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EMPLOYING DEEP PROGRAMMABILITY AND DISTRIBUTED INTELLIGENCE FOR REAL-TIME 6G NETWORKS

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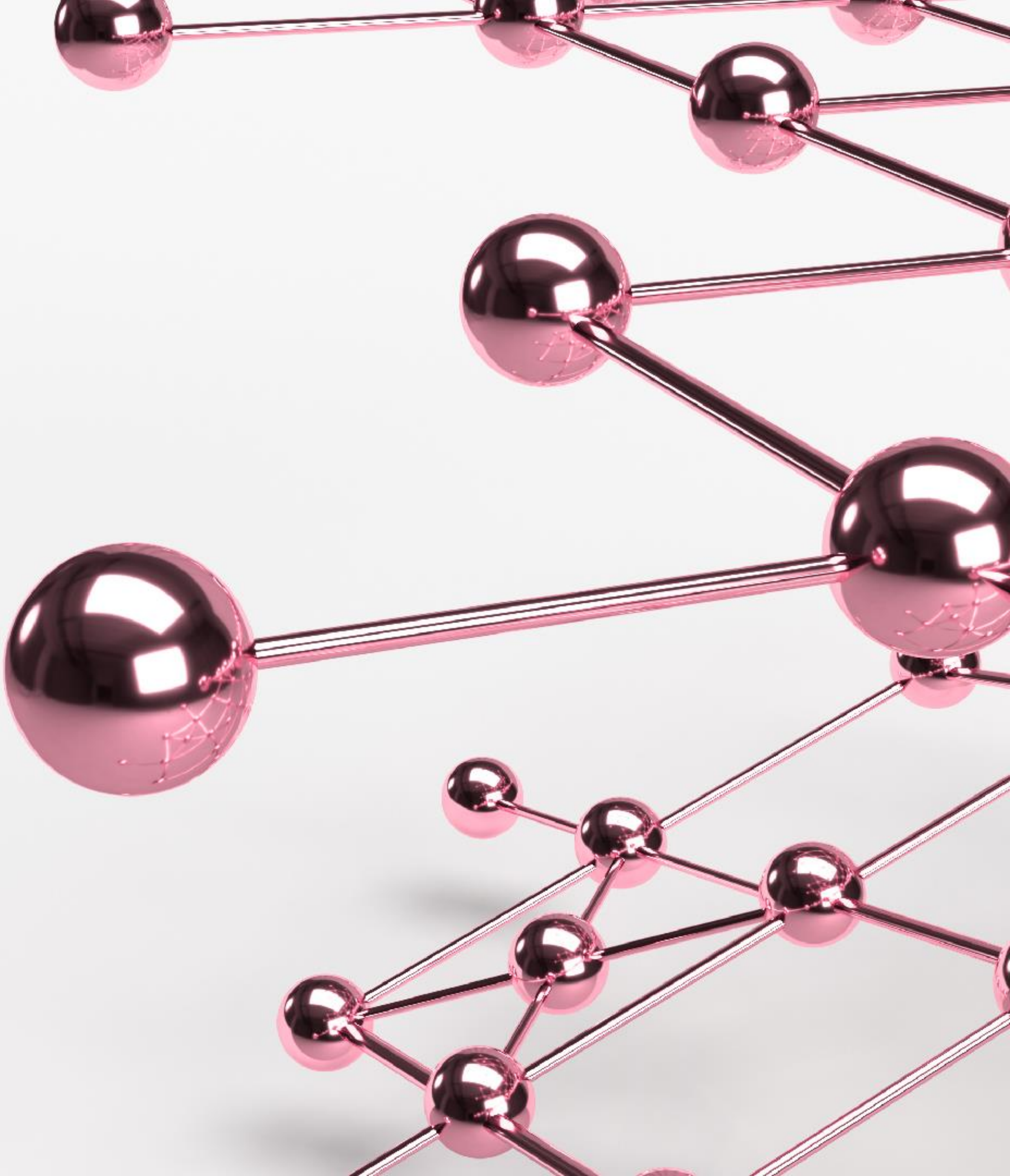
Co-funded by the European Union

