-loop, experimentation approach for gaining knowledge and making decisions from data with varying and extreme characteristics (Figure 1). An experiment for ExtremeXP considers alternative means (datasets, features, algorithms, models, simulations, visualizations) of responding to an end user intent – knowledge requirement, executes a particular variant for each user, and evaluates it based on both system-level metrics (latency, accuracy, precision, specificity, anonymity) and feedback from the user in an automated or semi-automated way. This way, it gradually builds up knowledge to associate users to complex analytics workflows that meet their needs, i.e., consider their constraints and preferences regarding outcome attributes such as latency, precision, and anonymity. ExtremeXP integrates interactive visualization and explainability techniques to increase the trustworthiness of not only the outcomes but also of the process to reach such outcomes. Towards the latter, it is important to transparently and immutably persist any access control

decisions regarding datasets used for deriving valuable insights and highlight their characteristics and therefore potential value in terms of the data analysis workflow. The provided framework automates the process of (i) running complex analytics as part of experiments and of (ii) building up the knowledge base for user-experience-driven analytics, reducing the complexity associated with manual tuning of complex analytics.

The ExtremeXP project will deliver the following assets:

ER1: Modelling framework and reference architecture for complex experiment-driven analytics

ER2: Experiment engine for automating scheduling, evaluation, and adaptation of complex analytics

ER3: Analysis-aware data integration concept and methods

ER4: Methods for Automated ML (AutoML) with user constraints

ER5: Support for user involvement in complex experiment-driven analytics

ER6: Explainability-oriented user interaction toolset

ER7: Interactive visualisation support including augmented reality and serious games

ER8: Holistic data and knowledge management supporting privacy and security

ER9: 5 pilot demonstrators to validate results through deployment in relevant environments

Expected activities on "Dissemination & Impact on Standards":

The ExtremeXP consortium will leverage the participation of partners in several initiatives, **standardisation** bodies, collaboration platforms and hubs related to AI, Data, European Open Science Cloud (EOSC) and Industry in general. In particular:

BU will liaise with *BDVA* and *AIOTI*

ICOM will contribute to *AIOTI* and participate in *ETSI CIM* (Standards – Context Information Management), *ETSI ENI* (Experiential Networked Intelligence) as well as to *TM Forum* (active in AIOps)

AE will work with *OW2* to promote Market Readiness for open-source project developments

ARC will cooperate with EOSC Association

ICCS will work with *BDVA*, *IDSA*, *NESSI* and Gaia-X

Direct access and open communication channels with these entities are available to the consortium through the engagement of the partners. Such liaisons will significantly strengthen the ExtremeXP capacity for reaching many stakeholders and disseminating the project results.

2.2.27 Intent-driven native AI architecture supporting compute-network abstraction and sensing at deep edge (HORIZON-JU-SNS-2023 "6G-INTENSE")

URL/Reference:

https://6g-intense.eu/

https://cordis.europa.eu/project/id/101139266

Abstract:

The 6G Smart Networks of the future will provide the high-performance and energy-efficient infrastructure on which next-generation internet and other future-looking applications can be developed and deployed. 6G will foster an Industry revolution and digital transformation and will accelerate the building of smart societies leading to quality-of-life improvements, facilitating autonomous systems, haptic communication, and smart healthcare.

To achieve the objectives sustainably, it is well understood that new approaches are needed in the way the telecom infrastructures are architected, federated, and orchestrated. These new approaches call for multi-stakeholder ecosystems that promote synergies amongst the Mobile

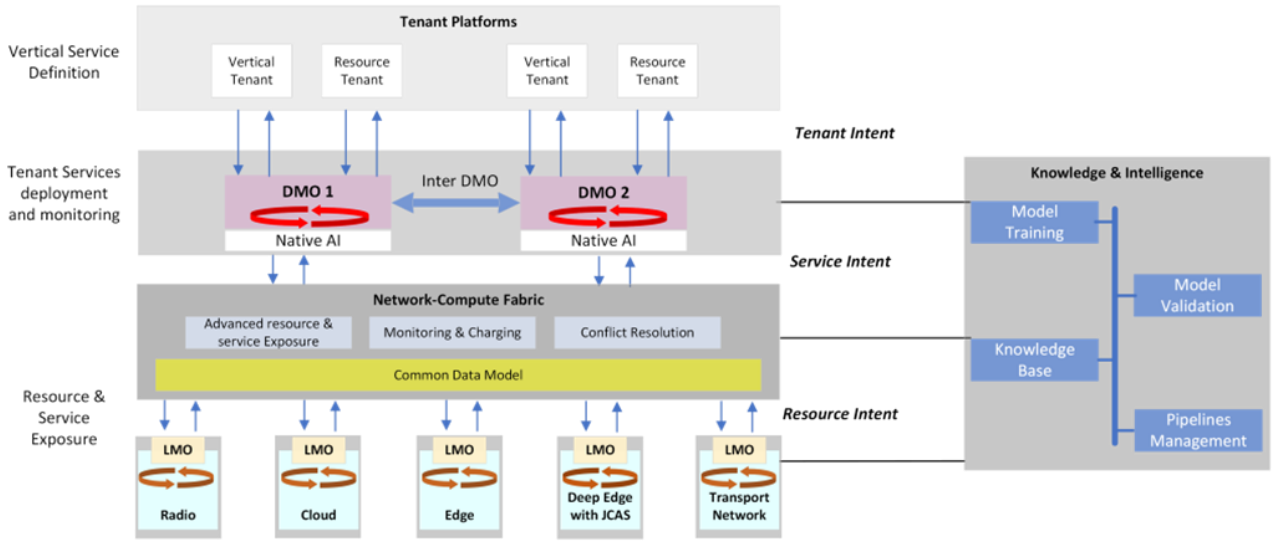
Network Operators and owners of all kinds of computational and networking resources that will share the extraordinary costs of yet another generation upgrade from 5G to 6G, while facilitating new business models. New architectural paradigms are making things more complex due to their large scale and diverse orchestration domains. As a result, automation needs to step up to handle this complexity. That is why 6G is aiming for the ambitious goal of pervasive AI-driven intelligence, known as Native AI. However, the multi-stakeholder infrastructures foreseen in 6G as per the "network of networks" concept, will add a level of unprecedented management complexity due to a sheer scale and heterogeneity of involved orchestration domains.

