Enabling DetNet multi-domain: Some results, lessons learned and future work items from collaborative projects

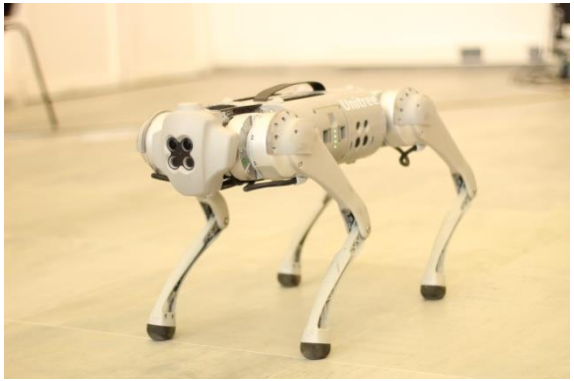
Carlos J. Bernardos – Universidad Carlos III de Madrid

DetNet – TSN Workshop

26 July 2025

Selected example: PREDICT-6G multi-domain demo

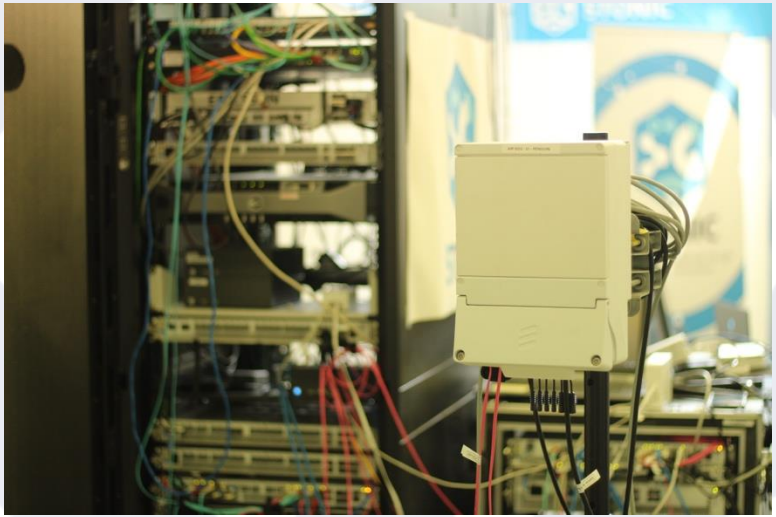
- Remote tele-operation of a robotic “dog” via a real-time Digital Twin video feed and gesture controls
- End-to-end deterministic communication **over three heterogeneous domains:** Wi-Fi TSN → Ethernet TSN → 5G TSN



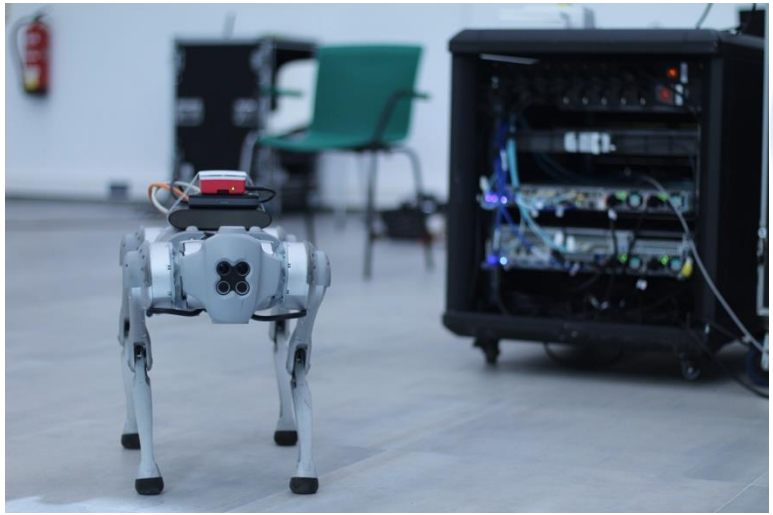
- Powered by PREDICT-6G’s Multi-Domain Data Plane (MDP) together with an AI-driven Inter-Domain Control Plane (AICP)
- Showcases **seamless cross-technology synchronization and QoS enforcement** in an Industry 4.0 setting

E2E TSN across multiple domains

- True end-to-end TSN guarantees
- Cross-domain consistency
- Industrial-scale orchestration challenge
- Our demo as proof-point