6GSNS



DEEP PROGRAMMABILITY & SECURE DISTRIBUTED INTELLIGENCE FOR REAL-TIME END-TO-END 6G NETWORKS

Project coordination:
University of Amsterdam

Technical coordination:
Ericsson Hungary

Duration:
01/01/2023 - 31/12/2025

Total Cost:
6.227.919€

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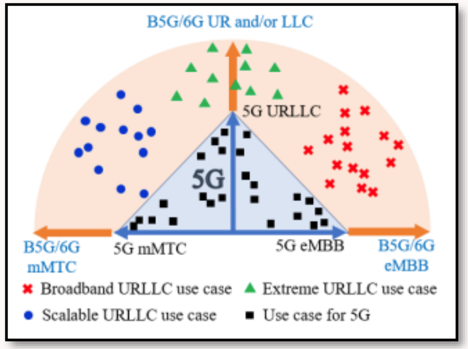
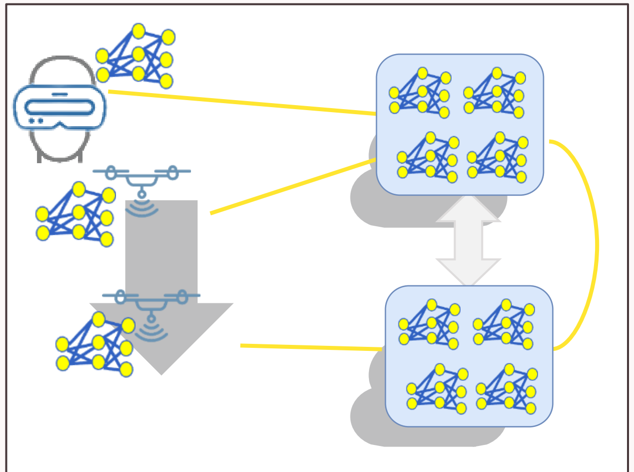
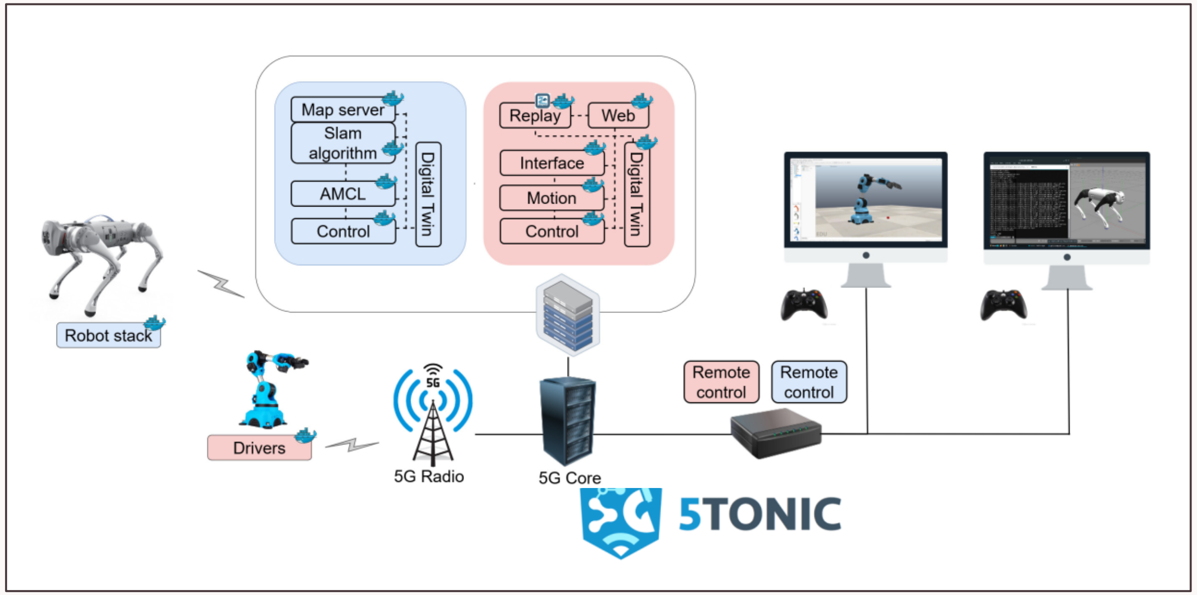
PROJECT SCOPE & OBJECTIVES

- **Zero-touch control, management & orchestration platform, with native integration of AI, to support eXtreme URLLC requirements over a performant, measurable & programable data plane.**
- **Use cases: AR and a Digital Twin application at two distinct experimental infrastructures.**



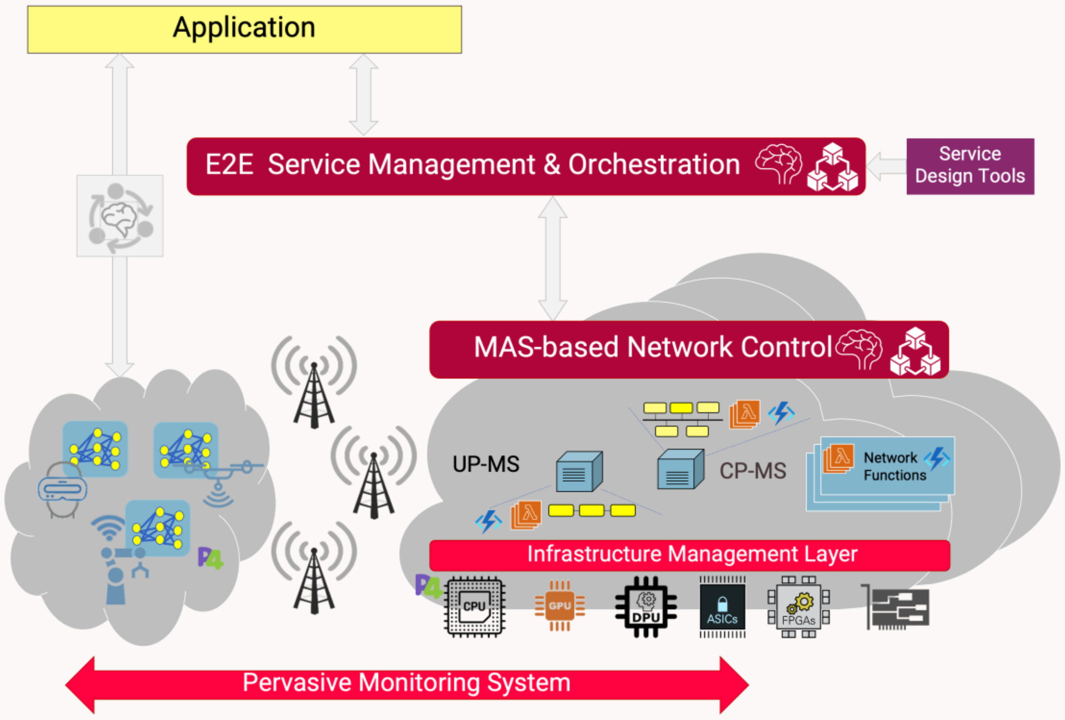
URLLC evolution and new service classes [1]