Starting and (target) end time of project:

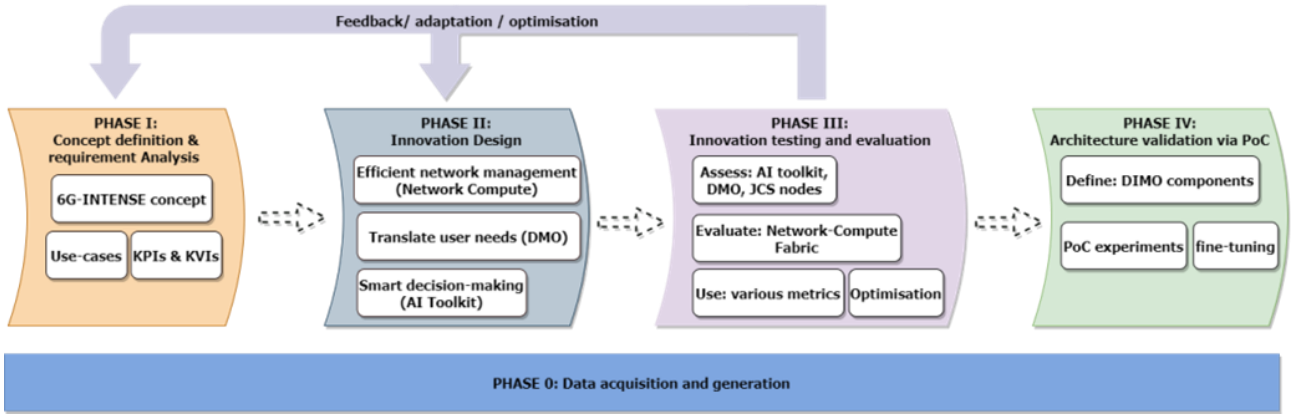
01/01/2024 – 31/12/2026

IoT and/or Edge Computing research challenges:

This is where 6G-INTENSE steps in, proposing a new System Architecture for 6G, as illustrated below, to deliver "6G as a Smart Service Execution platform", fully in line with the vision of sustainable infrastructure sharing to reduce space and energy costs and encouraging collaboration among all members of the value chain under a unified Network-Compute fabric. A key contribution is a novel automation architecture with a Native AI toolkit facilitating intent declaration, negotiation, and decision automation across autonomous domains, termed Distributed Intent-driven Management and Orchestration (DIMO). Moreover, sensing is adopted as a key enabler, helping to navigate the complexities and lack of reliability of the Deep Edge.



The 6G-INTENSE project introduces a transformative scientific approach, uniting all computational and networking resources under a revolutionary, open controllability framework. The project aims to drive innovations across business, management, and infrastructure layers. Through a systematic five-phase methodology, as depicted in the figure below, 6G-INTENSE pursues ambitious goals. These include advancing 6G technologies to enhance performance, efficiency, and capabilities, establishing a single, unifying framework that redefines controllability in network infrastructure.



The 6G-INTENSE project will validate its key technologies and innovations through relevant Proof-of-Concepts (PoCs). Embracing technologies like AI/ML, edge computing, and intent-driven orchestration, the project employs cutting-edge platforms, such as the infrastructural platforms provided by Orange Romania, Eurecom and Athena/ISI. These platforms form the backdrop for a diverse set of experiments, exploring distributed continuum computing, metaverse services, and pervasive location awareness. With a commitment to fostering progress, 6G-INTENSE also places a significant focus on data acquisition, creating open datasets to fuel ongoing research in the dynamic 6G landscape. This holistic approach positions 6G-INTENSE at the vanguard of shaping the future of wireless networks. PoCs are listed below:

Distributed Continuum towards pervasive computing (PoC-1)

Experiment 1 *"Pervasive Computing in a Distributed Continuum":*

It explores efficient media content distribution across diverse domains using a converged infrastructure. It employs dynamic Edge Cache instances for reliable streaming, adapting to user connectivity, content popularity, and network conditions. The 6G-INTENSE framework enables hierarchical, intent-driven automation for optimal Edge Cache services, including auto-scaling, auto-healing, and migration. INTRACOM's content delivery network platform is deployed in various environments, and a multi-testbed setup showcases the INTENSE-6G Orchestration Continuum with πEdge local managers and orchestrators orchestrating Edge Cache container network functions. It aims to:

- Manage smart services through the Network-Compute Fabric, trained by Generative AI models
- Ensure security in the Deep Edge infrastructure by monitoring links and performance

Experiment 2 "*Edge intelligence and Compute interconnection*":

It evaluates the Composable AI and learning capabilities of the 6G-INTENSE system in the context of distributed content delivery network video streaming. It introduces an automated service level objective setting and adjustment across domains, utilising Machine Learning as a Service (MLaaS) for domain adaptation. The experiment demonstrates automated resource brokerage, knowledge sharing, and cognitive enablement to ensure consistent service level agreement assurance across domains. It aims to:

- Efficiently connect network points using smart network technologies for enhanced video streaming
- Flexibly use resources within the system to optimize video streaming
- Ensure reliable quality of service through monitored intentions
- Improve video streaming quality by smartly training models on the edge

Metaverse (PoC-2):

Experiment 3 "*Joint Communication and Sensing for optimal user tracking in the Metaverse*"

It focuses on intelligent algorithms for Joint Communication and Sensing in future 6G systems, specifically in user equipment tracking scenarios. While current algorithms excel outdoors, their precision diminishes indoors, impacting users connecting to Deep Edge devices via non-3GPP access. Sensing user location is crucial for predicting disruptions and enhancing location awareness. The scenario involves users connected through non-3GPP access to a 6G-INTENSE distributed intent-driven management and orchestration-deployed Metaverse service. Distributed intent-driven management and orchestration, relying on communication and sensing, showcases components translating users' intents and demonstrating resource-level optimisation, such as handovers triggered by sensed information. Its objectives are to:

- Demonstrate joint communication & sensing to provide pervasive location awareness by Metaverse
- Explore trade-offs on sensing accuracy vs. energy efficiency at the Deep Edge

Experiment 4 "*Fully autonomous Metaverse fault, configuration, accounting, performance and security management, sensing, continuum abstraction*"

It showcases distributed intent-driven management and orchestration end-to-end functionality, emphasising intent translation and propagation. Orange and Eurecom testbeds, interconnected via 6G-INTENSE domain management and orchestration, convey preferences through intent. A Metaverse Service Mesh aligns with 6G-INTENSE, featuring cloud-native network functions, micro-services, and a cyber-physical systems service. Domain management and orchestration autonomously handles onboarding and intent negotiation, while testbeds deploy services via their Network-Compute Fabric abstraction frameworks. Its objectives are to:

- Showcase how Native AI mechanisms drive intent (re-) negotiation at the Tenant domain
- Deliver the Orchestration Continuum vision at the Service domain
- Demonstrate adaptation based on inputs of a Sensing service being part of a generalized Service Mesh

Local managers and orchestrators like Eurecom O-RAN and Intracom pi-Edge orchestrate resources. The experiment tests adaptability, intra- and inter-domain coordination, and conflict resolution, highlighting Native AI toolkit's hierarchical reinforcement learning capabilities. Fault, configuration, accounting, performance and security management decisions include intent adaptations, service migrations, and resource scaling, illustrating collaborative orchestration by O-RAN and pi-Edge local managers and orchestrators.

Expected activities on "Dissemination & Impact on Standards":

6G-INTENSE will achieve long-lasting impact by influencing standards, thus obtaining the seal of approval for its newly implemented components. Key industrial consortium partners as active members in various key standardisation organisations (3GPP, TMForum, IETF/IRTF, and ETSI) will contribute to new standards bringing in new requirements to identify and fill gaps, as well as evolve existing standards related to 6G architectures.

Participation in 6G initiatives: 6G-INTENSE will contribute to 6G-IA activities and it will participate in any Working Groups. Moreover, the consortium has already identified several relevant projects, while during the project active monitoring of any other initiatives that might be essential to liaise with or contribute to will be also actively pursued (e.g. IEEE Future Networks Enabling 5G and beyond, IEEE 5G Summit). Moreover, 6G-INTENSE consortium commits its presence in EuCNC (2023-2026), where demos of the project's solutions will be presented.

Standards body/forum	Working Group (WG)	Planned 6G-INTENSE contributions
IETF	Routing Area WG (RTGWG)	Contribute with the research activities on SDWAN. More precisely, devised 6G-INTENSE mechanisms to interconnect, manage and orchestrate Cloud Edge Interconnection using SD-WAN.
IRTF	Network Management Group	Contribute to the intent-based network management using 6G-INTENSE native AI kit.
3GPP	Experts Group SA6	Contribute with business intent translation replacing classical BSS model with a fully distributed systems using LLM and Generative AI.
	Experts Group SA5	Contribute with the programmable intent model translation and propagation, paving the road to the beyond 5G SBA architecture by replacing classical API by intents.
ETSI	ENI	Contribute to ETSI ENI ISG with technical reports and PoC activities on intent-driven, hierarchical closed loop automation solutions developed within 6G-INTENSE.
	ZSM	E2E and domain specific management architecture and AI based closed-loop automation. Contribution to ZSM016 (Intent Driven Closed Loop Automation). Contribute to ISG PoC activities through proposing and implementing a PoC on intelligent predictive, intent-based declarative multi-domain monitoring, which will showcase mechanisms developed within the 6G-INTENSE
	MEC	Contribute with extension of the Mobile Edge platform at the system and host level, to allow containerized MEC apps to be disaggregated at any MEC host. Also to contribute with CNIT JCS using MEC.
ITU-T	ITU Focus Group on Autonomous Networks (FG-AN)	Contribute with the Native AI tool kit applied to support zero-touch management and orchestration toward supporting autonomous network management
O-RAN	Non-Real-time RAN Intelligent Controller and A1	Contribute the integration of intent propagation and translation mechanism to O-RAN SMO.
OAI Alliance	Open Air Interface	Contribution of the developed modules integrating Intent to SMO and their enforcement using OAI 5G RAN.
TM Forum	Catalyst projects	Participate a TM Forum's Catalyst project to promote 6G-INTENSE intent-driven processes for intelligent continuum management

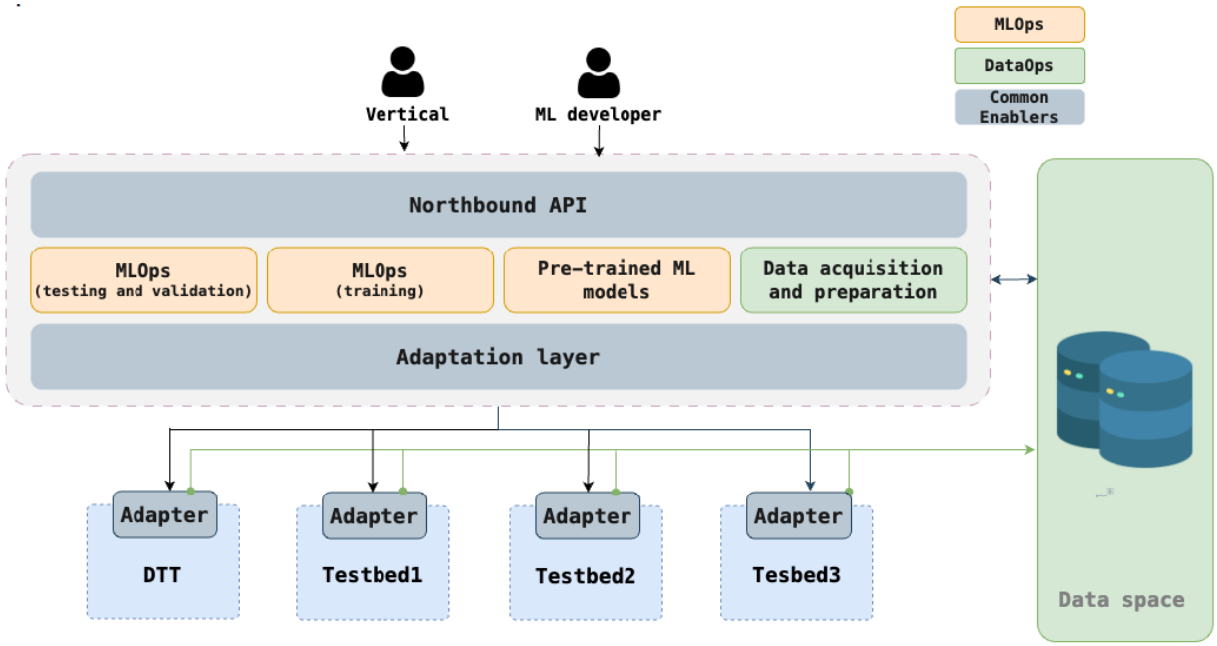
2.2.28 6G Data and ML operations automation via an end-to-end AI framework (HORIZON-JU-SNS-2024 "6G-DALI")

