PREDICT-6G

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Towards a deterministic 6G network

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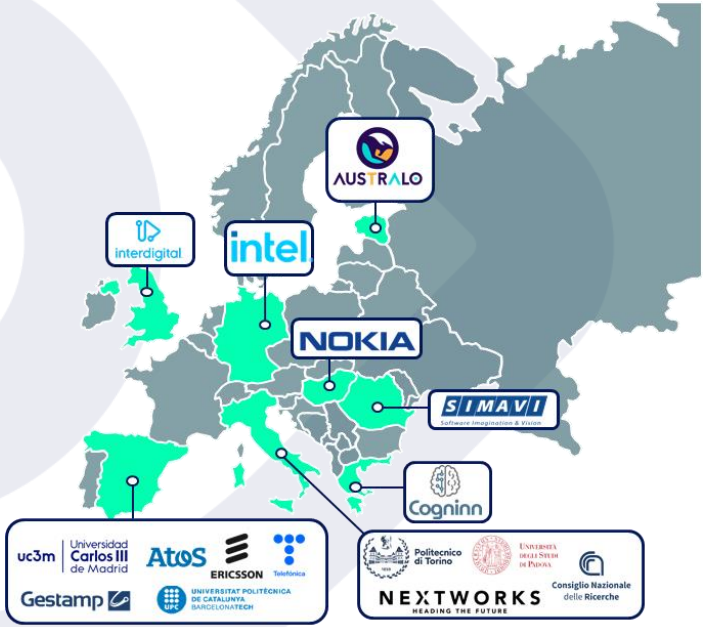
Project Overview

PREDICT-6G aims to design, create and validate **end-to-end (E2E) 6G solutions providing deterministic services** over multiple interconnected domains and technologies (incl. wired and wireless).

- Call: [Horizon-JU-SNS-2022-Stream-B-01-01-System-Architecture]
- Time frame: January 2023 – June 2025
- Duration: 30 Months
- Coordinator: Antonio de la Oliva (UC3M)
- Consortium: 17 organizations, 8 countries.
- More information: https://predict-6g.eu/



Vision

Building a deterministic 6G network

Reliable

Availability

Low packet Loss

Failure resilient

Time sensitive

Bounded latency

Low jitter

Predictable

Use of AI to predict events, states, demands, resources

Autonomous proactive actions based on predictions

Project Approach

3 pillars

- To extend the **reliability** and **time sensitiveness** features of IEEE 802.11 and 3GPP networks, including APIs for the monitoring and control.
- To develop a **multi-technology multi-domain Data-Plane** jointly with an **AI-driven multi-stakeholder inter-domain Control-Plane (AICP)**
- To enhance the **predictability** of the network through **Artificial Intelligence**, enabling the forecasting of the occupancy of network resources and the effect of accepting a new flow into the network.

3 use cases

1. Smart manufacturing
2. Multi-domain deterministic communications
3. Determinism for Critical communications

2 testsites

1. 5TONIC Open Lab (Madrid, Spain)