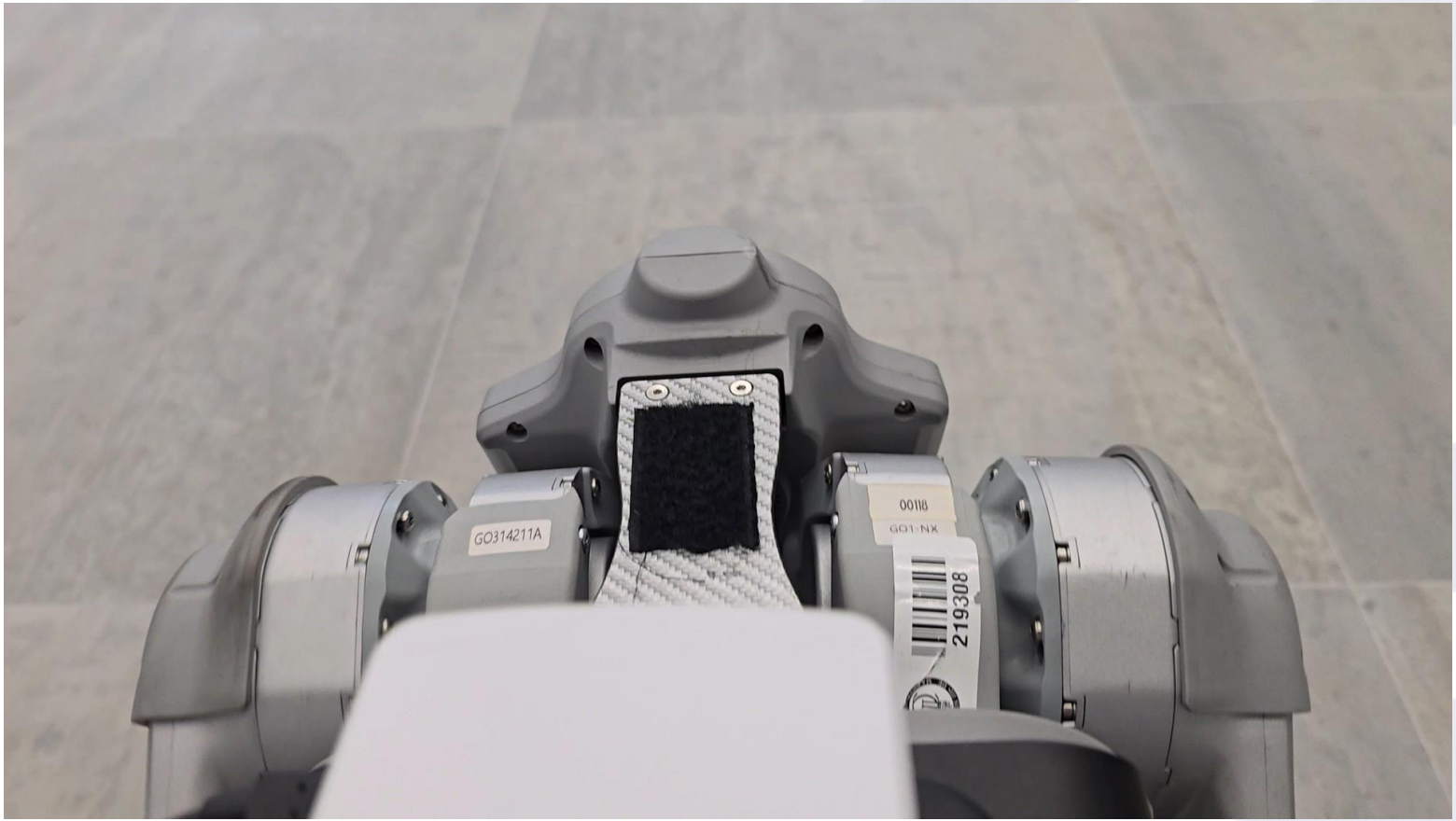


PREDICT-6G KPIs



- **Latency:** 14–15 ms delay
- **Jitter:** <1ms jitter
- **Reliability:** zero packet loss 99%
- **AI-Driven Orchestration**
- **Cross-Domain TSN**