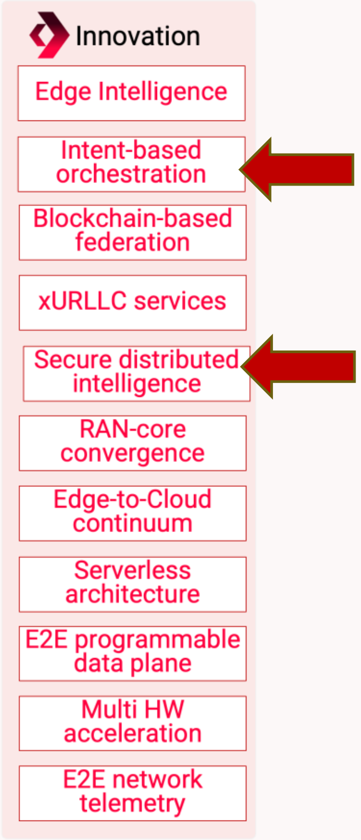

ARNO testbed



[1] Alves H. et al. "Beyond 5G URLLC evolution: New service modes and practical considerations." ITU Journal on Future and Evolving Technologies, 202

DESIRE6G KEY INNOVATIONS





SMO for Non-RT intelligent service/resource management

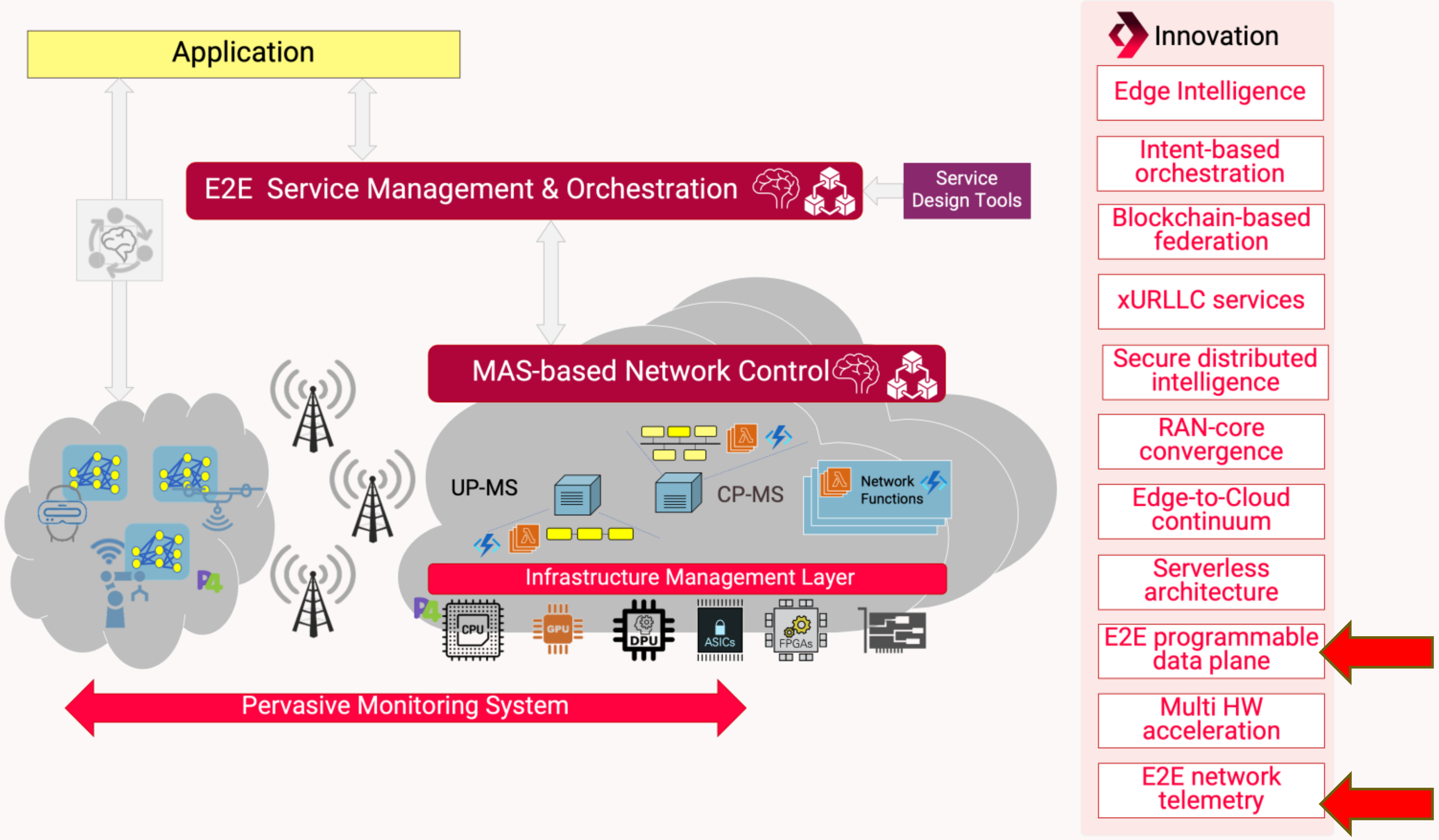
MAS enables NRT distributed control

- **Telemetry collection**
- **AI-driven decision making**
- **Actuation / reconfiguration**

➢ **MAS challenges: heterogeneity, dynamicity, coordination and cooperation, security etc. [2]**

[2] Dorri A et al. "Multi-agent systems: A survey". IEEE Access. 2018 Apr 30;6:28573-93.