URL/Reference:

https://cordis.europa.eu/project/id/101192750

Abstract:

One of the key enablers of 6G is undoubtedly the Native support of AI/ML at all the system levels, components, and mechanisms, from the orchestration and management levels to the low-level optimization of the infrastructure resources, including Cloud, Edge, RAN, Core Network, as well as a transport network. Despite the opportunities, there are several gaps that hinder the adoption of AI/ML in 6G, such as the lack of extensive and high-quality datasets that are required to train the models. On the other hand, AI model testing and performance evaluation in a representative staging environment (by emulation or real deployment) is also challenging without access to an end-to-end 6G testbed or representative Digital Twin environment.



Hence, 6G-DALI will deliver an end-to-end AI framework for 6G, structured in two pillars:

(1) AI experimentation as a service via MLOps

It will deliver an AIaaS framework for 6G experimentation, aiming for highly efficient and automated ML operations (MLOps). A meta-orchestration solution encompassing heterogeneous MLOps/RLOps software stacks will be delivered, covering all the steps constituting the life cycle of development of AI and ML models, i.e., training, validation, finetuning, hyperparameter optimization, and performance benchmarking. The 6G-DALI e2e AI framework supports a wide range of ML algorithms, including federated learning (FL) models, time series models, and reinforcement learning.

(2) Data and analytics collection and storage via DataOps

The AI framework will deliver an intent-driven DataOps framework that allows users to find datasets to train their models and also improves the collected data to ensure high quality and increase their quantity if more data is needed (data augmentation). In regard to data generation and collection, we distinguish between cold data, which correspond to datasets available at the 6G Dataspace, i.e., those already collected via precedent experiments or produced by other projects or third-tier experiments, and hot data that need to be generated using one or more testbeds connected to the framework. In 6G-DALI, we embrace the Extract Load Transform (ELT) pipeline approach for DataOps.

The 6G-DALI DataOps pillar provides the mechanisms for preparing clean and processed data that are stored within a 6G Dataspace and are made available for training and validating machine learning models as a service, a part of the MLOps Pillar. The end-to-end framework also delivers continuous monitoring, drift detection and retraining of models. Finally, 6G-DALI will deliver open datasets, a 6G Dataspace for dataset storage and secure sharing, and a Digital Twin testbed for data generation on demand.

Starting and (target) end time of project:

01/01/2025 – 31/12/2027

IoT and/or Edge Computing research challenges:

This is where 6G-DALI steps in, building a novel e2e AI framework that aims to connect 6G data with verticals and ML developers and experimenters, while relying on 6G testbeds selected from the flagship SNS C phase 2 (SUNRISE-6G) project.

To this end, 6G-DALI is bringing together 3 communities; experts on the design and experimentation on 6G systems, experts on AI and MLOps with a good mix of industry and

academic experience, and finally experts on DataOps and the Gaia-X community, that all collaborate for the first time to build an efficient, realistic, and trustworthy framework for e2e AI/ML experimentation for 6G. The 6G-DALI will pursue the following challenging objectives:

Objective 1: Deliver a user-friendly e2e AI framework for DataOps and MLOps in 6G

Devise a user-friendly e2e AI framework for 6G, structured in two interdependent pillars; a DataOps pillar that provides the clean, processed data that are stored in the 6G Dataspace and are available for training and validating machine learning models a part of an MLOps Pillar. Deliver high-level user interfaces (graphical and API-based) to interact with the 6G-DALI's DataOps and MLOps systems, offering AI experimentation as a service as well as intent-based approaches and Large Language Models (LLM). The envisioned interfaces will allow

(i) to discover available datasets following the Gaia-X approach

(ii) to express data request as intent

(iii) to run data generation and quality improvement

(iv) to trigger the test of trained ML models

(v) to test and validate the ML model by deploying it on top of the existing testbeds, including the 6G-DALI Digital Twin Testbed (DTT).

Objective 2: Deliver Gaia-X & Extract Load Transform (ELT) for DataOps in 6G environments

Deliver procedures to satisfy user requests, either for cold data (i.e., available datasets at the local or data space catalogues) or hot data via the AI experimentation as service using the 6G testbeds as well as DTs that collect and construct the needed datasets. Adopt the Gaia-X approaches for cold data search (service catalogue) and data security (trust and security) and integrate these procedures to the user interface (Obj. 1). Regarding hot data, devise and implement ELT pipelines to collect datasets if they are not available in the 6G data space. The ELT process, specifically Transform phase, will be improved by novel data augmentation and cleaning algorithms devised in 6G-DALI. Indeed, one of the key criteria that guarantees an accurate and performing ML model is the quality of the used dataset. Finally, the DataOps of 6G-DALI will not only support the project, but it will also be open to other SNS projects that generate data sets using their testbed and PoCs to share the data through the envisioned 6G Data space, ambitioning to end up being a common and a reference data space that can be harmonized with other SNS JU projects, including the EU-US 6G-XCEL project (through IBM who is also involved), to support their activities on ML and AI for 6G.