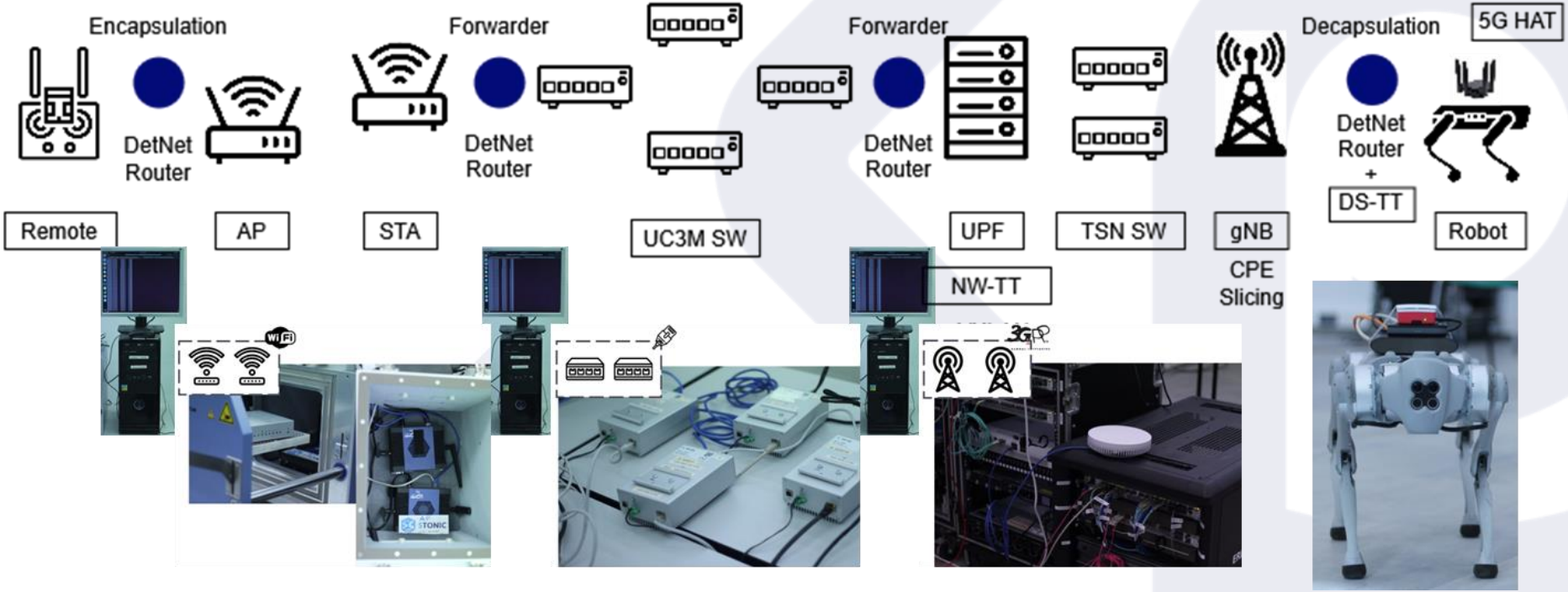
A glimpse of the multi-domain demo




ROHDE&SCHWARZ
TS7124M
DetNet 1 ENCAP
163.117.140.101
M-DISC
LG

Demo Setup

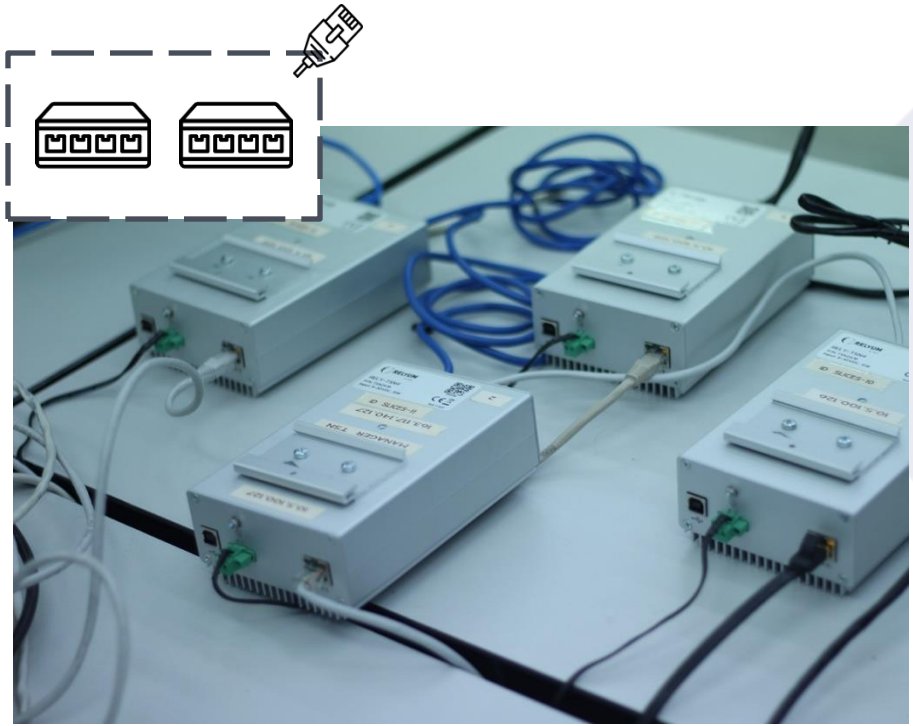
802.11 TSN | 802.1 TSN | 3GPP 5G TSN



3GPP 5G TSN

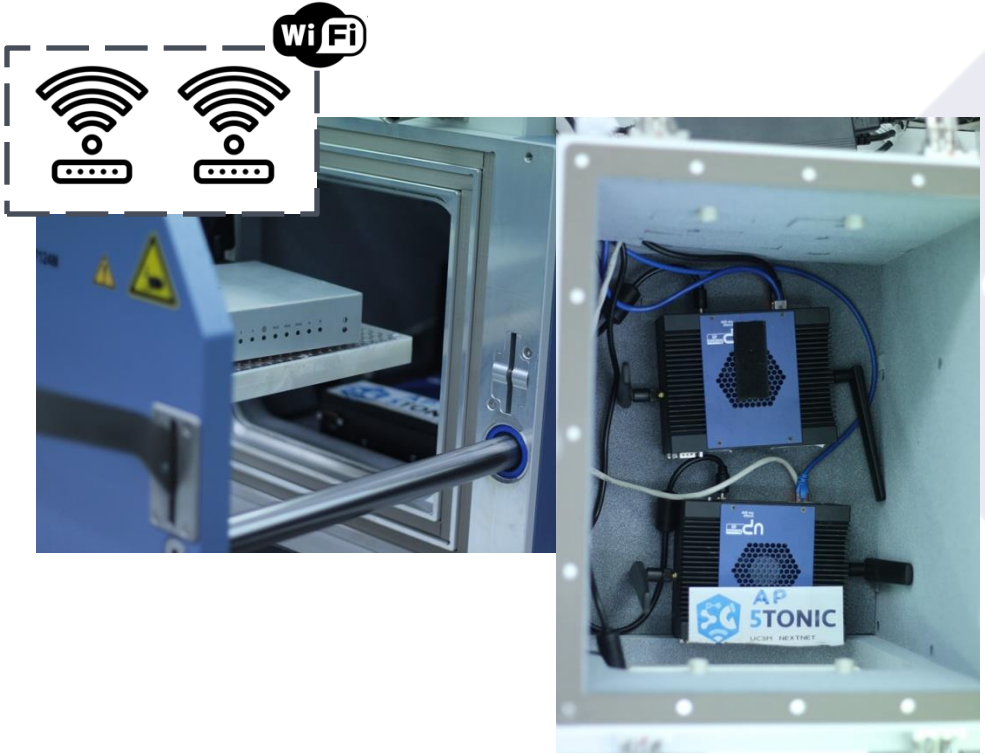
- Enhanced Scheduling for Determinism
- Integrated TSN Support

