6G-GOALS

6G GOAL-ORIENTED AI-ENABLED LEARNING AND SEMANTIC COMMUNICATION NETWORKS

SNS JU Call 2
Project intro WEBINAR,
March 14th

Semantic and Goal-oriented communications
the 6G-GOALS approach

Petar Popovski, Aalborg Universitet,
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European Commission | 6G SNS

6G-GOALS Project WHO

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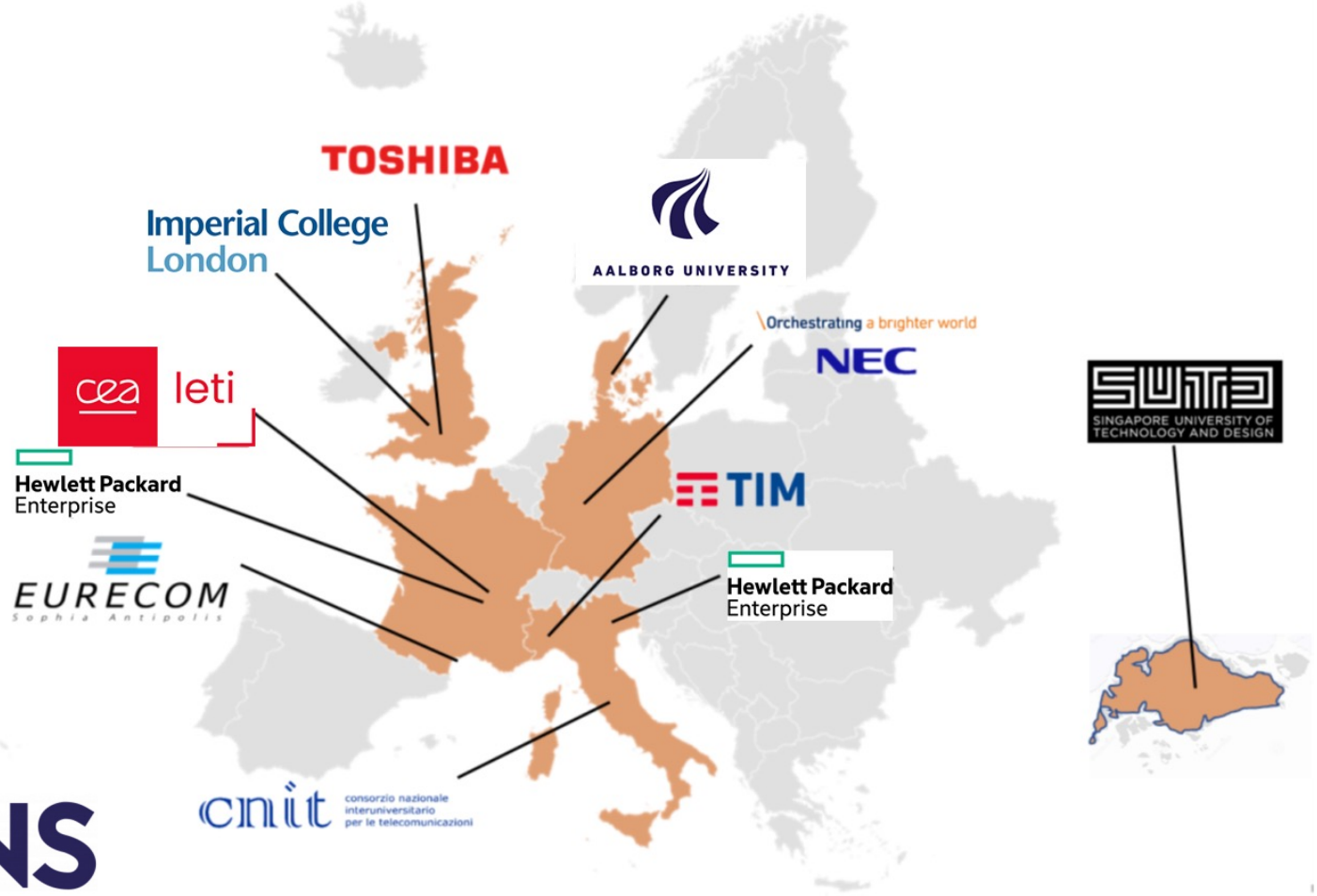
11 Consortium Partners