DESIRE6G KEY INNOVATIONS



- **In Band Network Telemetry: per flow aggregation, postcards etc.**
  - **Challenges: scalability and performance**
  - ✓ **First stage of collection at the PDP**
  - ✓ **Intelligent telemetry data aggregation**
    - **e.g., 625:1 compression ratio using AEs [3]**

Flexible, customized packet processing operations and protocol support

Network Telemetry

[3] L. Velasco et al., "Is intelligence the answer to deal with the 5 V's of telemetry data?," OFC, 2023

EARLY RESULTS: D6G ILLUSTRATIVE SCENARIO

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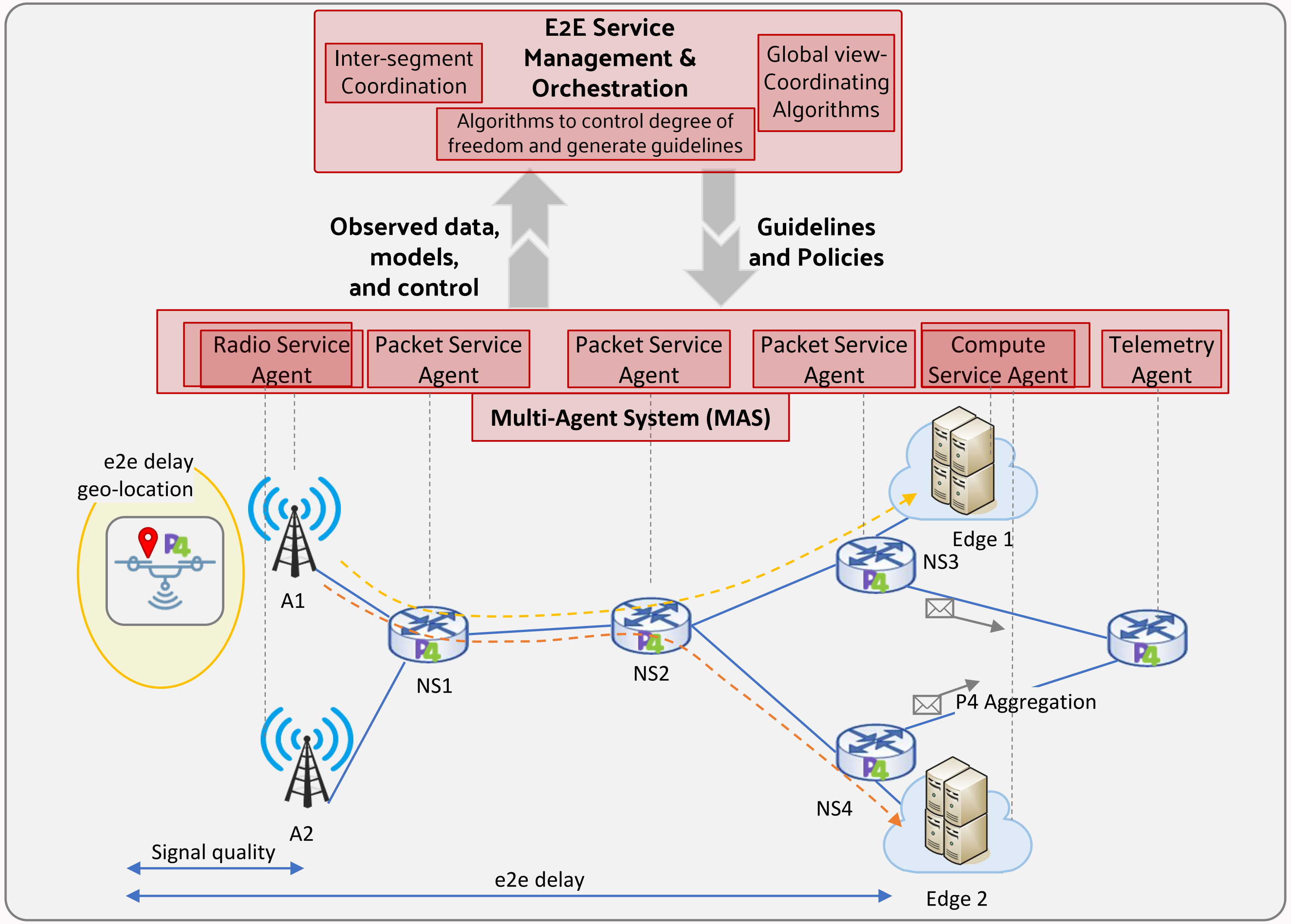