TSN Ethernet



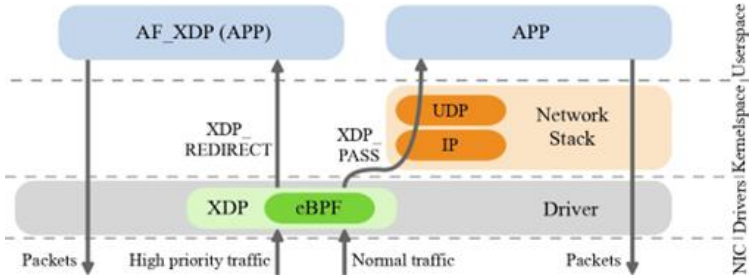
- Full IEEE TSN Stack Integration
- Modular Linux-Based Architecture

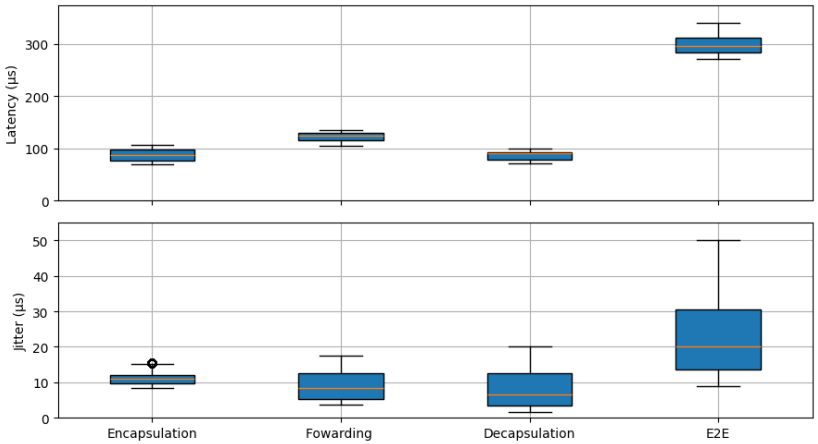
TSN WiFi



- Deterministic Scheduling with IEEE 802.1Qbv
- Real-Time and Best-Effort Coexistence

Multi Domain Data Plane-DetNet routers





Fully **open-source, programmable DetNet router** on Linux using **XDP and eBPF**

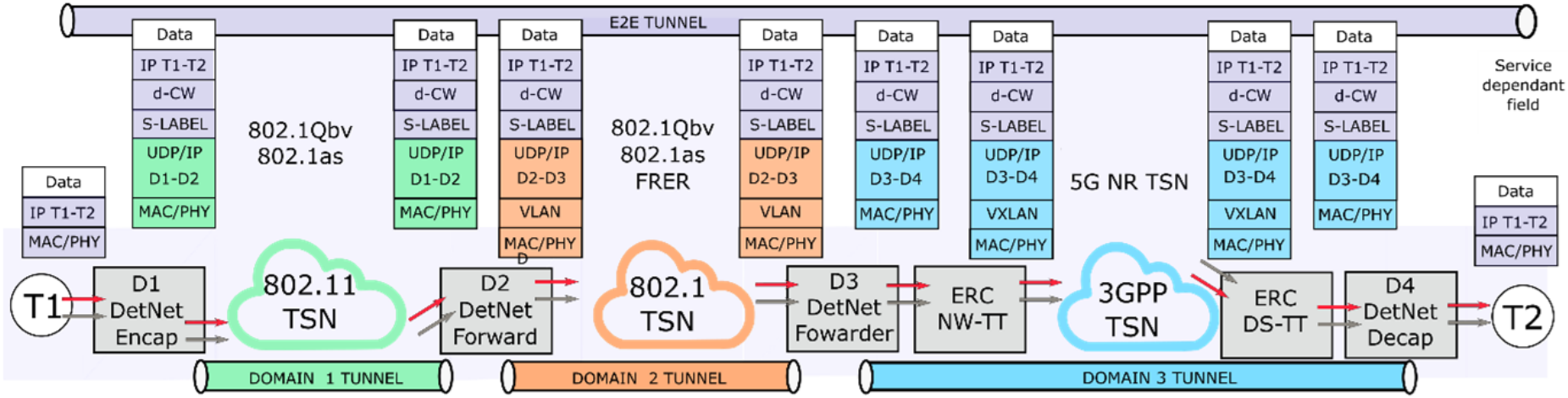
https://gitlab.netcom.it.uc3m.es/predict-6g

The platform integrates **IEEE 802.1AS time synchronization** with **DetNet dataplane functionalities** and **PREOF** capable service sub layer

Each node:

100us latency and **<20us jitter**

Multi Domain Data Plane-DetNet Encapsulation

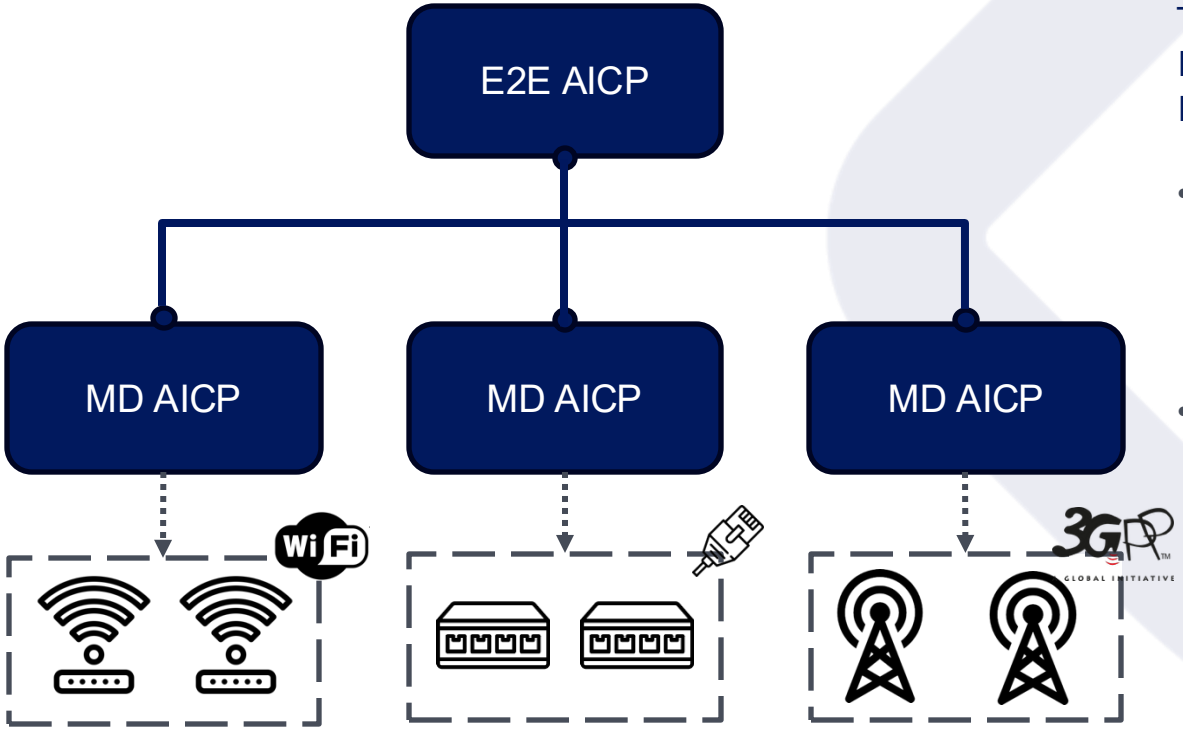


MPLS-encapsulation spans Wi-Fi TSN → Ethernet TSN → 3GPP 5G TSN, preserving flow identity and timing metadata

Label stacking embeds per-domain scheduling context (time-aware shaping, FRER) without reclassification

Single E2E tunnel abstracts heterogeneous MAC/PHY layers, ensuring consistent SLAs across all domains