Objective 3: Streamline 6G testbed's trustworthy AI/ML operations via MLOps and AutoML

Deliver efficient, automated and trustworthy ML operations (MLOps) for 6G via AutoML and AutoRL workflows, covering the entire life cycle of AI and ML models, i.e., training, validation, finetuning, hyperparameter optimization, and performance benchmarking, an approach termed as AIaaS for 6G experimentation. Also Incorporate Reinforcement Learning operations (RLOPS) as well as Federated learning (FLOps) on top of 6G testbeds and Digital Twins. Devise a meta-orchestration solution encompassing heterogeneous MLOps/RLOps software stacks, covering all the steps constituting the life cycle of development of ML/RL/FL-based models by (i) providing pre-trained models via an ML catalogue and (ii) providing tools for ML model testing and validation (i.e., validate if the model runs as expected), on model performance (i.e., if the model is accurate and achieves the expected performances) and the model trustworthiness (in terms of drift and uncertainty quantification).

Objective 4: Deliver plug-able adapters to easily integrate 6G testbeds from future calls

One of the key objectives of 6G-DALI is to allow ML developers (including verticals) to collect data and train ML/RL models for 6G systems via DataOps and MLOps. To achieve this, it is important to rely on existing 6G testbeds and additional testbeds constituted of Digital Twins (DT) and emulation approaches.

Although the project has identified testbeds participating in the SUNRISE-6G federation as the initial testbeds for developing the experimentation facility, 6G-DALI aims to deliver an e2e AI framework that easily integrates new testbeds and additional enablers (e.g., THz) from future

calls. Consequently, the project aims to implement and release as open source 2 key innovations to ease the integration of the testbed:

- the adaptation layer at the AI framework level that allows having a common set of Northbound MLOps & DataOps APIs
- a set of adapters deployed at testbeds to translate the Northbound APIs to Southbound 6G testbed (and DT) APIs, and to the 6G Data space through Dataspace Connectors.

Though this modular approach 6G-DALI aims to allow new 6G testbeds, which will be developed by other ongoing or future SNS projects, to be integrated easily into the framework by building the adapter for the specific 6G testbed enabler and local experiment management system.

Objective 5: Build / Integrate Digital Twin Testbed to generate representative datasets for 6G

In complement to the existing 6G testbeds, in 6G-DALI, we will develop one reference Digital Twin Testbed (DTT) to allow running tests and create datasets including scenarios that require, for instance, large-scale deployment, such as connecting several cells to test mobility or generate a high amount of traffic via the connection of thousands of UEs. Such a scenario is difficult to deploy today in existing 6G testbeds, which lack scalability. The envisioned DTT will be enriched with a management layer that allows automating tests and experiments while being able to collect data to create a dataset. To create this reference DTT we combine the well-established OpenAirInterface (OAI) platform and the VIA´s testing tools to enable large-scale and high-fidelity DT of 6G (RAN and CN). We envision an Open RAN approach where the gNB is decomposed into CU, DU, RU.

Objective 6: Ethical data sets and validation methodologies and legislative compliance

6G-DALI will adopt a methodology to embed ethics into the design and implementation of a trustworthy e2e AI framework, aiming to ensure the societal acceptance, especially for the usage as well as the compliance of data sets and validation methodologies with the rules of current and forthcoming data legislation, e.g., GDPR, Data Governance Act, Data Act, AI Act. Moreover, 6G-DALI aims to provide final policy options for policy makers to cover eventual gaps as well as final recommendations for future endeavours in 6G field.

Expected activities on "Dissemination & Impact on Standards":

The 6G-DALI pillars relate to current standardization efforts and Open-Source frameworks that will be leveraged to implement both project Pillars. Pillar 1 will build a comprehensive AIaaS experimentation framework (Objectives 1 & 3) on top of Open Source MLOps toolkits (Kubeflow, Prefect, ZenML, MLFlow, RAY) that will provide full automation for ML models and AI software artifacts lifecycle management. The 6G-DALI e2e AI framework is also fully aligned with 3GPP standards. On the other hand, Pillar 2 is aligned with Data Spaces (IDS) and GAIA-X initiatives (Objective 2) aimed at establishing standards for data exchange and sharing among participating organizations. These initiatives empower entities to retain control and sovereignty over their data while facilitating the open accessibility of data and services. 6G-DALI will embrace the mechanisms proposed by Gaia-X and IDS for handling data life-cycle, which will be collected from 6G testbeds and DTT. Furthermore, 6G-DALI commits to open-source the adapter component to ease collaboration with other on-going and future SNS projects and integration of their testbeds. As per the standardisation activities, the DTT to be delivered by the project and NWDAF-based MLOps/RLOps/FLOps are 100% compliant with 3GPP specifications. In addition, all interactions with RAN to control it are based on O-RAN's well-established interfaces. Further, 6G-DALI has a specific standardisation plan (Table 2.4) that target contributions to key SDO groups (3GPP, ETSI, and IRTF), by formal contributions or PoC using DTT and other project artifacts.