2. Nokia Open Lab (Budapest Hungary)

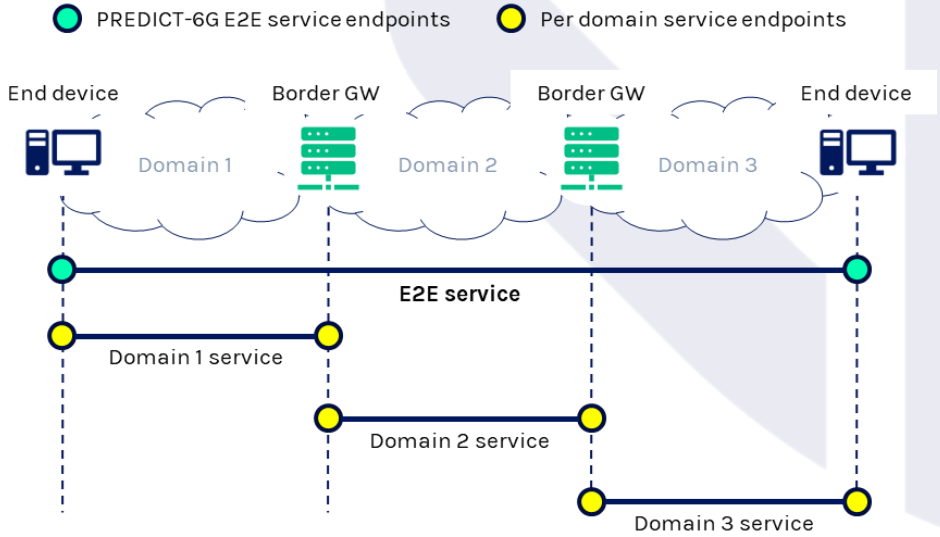
Specific Innovations

1. Cross-domain E2E deterministic service management and automation
2. Emulate deterministic network capabilities on top of non-deterministic network segments
3. Predictability through AI and Network Digital Twinning
4. User, resource, and function mobility under deterministic constraints
5. Highly configurable monitoring platform for multi-technology deterministic networks
6. Improvement of L2 deterministic capabilities of IEEE 802.11 and 3GPP
7. Data-plane integration of multiple deterministic and non-deterministic domains

Service Architecture Reference Model

E2E services: E2E deterministic services **spanning multiple domains**. There services are defined and managed through the composition and orchestration of domain level services. The endpoints of an E2E service may be in different domains.

Domain level services: Deterministic services **at the domain level** created and managed to fulfil the domain's role in the E2E services. The endpoints of a domain level service are in the same domain.



Service Architecture Reference Model

The components of an E2E deterministic service request are the following:

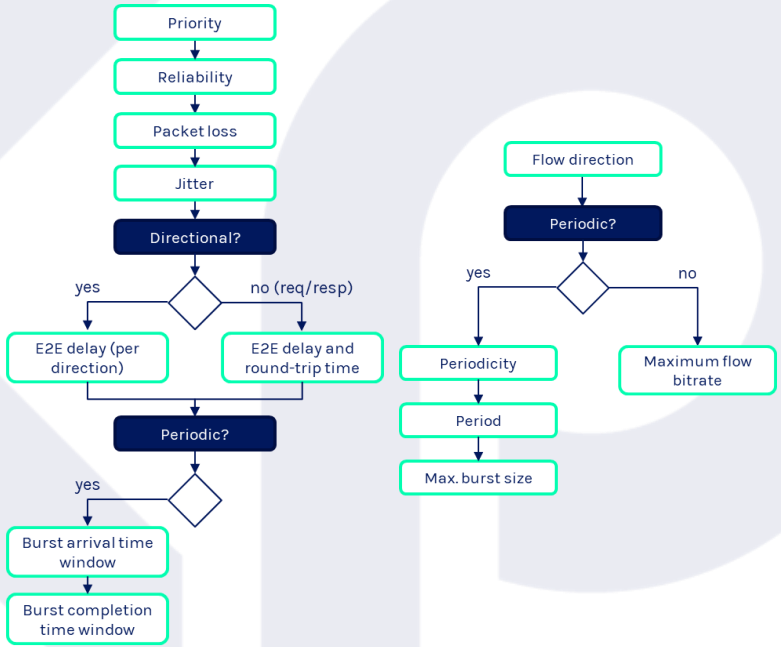
1. E2E service endpoints (mandatory): defines the logical endpoints, which are the termination points of the service that is to be provided.

2. QoS characteristics (mandatory): defines the expected packet forwarding treatment between service endpoints.

3. Traffic characteristics (optional): defines the pattern of the traffic that is expected to be transferred in the service.

4. Traffic flow template (TFT) (optional): defines packet filters to select the traffic that is transferred within the service.