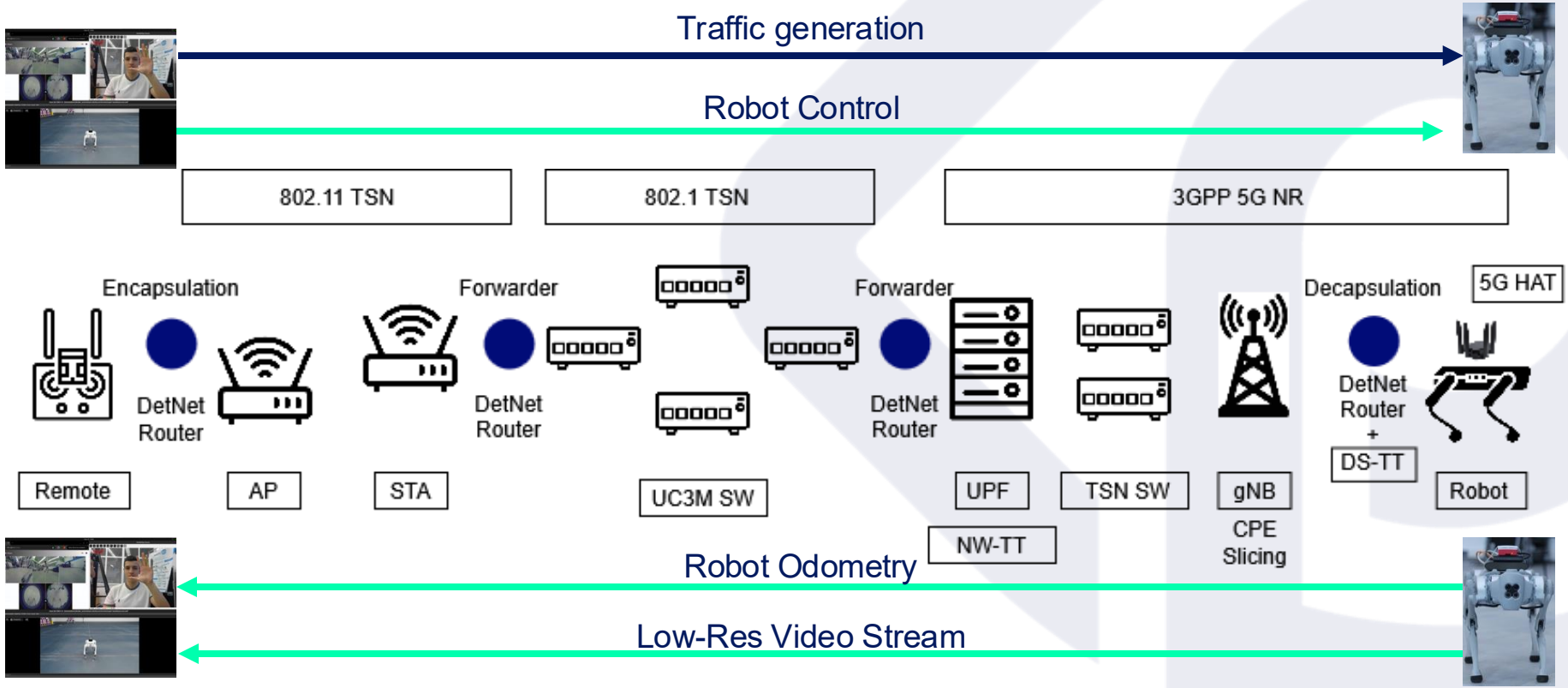
AICP Architecture

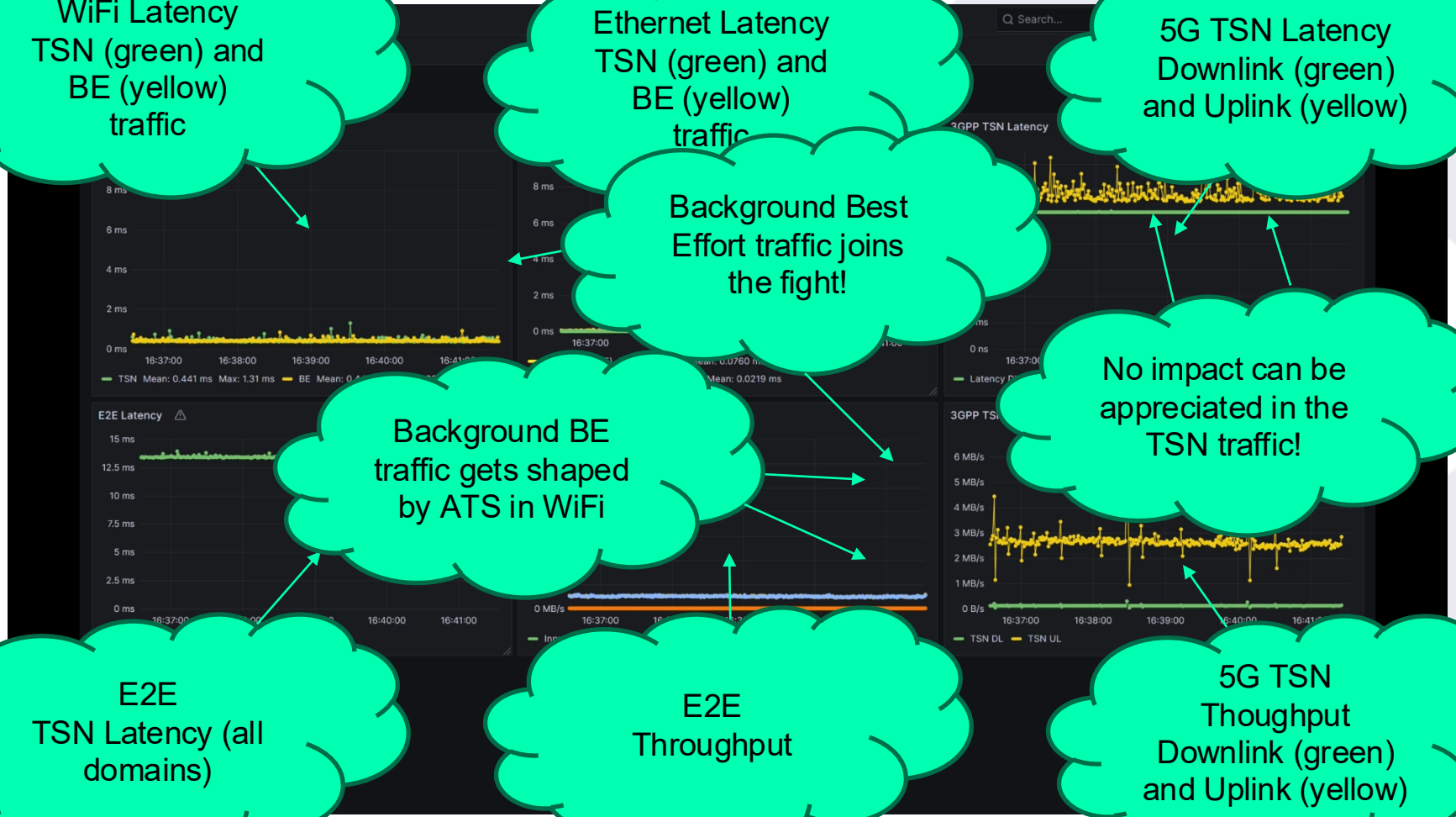