Standards body/forum	Working Group (WG)	Planned 6G-DALI contributions
ISO/IEC	JTC1/SC42	Contribution to the ongoing initiative of a Joint Technical Committee (JTC1/SC42) for definition of "Reliability of AI systems".
EU Committees	CEN/CLC JTC21	Contribution to the ongoing initiative of the Joint Technical Committee (JTC21) of the CEN/CLC for the definition of "Data Governance and quality in AI"
IRTF	Network Management Group	Contribution to Network Digital Twins architecture and its involvement on network management aspects of future networks
3GPP	SA2/SA4	Contribute with the mechanisms related to data collection for AI/ML using NWDAF, MLOps and Federated learning relaying NWDAF.
	RAN1/2/3/4	Distillate appropriate contributions from DALI work towards relevant 3GPP activities, especially on AI/ML related study and specification work, such as AI for Air Interface
ETSI	ENI	Monitor and contribute LLM-based translation activities to the GS ENI 030 "Transformer Architecture for Policy Translation
	ZSM	Monitor the related standards evolution, with specific focus on AI-related enablers and services definition. Contribute to the proposal of ZSM PoC activities (e.g., implementing PoCs related to the MLOps work carried out in the project). NXW and VIAVI will coordinate these activities as both are ZSM members, while VIAVA is ZSM013 rapporteur on CI/CD automation.
ITU-T	Focus Group on Testbeds Federation for IMT-2020 and beyond	Monitor and make awareness of the 6G-DALI framework and its extensibility to integrate new testbeds and platform to participate to the 6G Dataspace
O-RAN	WG1/2/3/9/10	Monitor opportunities to contribute to testing aspects in O-RAN, including AI/ML specific requirements and use-cases, particularly with the support of the activities conducted in 6GDALI about Digital Twins Testbed (DTT) for RAN. All the experiments of PoC3 that uses DTT will uses O-RAN interfaces (E2, Fronthaul, O1, etc.).
OAI Alliance	Open Air Interface	EUR, founder of the OAI Alliance, will contribute to the software development of the 6G network stack and their control and management subsystems
TM Forum	Catalyst projects	Contribute to catalyst program on intent-driven automation of MLOps pipelines for network operation
Linux Foundation	Data and AI Foundation	IBM is a member of the Linux Foundation Data and AI Foundation, and will consider it as a target venue for donating the packages related to HPO Experiment as a Service
ZenML	ZenML Hub	ICOM, a telco vendor with significant industry experience, will implement and contribute back to the Open Source ZenML project the stack component flavours, pipelines, steps, materializers, and other pieces of code implemented within 6G-DALI as part of the 6G meta-orchestration solution.
SIMPL (Gaia-X)	SIMPL	Contribute and align the 6GDataspace using the SIMPL project open-source software including SIMPL middleware (Simpl-Open).
Garnet Framework	-	Contribute to the usage of the 6G-Data Space in the context of the Garnet Framework for storing and processing Smart City Data

2.2.29 A-IQ Ready: Artificial Intelligence using Quantum measured Information for real-time distributed systems at the edge

URL/Reference:

https://www.aiqready.eu

https://cordis.europa.eu/project/id/101096658

Abstract (IoT project):

The onset of climate change and widespread geopolitical conflicts and social inequalities showcase the need for innovation and change that require a better world.

Global environmental issues, social inequality and geopolitical changes will pose numerous problems for our society in the future. To face these new challenges and deal with them, there

is a need to understand and appropriately utilize new digital technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), robotics and biotechnologies. The EU-funded project A-IQ Ready proposes cutting-edge quantum sensing, edge continuum orchestration of AI and distributed collaborative intelligence technologies to implement the vision of intelligent and autonomous Electronic and Software-Based Systems for the digital age. Intelligent quantum sensing will improve timing and accuracy of autonomous agents and reduce false alarms or misinformation by means of AI and multi-agent system concepts. Edge continuum orchestration by AI will allow decentralizing the development of applications, while ensuring an optimal use of the available resources. The edge continuum will be equipped with innovative, multi-physical capabilities to sense the environment, distributed intelligence will enable emergent behaviour and massive collaboration of multiple agents towards a common goal. By exploring the synergies of these cutting-edge technologies through civil safety and security, digital health, smart logistics for supply chains and propulsion use cases, A-IQ Ready will provide revolutionary means for most services and industries. These technologies and their combination will propel the transition to a Europe of Society 5.0.

More details are provided in Section 1.2.13.

2.2.30 INSTAR: Shaping international standards for advanced technologies

URL/Reference:

https://www.instarstandards.org/

https://cordis.europa.eu/project/id/101135877/

Abstract (IoT project):

INSTAR is an EU-funded project that aims to support the implementation of Europe's Digital Partnerships and the EU-US TTC by working together with Australia, Canada, Japan, Singapore, South Korea, Taiwan and the USA to drive international common standards for AI, Cybersecurity, DigitalID, Quantum, IoT, 5G, 6G and data technologies. Following the EU Standardisation strategy of February 2022 that "*Europe needs to bring the European angle of standardization at international level, rather than create EU-specific standards.*" (Commissioner Thierry Breton), **INSTAR** helps achieve this by

- promoting EU's thought leadership for a common ICT standardization vision with strategic international partners on key advanced technologies,
- shaping the definition & uptake of standards in relevant target entities,
- delivering studies & analyses on ICT standards,
- monitoring international standards in trade & cooperation agreements

INSTAR works with Task Forces built up by a number of European experts in the following areas of advanced technologies to be addressed:

- TF1 – AI: Secure, trustworthy and ethical development and use of AI systems (ML algorithms, neural networks, analytics, autonomous systems), AI Act, ETSI's Operational Coordination Group on AI (OCG AI), CEN/CENELEC, ISO/IEC, and others.
- TF2 – Cybersec-eID: Cybersecurity & electronic identification in industries like healthcare, manufacturing, financial services, energy, automotive European Cyber Resilience Act (CRA).
- TF3 – Data: Data quality, syntactic, semantic and pragmatic characteristics of data (ISO 8000-1), Standards impact on policy & regulation, investment & innovation, cross-industry scenarios.
- TF4 – IoT Edge: Cloud, Edge (near vs. far edge), IoT in smart manufacturing, precision agriculture, mobility, energy grids, smart cities, healthcare etc.
- TF5 – 5G+: Convergence of communications, sensing, sustainable services & AI, Human-centric, cognitive network of networks system.

- TF6 – Quantum: Quantum computing, communication, sensing and cryptography, as well as post-quantum cryptography techniques, Specific focus on technologies that can be integrated into European infrastructure and interoperability aspects.

Key activities include setting up Roadmaps for each area, pointing at priority areas for standardization from the European point of view (ETF – European task Forces of experts) and then aligning with the international partners (ITF – International Task Force) in a collaborative communication process.