5. Service lifetime (optional): the time boundaries and recurrences when the service should be available.

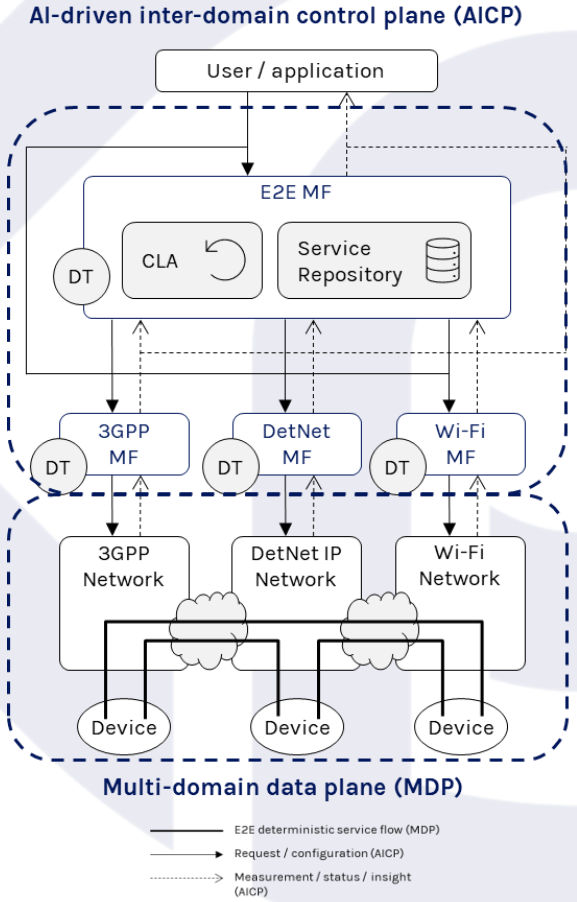


Architecture overview

PREDICT-6G targets the provisioning of E2E deterministic services in **multi-domain** and **multi-technology** (3GPP, DetNet, WiFi) scenarios.

To achieve this, the system architecture is split in two main architectural planes:

- **Multi-domain multi-technology data plane (MDP)** to deliver deterministic services in the data-plane, addressing also cross-domain integration, integration between the AICP and the MDP, and handling non-deterministic network technologies.
- **AI-driven inter-domain control plane (AICP)** to provide service management capabilities at end-to-end and domain level of PREDICT-6G.



Multi-domain Multi-technology DP architecture concepts

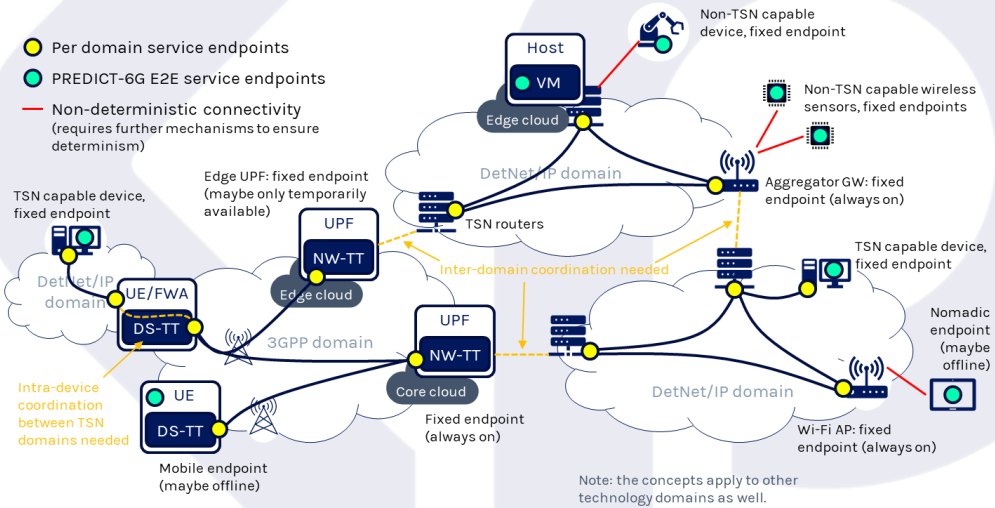
PREDICT-6G's MDP builds on a collection of **existing network technologies (3GPP, IETF DetNet, WiFi)**. Its architecture focuses on:

(1) How to **integrate those technologies** at domain borders.

(2) How to **make them programmable from an E2E perspective** to realize PREDICT-6G's mission of cross-domain determinism.

The main PREDICT-6G MDP architectural concepts are:

- **E2E deterministic service flow:** Logical connection across one or more domains with deterministic QoS characteristics. User plane packets mapped to the same E2E deterministic service flow should receive the same treatment in the data plane and must not be reordered.
- **E2E service endpoints:** Logical endpoints of E2E deterministic service flows. The endpoints are implemented by the network/technology stack of the domain that is hosting the endpoint. For example, in 3GPP, the service endpoints are the UE and the UPF.
- **Per domain service endpoint:** Logical endpoints of a domain level service, according to the concept of service in the corresponding domain. For example, in 3GPP, a domain level service is a PDU Session.
- **Inter-domain coordination:** Potential mechanisms applied on the data plane endpoints between domains, where user plane packets are transferred from one domain to an adjacent one.
- **Intra-device coordination:** Mechanisms applied within the network and technology stack of a single device or equipment to facilitate deterministic packet processing.