D6G: "Pervasive monitoring and distributed intelligence for 6G near real time operation". EUCNC Post

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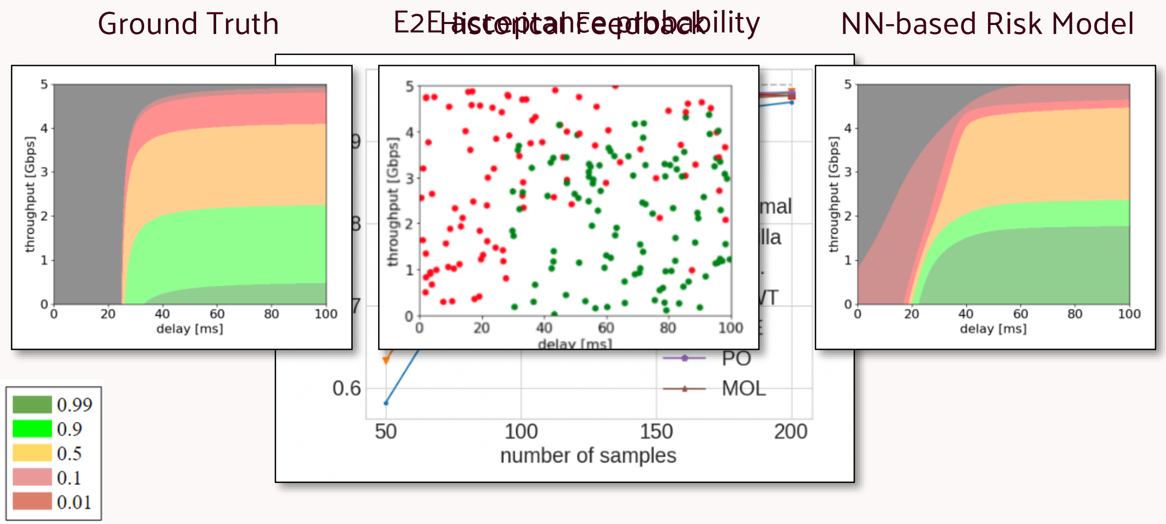
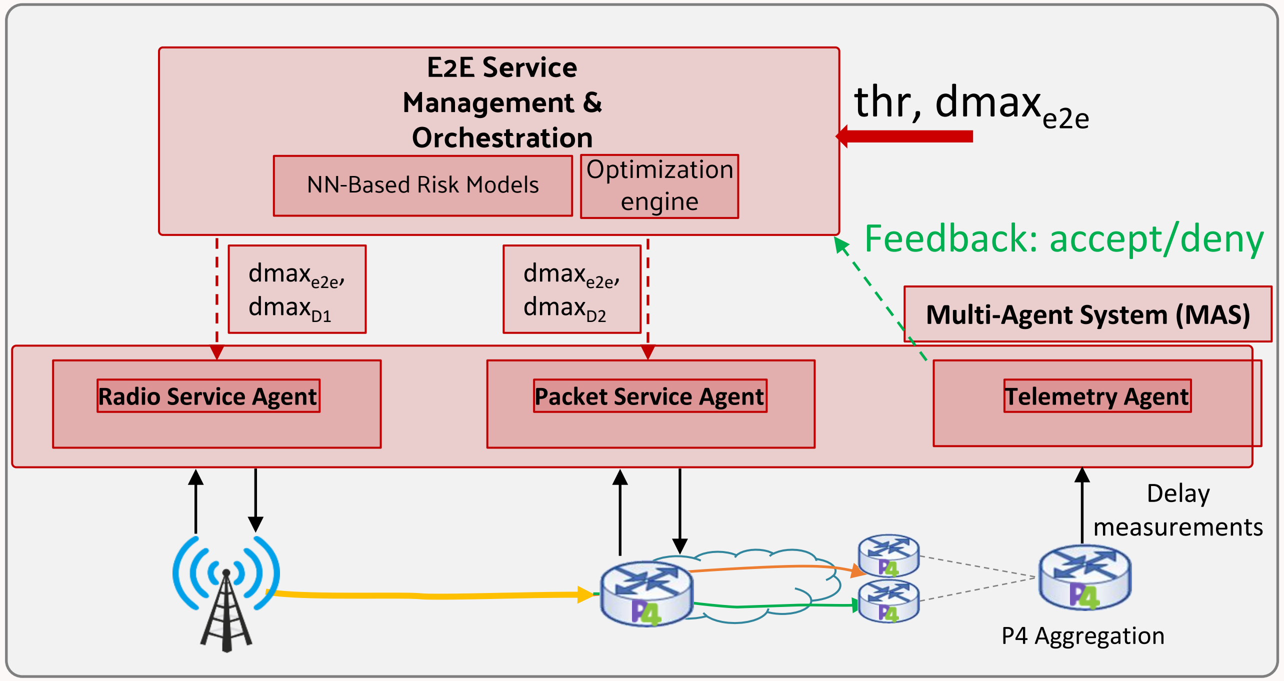
EARLY RESULTS: SLA DECOMPOSITION