More details are provided in Section 1.2.14.

2.2.31 Visualization of the Edge Computing EU funded ongoing projects landscape

This section provides a landscape visualization of the ongoing Edge Computing EU funded projects, introduced in this report.

The "Edge Computed EU funded ongoing projects landscape (Technology and Marketing Dimensions)", shown in **Figure 14**, is a graphical representation that highlights the main activity (up to the day of generating this representation) of the ongoing projects in the area of Edge Computing, according to the Business to Consumer (B2C) vs. Business to Business (B2B) (horizontal axis) and the Connectivity vs. Service & App (vertical axis) classifications.

The projection of these ongoing projects into vertical industry domains is shown in **Figure 15** and for standardisation activities in different SDO's and initiatives is shown in **Figure 16.**

The dimensions, the vertical/horizontal domains and standardisation organisations and initiatives of the landscapes and the method used to visualize ongoing projects into these landscapes shown in **Figure 14**, **Figure 15** and **Figure 16** respectively, are the same ones as defined in Section 1.1.28.

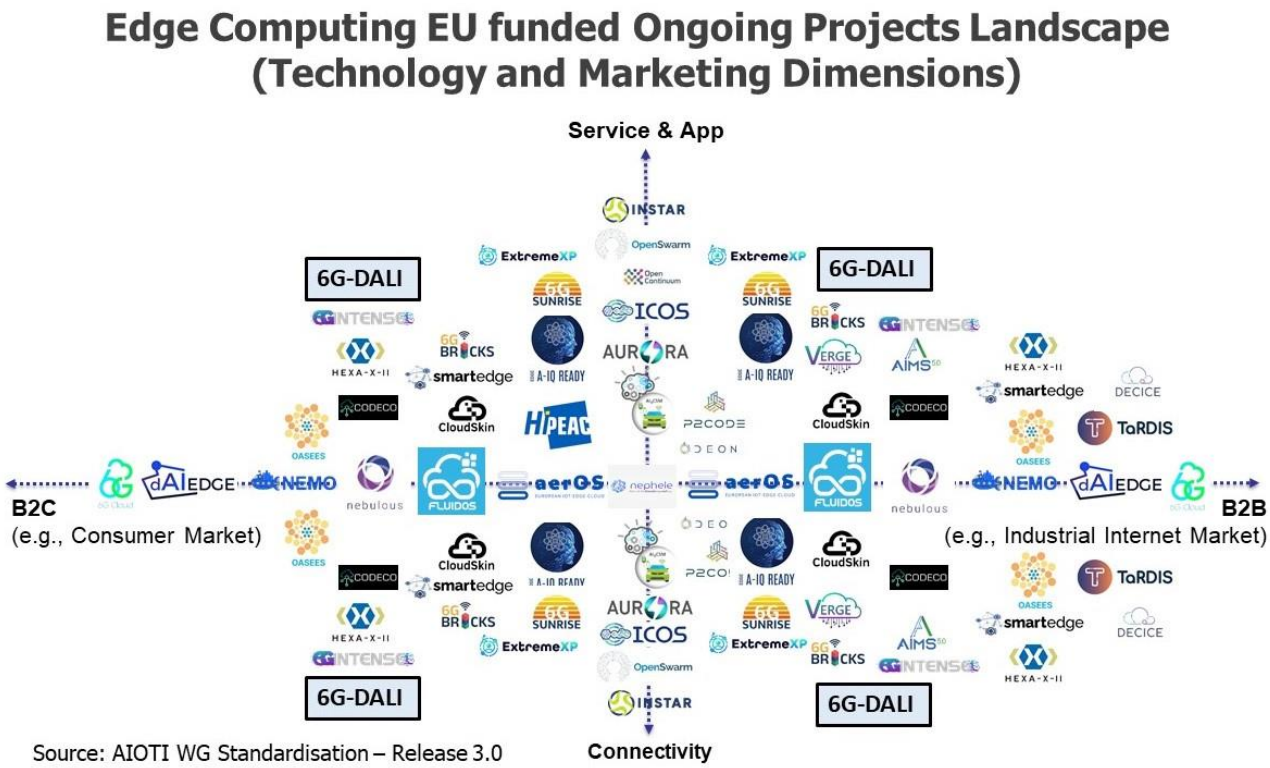


Figure 14: Edge Computing EU funded ongoing projects landscape, when Technology and Marketing Dimensions are used