AICP Architecture Design and Components

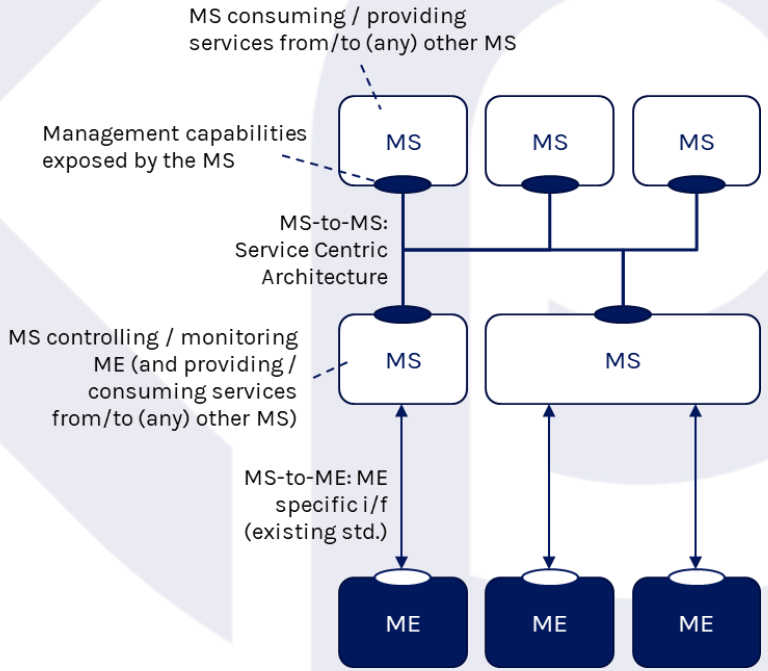
The **AI-driven inter-domain control plane (AICP)** is designed under a service-based architecture to collect all capabilities needed to control and manage the MDP to create and assure deterministic E2E services. The AICP is composed of:

Managed Entities (ME)

- Architectural components of the PREDICT-6G MDP, i.e. technology domains (3GPP, WiFi, etc). In AICP, a MS may or may not interact with one or more MEs.
- The interaction is done via ME's API, which are defined in state-of-the-art standards such as 3GPP IETF DetNet, etc.

Management Services (MS)

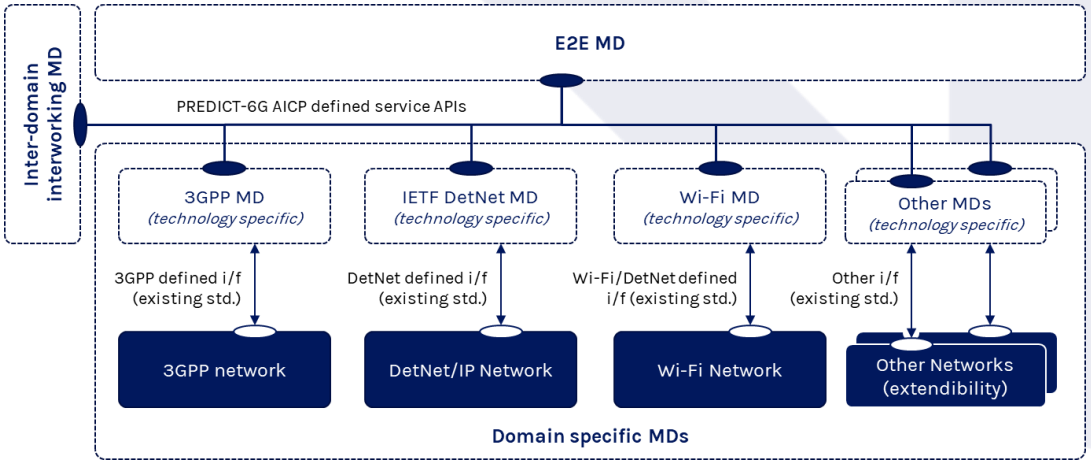
- Provide one or more management capabilities (configuration, data, measurement, performance, analytics, control, etc.) with a scope (e.g., to control one or more MEs, provide services to other MSs).
- MSs interwork via APIs defined individually per each MS.



AICP Architecture Design and Components

Management Domains (MD): Set of interworking (federated) Management Services with the same scope (e.g., operating over the same group or type of managed entities). The PREDICT-6G AICP defines three types of Management Domains:

1. **Domain specific MDs:** Provide MSs for a given network technology (or administrative domain implemented by a given network technology). MSs in these domains interact with MEs, DM and E2E MSs.
2. **End-to-end (E2E) MD:** Provide MSs for creating and managing end-to-end deterministic services over multiple networks with multiple technologies. MSs in these domains interact with E2E and DM MSs.
3. **Inter-Domain Integration MD:** MSs in this MD provide services for the PREDICT-6G framework itself (e.g., MS discovery and registration, high availability, resiliency, etc.).