- **SMO decomposes E2E SLA into partial SLAs for each segment (e.g., RAN, transport), such that the probability to be accepted by all segments are maximized.**
- **Behavior of each segment is modelled by an NN-based risk model given its historical feedback on admission control.**





D6G: "SLA Decomposition for Network Slicing: A Deep Neural Network Approach". IEEE Networking Letters [subm.]

EARLY RESULTS: SERVICE INSTANTIATION & ASSURANCE

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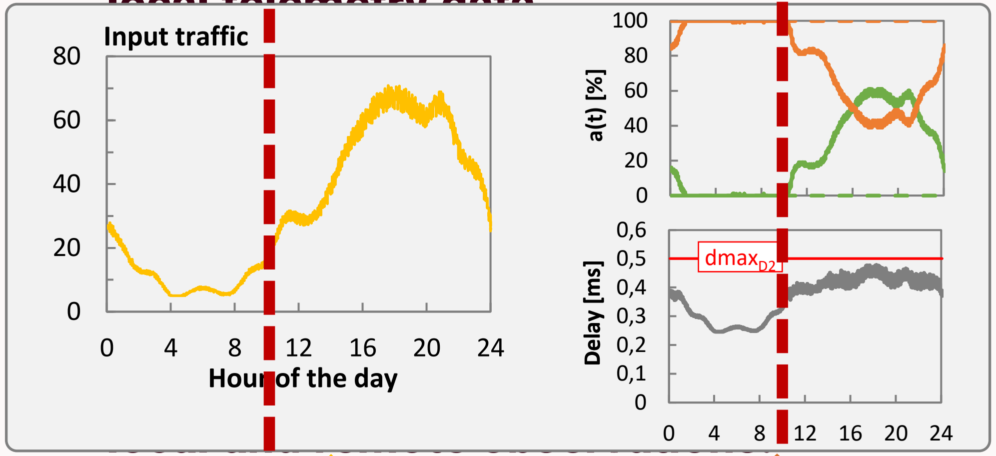
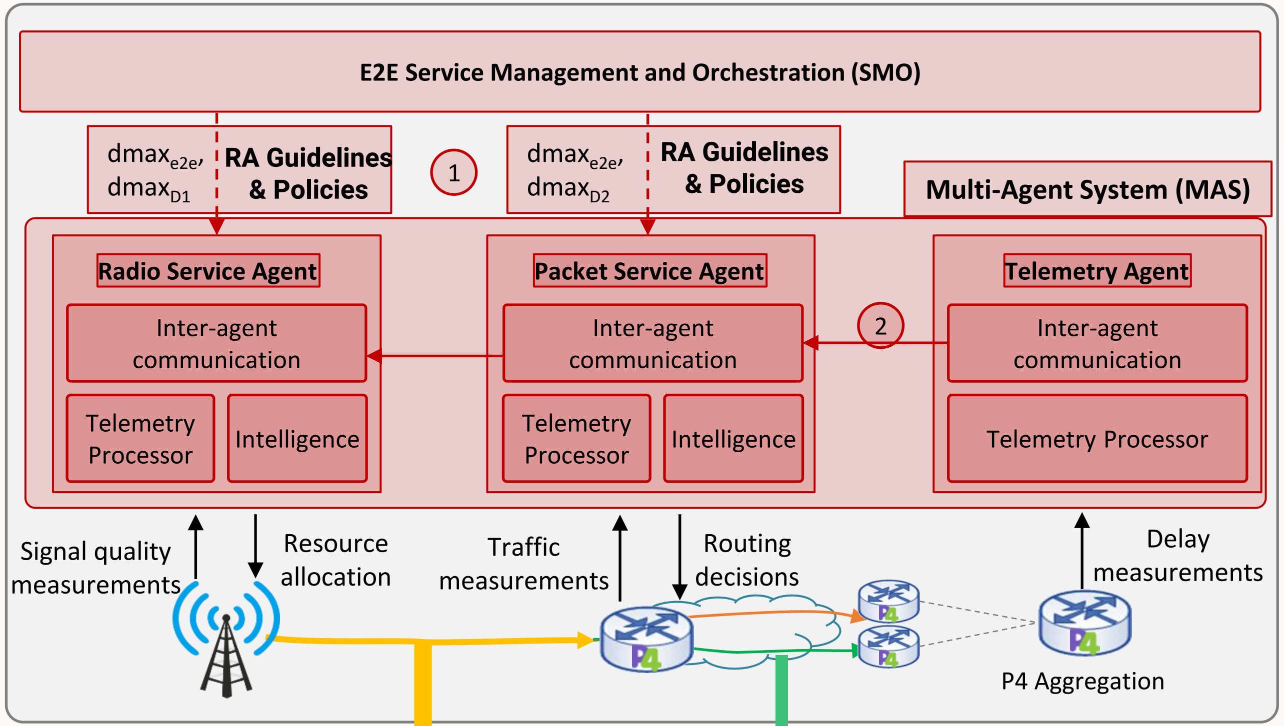
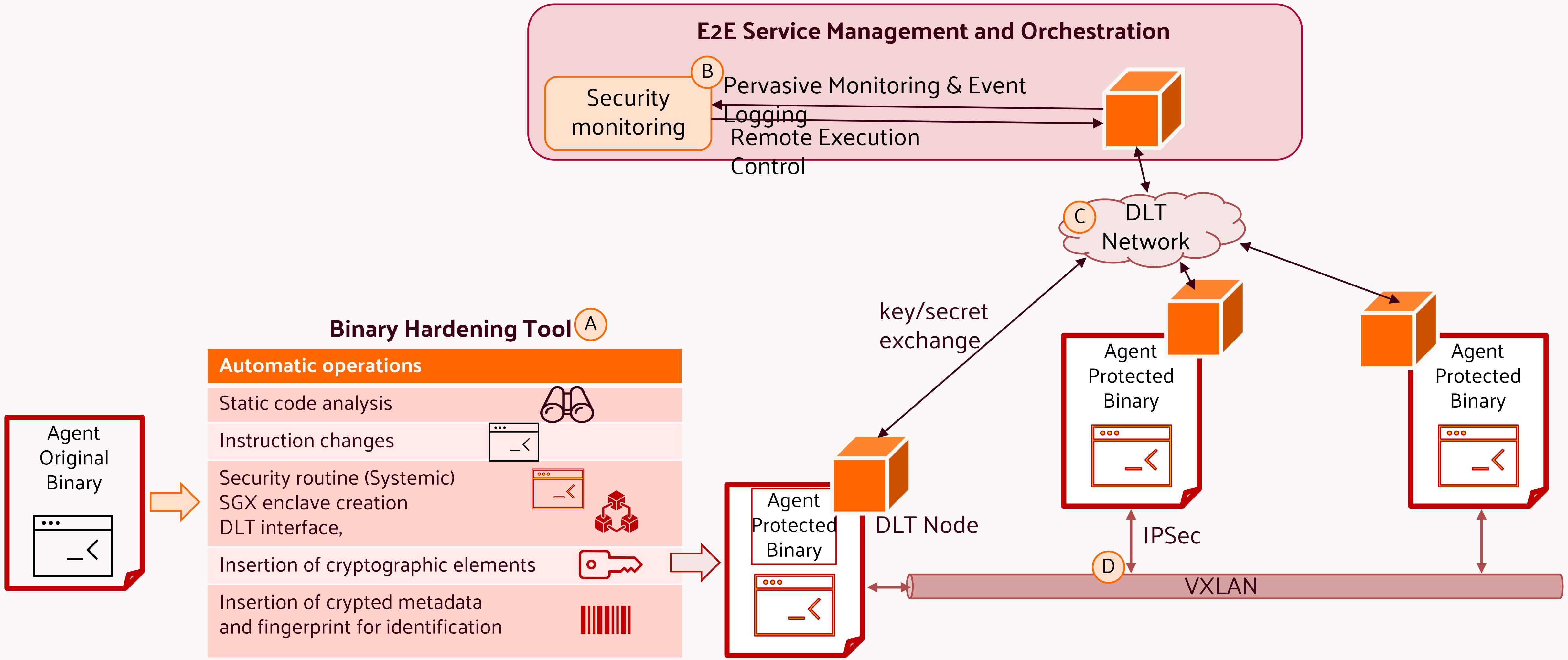
- Telemetry processor
  - collecting and processing/aggregating