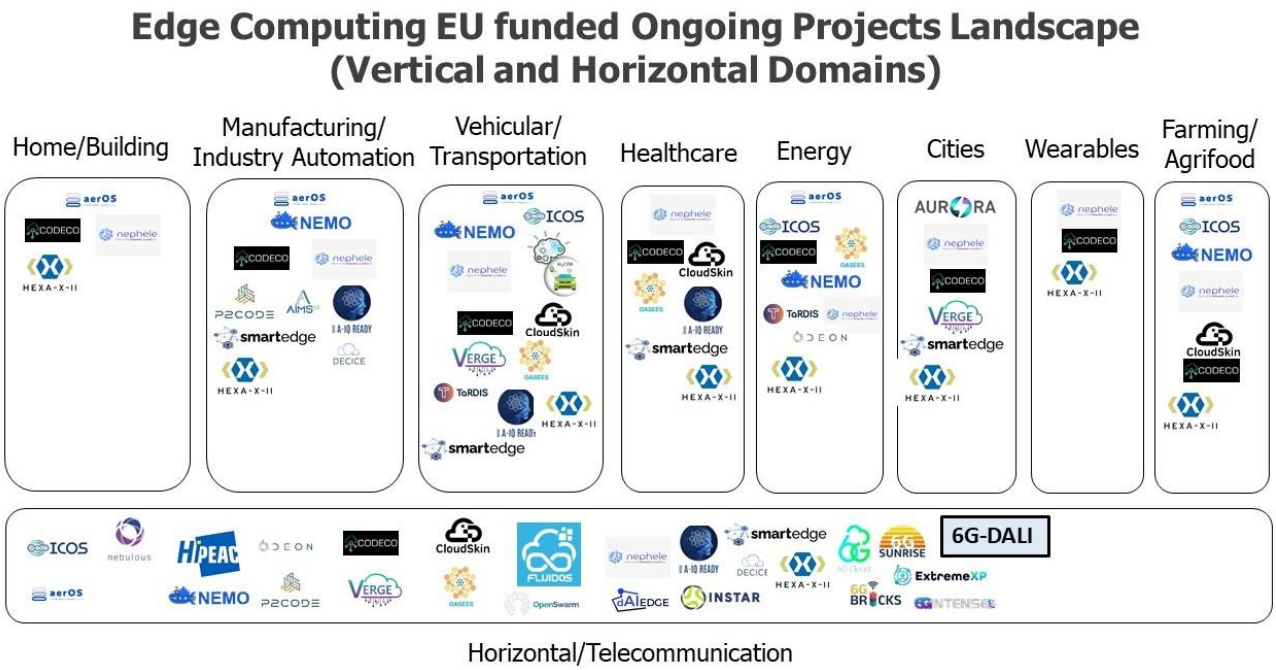


Figure 15: Edge Computing EU funded Ongoing Projects Projection on Vertical and Horizontal Domains

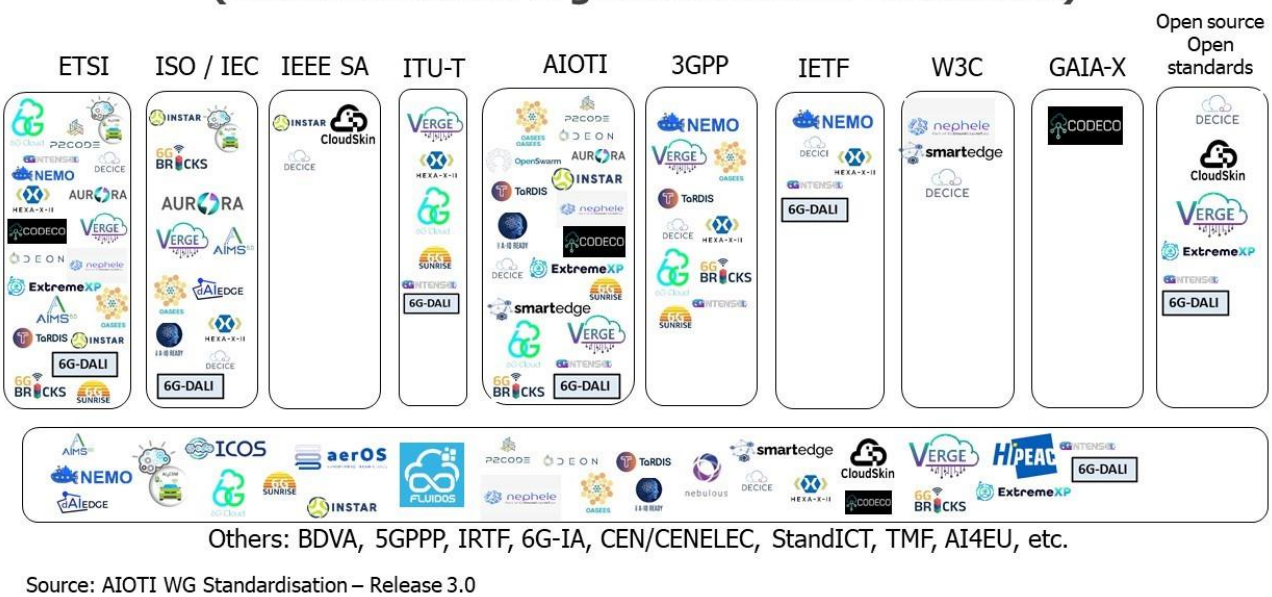


Figure 16: Edge Computing EU funded Ongoing Projects Projection on Standardisation Organisation and Initiatives

Annex I. Used Template for input collection

Proposed template for IoT and edge computing EU funded projects (version 25 February 2022)

This document includes the used template to collect contributions on IoT and edge computing EU funded projects; The key information to be collected is: (1) Title, (2) URL/Reference where information regarding the project can be found (Website, published documents (reports, position papers and reports, scientific papers), (3) abstract, (4) starting and (target) end time, (5) covered IoT and/or Edge Computing research challenges; Please fill in the Yellow coloured field; Note that if the required information is not available, please fill in "Unable to find information"

Title:

<<Please fill in the Project name>>

URL/Reference:

<<Location where information regarding the project can be found (Website, published documents (reports, position papers and reports, scientific papers). Please provide the URL/Reference of the project generated by the European Commission and the project official URL of your project (if available) >>

Abstract:

<<Provide the summary of the project, in particular emphasize the relation to IoT and/or edge computing>>

Starting and (target) end time of project:

<<Provide for the completed projects the start and end time; For the ongoing projects provide the starting and targeting end time>>

Format: DD/MM/YYYY – DD/MM/YYYY

IoT and/or Edge Computing research challenges:

<< List the IoT and/or Edge Computing research challenges that are being focused in the EU funded projects>>

Expected activities on "Dissemination and Impact on Standards":

<<Please provide information on:

(1) List of IoT and/or Edge computing related of SDO and Alliances that the project will interact with, on standardisation activities,

(2) How the project want to interact and

(3) timescales for this interaction>>

Contributors

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Acknowledgements

About AIOTI

AIOTI is the multi-stakeholder platform for stimulating AI, IoT and Edge Continuum Innovation in Europe, bringing together small and large companies, academia, researchers, policy makers, end-users and representatives of society in an end-to-end approach. We strive to leverage, share and promote best practices in the AI, IoT and Edge Continuum ecosystems, be a one-stop point of information to our members while proactively addressing key issues and roadblocks for economic growth, acceptance and adoption of the AI, IoT and Edge Continuum Innovation in society. AIOTI contributions goes beyond technology and addresses horizontal elements across application domains, such as matchmaking and stimulating cooperation by creating joint research roadmaps, defining policies and driving convergence of standards and interoperability.