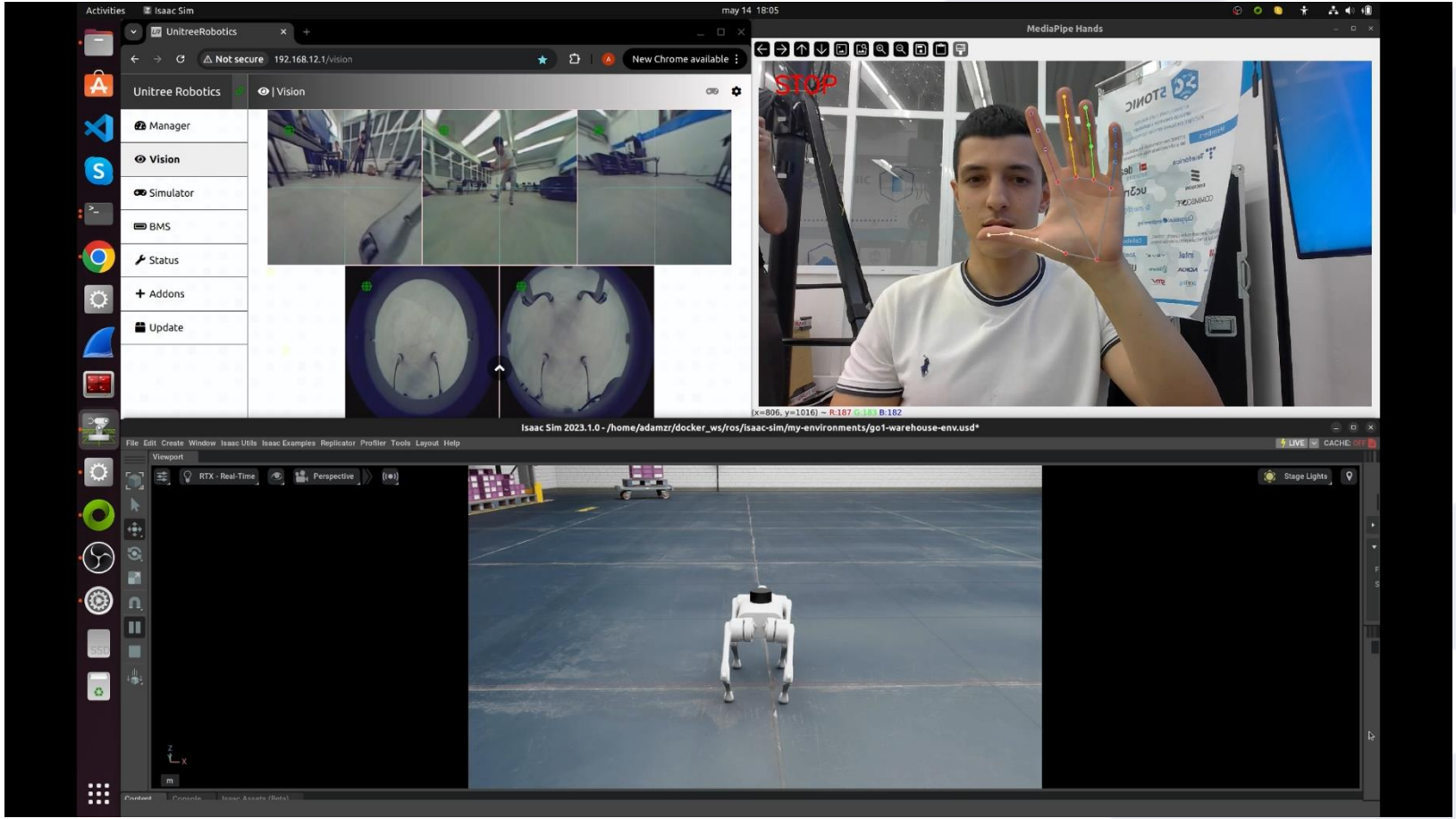
The AICP Architecture is divided into End-to-End (E2E) AICP and Management Domain (MD) AICP:

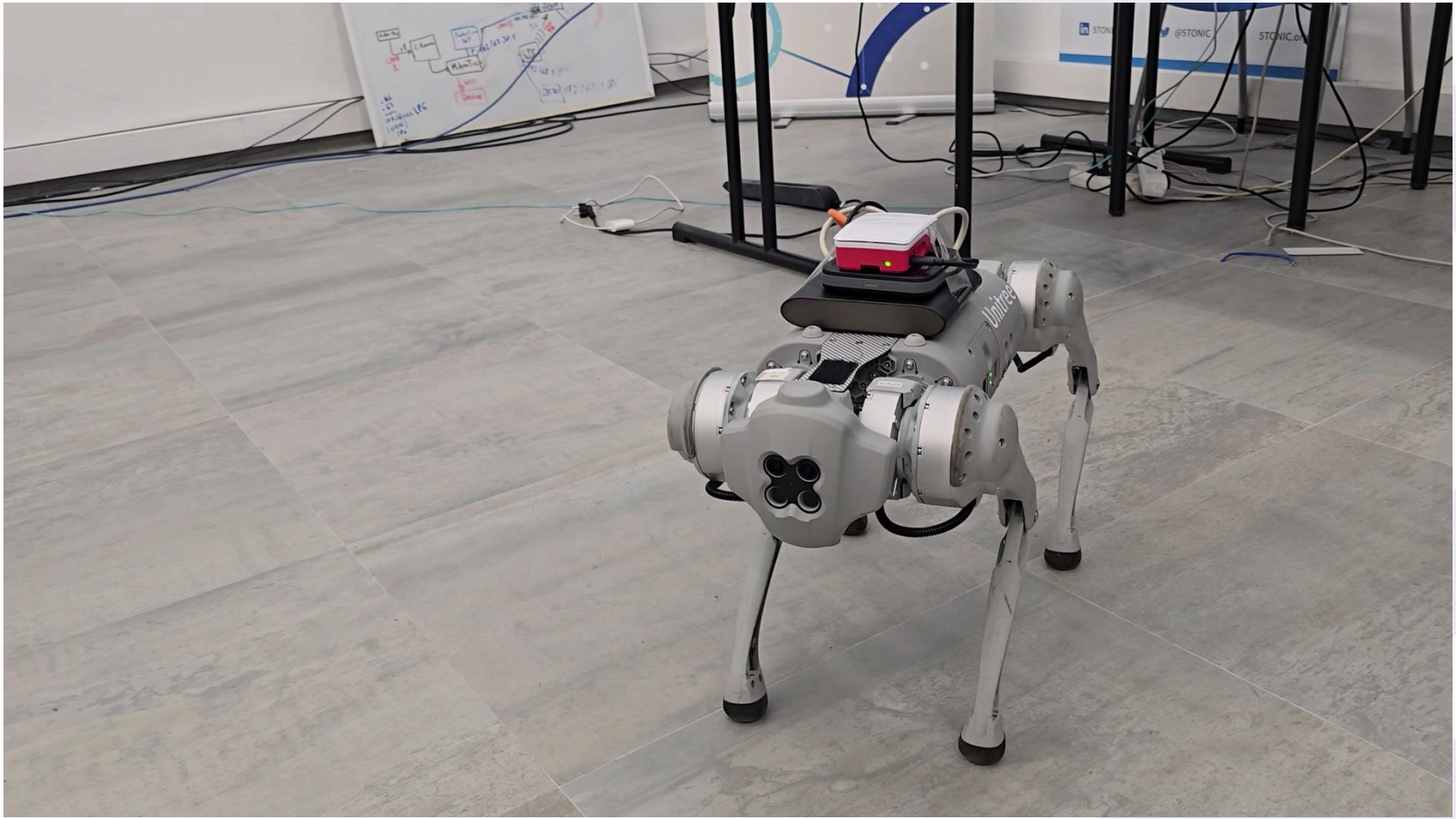
- The E2E AICP enables AI-driven orchestration of deterministic services across multiple network domains
- The MD AICP manages deterministic service deployment and monitoring within a single technology domain

Robot “Dog” Traffic & Services




WiFi Latency TSN (green) and BE (yellow) traffic
Ethernet Latency TSN (green) and BE (yellow) traffic
5G TSN Latency Downlink (green) and Uplink (yellow)
Background Best Effort traffic joins the fight!
No impact can be appreciated in the TSN traffic!
Background BE traffic gets shaped by ATS in WiFi
E2E TSN Latency (all domains)
E2E Throughput
5G TSN Thoughput Downlink (green) and Uplink (yellow)
3GPP TSN Latency
E2E Latency
TSN DL
TSN UL


Activities
Isaac Sim
may 14 18:05
UnitreeRobotics
Not secure 192.168.12.1/vision
New Chrome available
Unitree Robotics
| Vision
Manager
Vision
Simulator
BMS
Status
Addons
Update
MediaPipe Hands
STOP
(x=806, y=1016) ~ R:187 G:183 B:182
Isaac Sim 2023.1.0 - /home/adamzr/docker_ws/ros/isaac-sim/my-environments/go1-warehouse-env.usd*
File Edit Create Window Isaac Utils Isaac Examples Replicator Profiler Tools Layout Help
Viewport
RTX - Real-Time
Perspective
Stage Lights
LIVE
CACHE OFF


@STONIC
STONIC.co

Conclusions

- **AI-Driven Orchestration:** Predictive resource allocation and proactive anomaly detection via Digital Twin models
- **Cross-Domain TSN**
- **End-to-End Determinism:** under realistic Industry 4.0 conditions
- **Complemented by DESIRE6G and 6G-DATADRIVEN outcomes**

We built TSN! (**T**echnically, a **S**uper **N**etwork)

Acknowledgements

6G-DATADRIVEN-04

PREDICT-6G HE project

This project was awarded funding by the European Union's Horizon Europe Research and Innovation programme under grant agreement N° 1101095890.

Esta actividad es parte de la ayuda* TSI-063000-2021-132*, financiada por el Ministerio de Asuntos Económicos y Transformación Digital y la Unión Europea-Plan de Recuperación de la UE como entidades financiadoras, en el marco del Plan de Recuperación, Transformación y Resiliencia y el Mecanismo de Recuperación y Resiliencia.