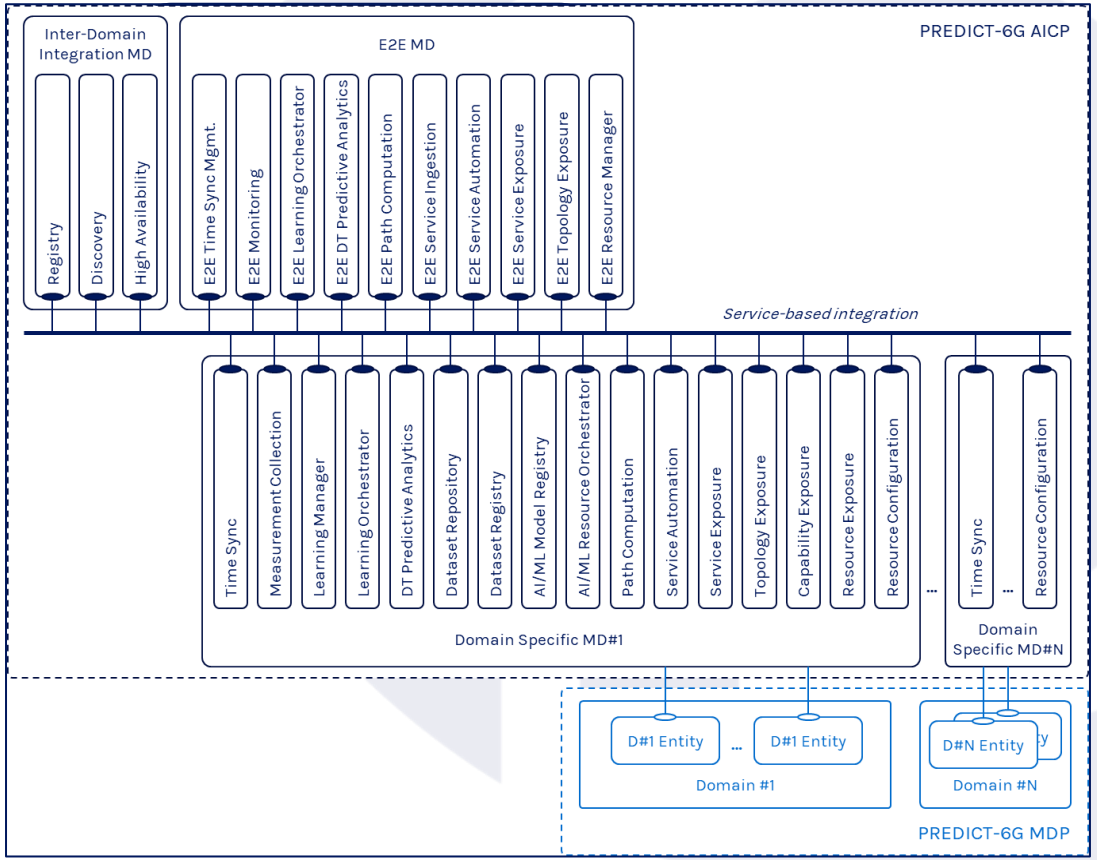
AICP Reference Architecture

PREDICT-6G AICP Reference Architecture is composed of:

- **1 E2E Management Domain:** composed of 10 E2E Management Services.
- **1 Inter-Domain Integration MD**, composed of 3 Management Services.
- **≥2 Domain Specific Management Domains**, each composed of 16 Management Services.

Main innovations with respect to AICP Management Services are:

- AI-based network control plane framework
- Network digital twins for predictability
- Monitoring platform
- Inter-domain orchestration and network control



AICP Key design principles

Service centric approach

- Define MS that can be implemented and produced/consumed via interfaces.
- A reference architecture with logical entities aggregating MSs is provided as implementation guideline.

Modularity and separation of concerns

- The management services are self-contained with well-defined scope and clearly defined interfaces.

Extensibility

- MSs (as well as new MDs) can be added without impact on existing ones.

Flexibility and scalability

- An implementation of the architecture may selectively include only a subset of MSs adapted to the domains existing in a specific deployment.
- Allow (self-)adaptation to the configuration, capabilities, size, resources, topology and other aspects of specific deployments.