D6G: "Pervasive monitoring and distributed intelligence for 6G near real time operation". EUCNC Poste
D6G: "Autonomous flow routing for near real time quality of service assurance". IEEE TNSM [subm

EARLY RESULTS: SECURING INTELLIGENCE



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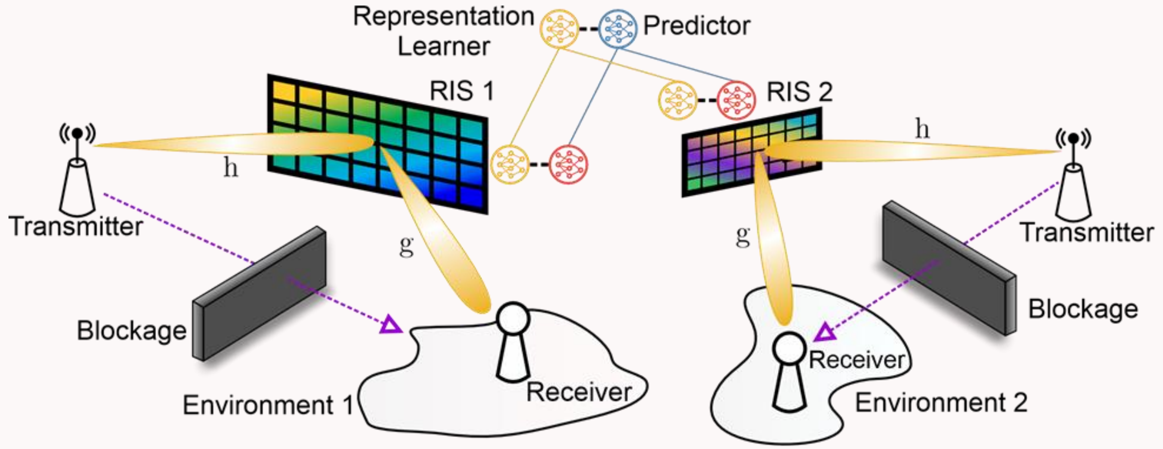
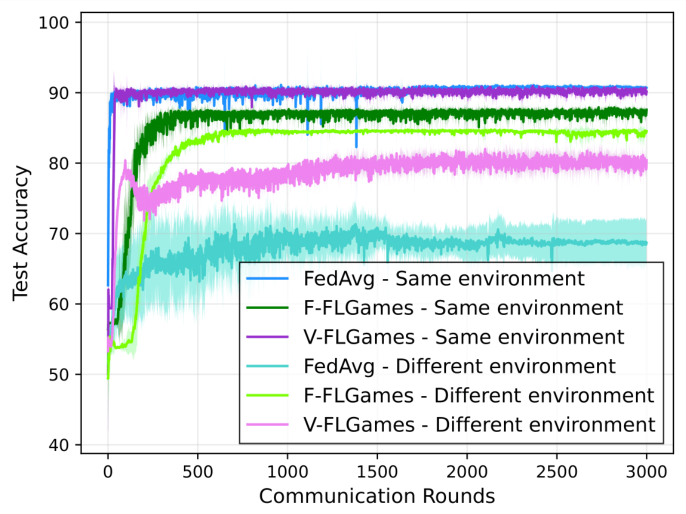
EARLY RESULTS: EDGE INTELLIGENCE



- Setting: Fed. AI for RIS over Heterogeneous Env.
- Goal: Downlink rate maximization through RIS phase tuning
- Method: Distributed Invariant Risk Minimization (IRM) aka FL Games
- Intelligence: Causal inference via representation learning



- Solution method is robust against heterogeneous environments
  - e.g., different user distributions, RIS architecture
- Solution method is privacy preserving, i.e., raw data need not be shared
  - inherited from federated setting
- Solution method is distributed
- Sample efficiency → enables effective use of EDGE resources, e.g., storage

D6G: "Federated Learning Games for Reconfigurable Intelligent Surfaces via Causal Representations", Globecom 2023.[subm.

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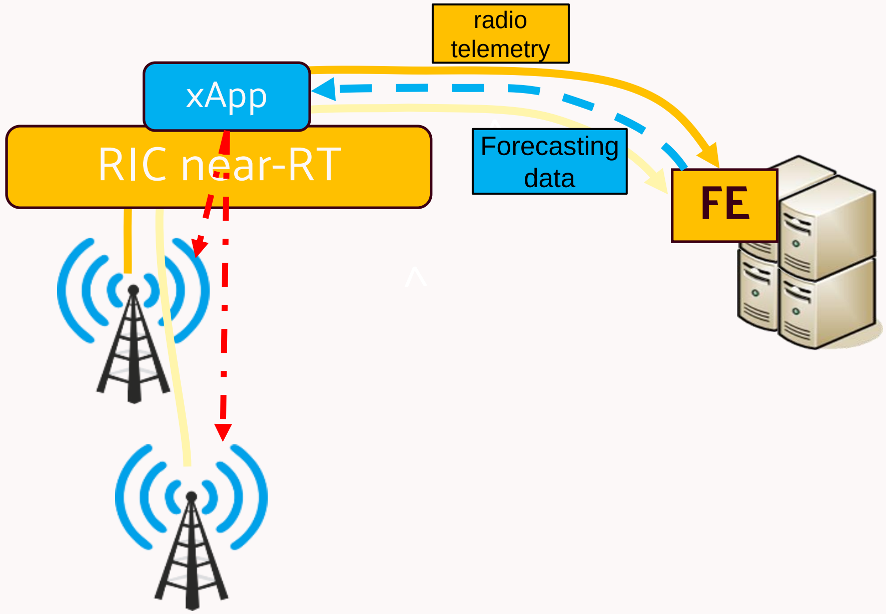
EARLY RESULTS: EDGE INTELLIGENCE



- Forecasting element (FE) running at the edge
- Goal: assisted slice control relying on forecasting metrics, allowing margin in time to implement near-real time operations
- Input features:
  - Collection of UE telemetry data from the radio segment (i.e., widebandCQI) as a xApp
- Each slice is allocated with a specific forecasting job, running a forecasting model
- Output: FE generates a forecasted version of the UE indicators
- The forecasted metrics can be used to perform the slice adaptation, with the resource block group (RBG) enforcement, with margin in time

THANKS!

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