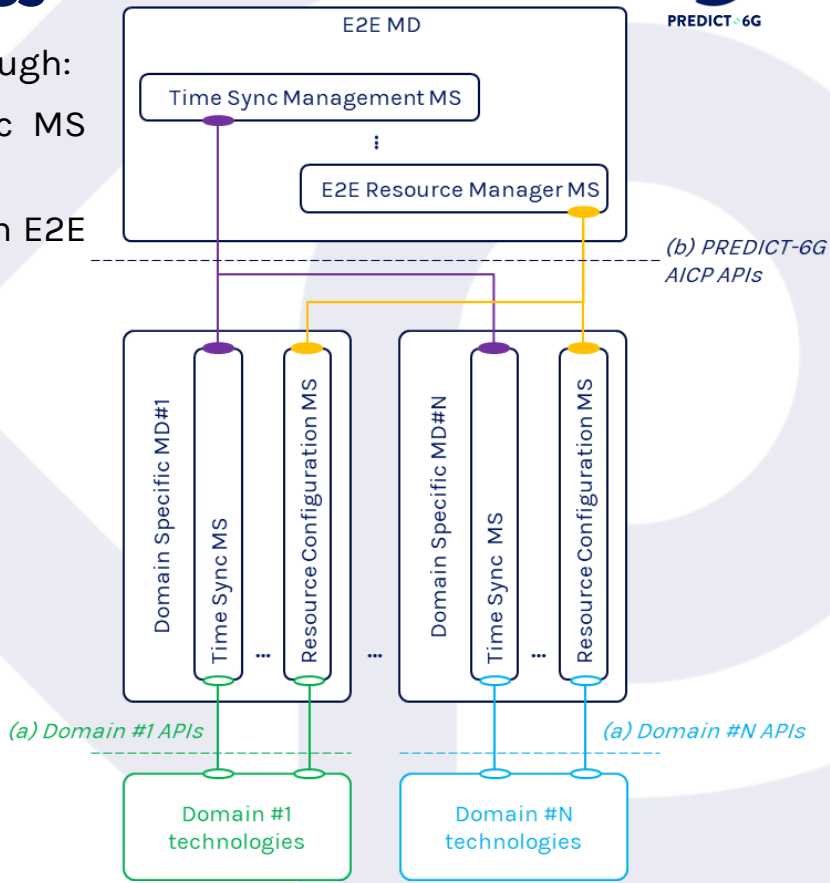
AICP – MDP Integration Principles

The integration between AICP and MDP is achieved through:

a) Technology specific APIs between domain specific MS and the corresponding technology

b) PREDICT-6G AICP defined service-based APIs between E2E MS and domain specific MS.

Technology specific MS in AICP	Technology domain	
	3GPP	IETF DetNet
Time sync	1. Provided by MDP as Open APIs (North-bound interfaces of programmable technology specific data-plane capabilities) 2. Consumed by AICP's domain specific MS implementations (on their South-bound interfaces).	
Measurement collection		
Resource Config.		
Topology exposure		
Capability exposure		
Resource exposure		



Summary

- **PREDICT-6G** considers that **networks need to be enhanced to become more deterministic** (i.e., predictable, reliable and time sensitive) to cope with emerging use cases.
- The **6G** network will be composed of **multiple heterogeneous networks merged together**. Not a single L2 solution will solve the problem.
- PREDICT-6G integrates **multi-domain layer-2 islands of deterministic technologies through layer-3 mechanisms** (DetNet, RAW).
- PREDICT-6G proposes **two main architectural innovations:**
  - **Multi-technology multi-domain Data-Plane (MDP)**
    - Enhance L2 technologies
    - Integrate them into a single E2E data plane
    - Expose APIs for control and monitoring
  - **AI-driven Multi-stakeholder Inter-domain Control-Plane (AICP)**
    - AI-based network control plane framework
    - Network digital twins for predictability
    - Monitoring platform
    - Inter-domain orchestration and network control

References

- D1.1 Analysis of use cases and system requirements
- D1.2 PREDICT-6G framework architecture and initial specification
- D2.1 Release 1 of PREDICT-6G MDP innovations
- D2.2 Implementation of selected release 1 PREDICT-6G MDP innovations
- D3.1 Release 1 of AI-driven inter-domain network control, management, and orchestration innovations
- D3.2 Implementation of selected release 1 AI-driven inter-domain network control, management and orchestration innovations
- D4.1 Integration and validation plans and Open labs design

More information available in https://predict-6g.eu/ and Zenodo

PREDICT-6G

Thank you!

For further information, please contact the project coordinator:
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