4 EU Member States

1 Asian Affiliated partner



5G PPP PUBLIC-PRIVATE PARTNERSHIP

6GSNS

PHASE 2

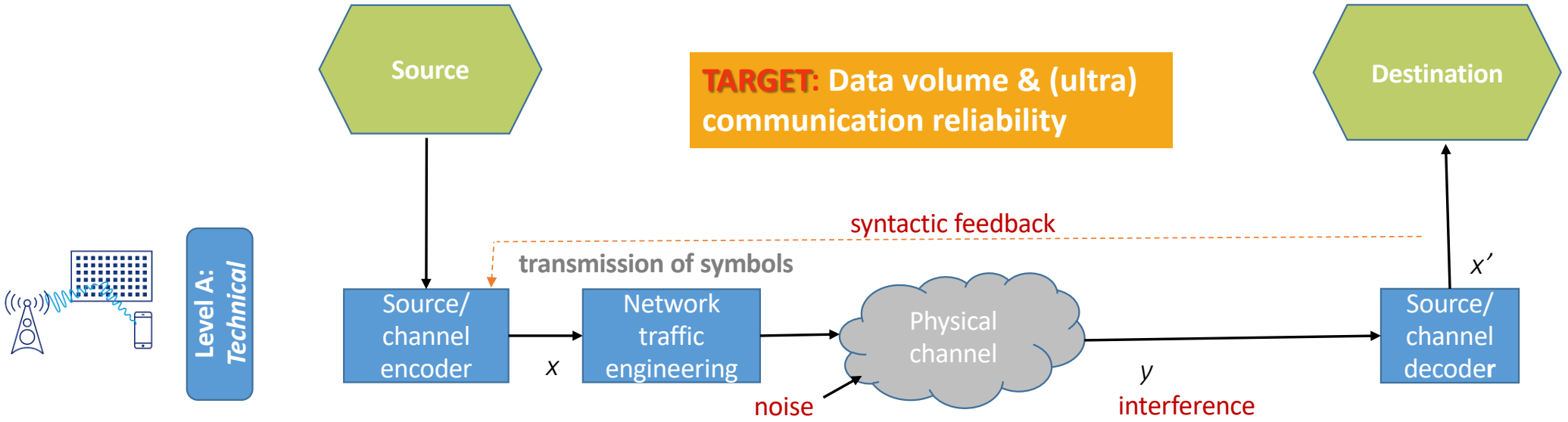
Runtime: January 2024 – December 2026

GENERATIONS OF CONTENT-BLIND COMMUNICATIONS

Current *content-blind transmit-without-understanding* approach:

Data is transmitted without any prior **understanding** of how informative it is (**semantic**) to the receiver or useful (**pragmatic**) for the end-goal of communications

The **technical** problem of communication:
How **accurately** can the symbols of communication be transmitted?



6G-GOALS:
THE SEMANTIC & GOAL-ORIENTED COMMUNICATIONS OPPORTUNITY

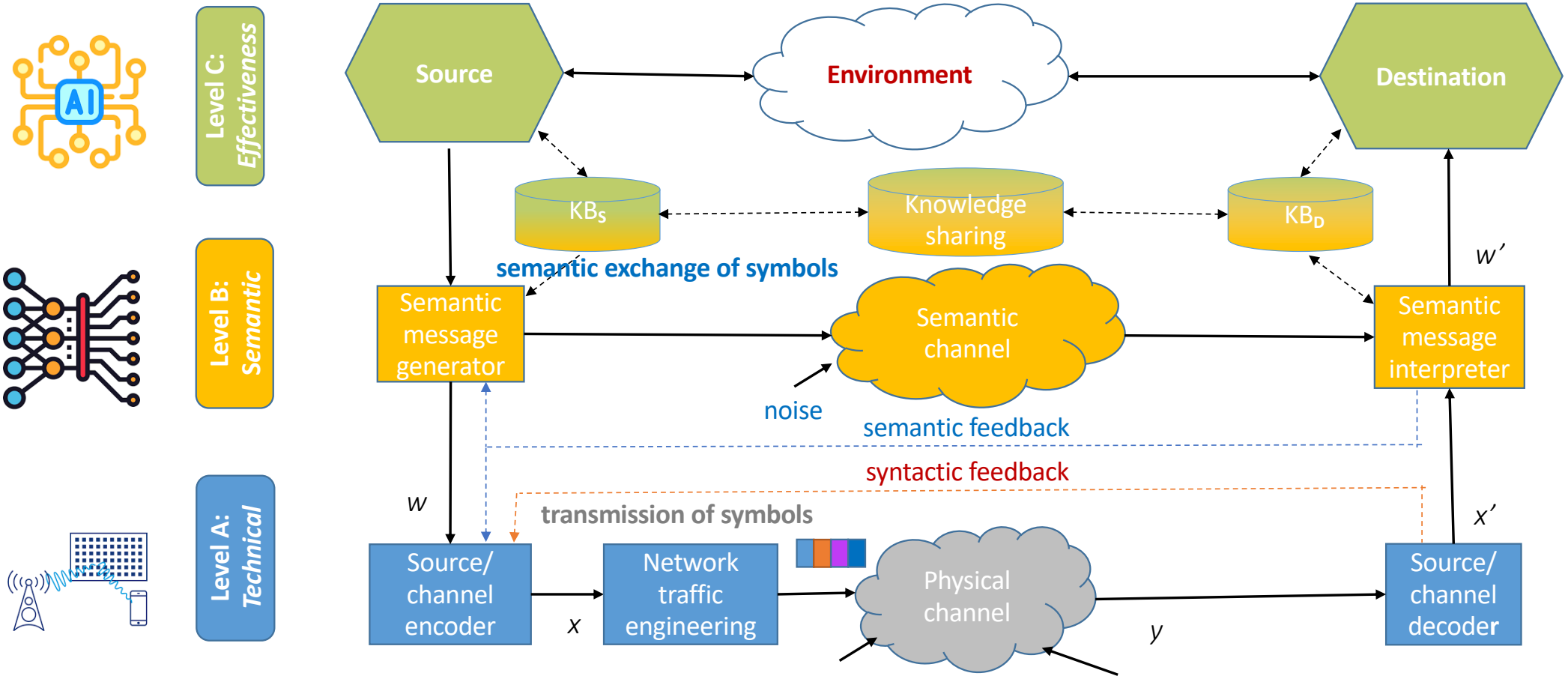
6G-GOALS Project WHY

Sustainability, Scalability, Interoperability

Sustainability, Scalability, Interoperability:

- (Edge) **AI/ML** and **5G/6G** systems are designed and operated as **separated silos**
- **Critical resources waste** due to **avoidable large volumes of data** being generated-communicated-processed-stored-recovered
  - Costs and complexity rather than gains in accuracy in decision-making.
- **Reduce overall PHY layer complexity** by targeting lower spectrum, less antennas, less densification of the network, etc.
- … at the potential cost of increased AI related complexity and costs
- **distil the data that are strictly relevant to conveying meaning and effectively achieve goals**
- **focus only on relevant, valuable, and timely information**

SEMANTICS & EFFECTIVENESS

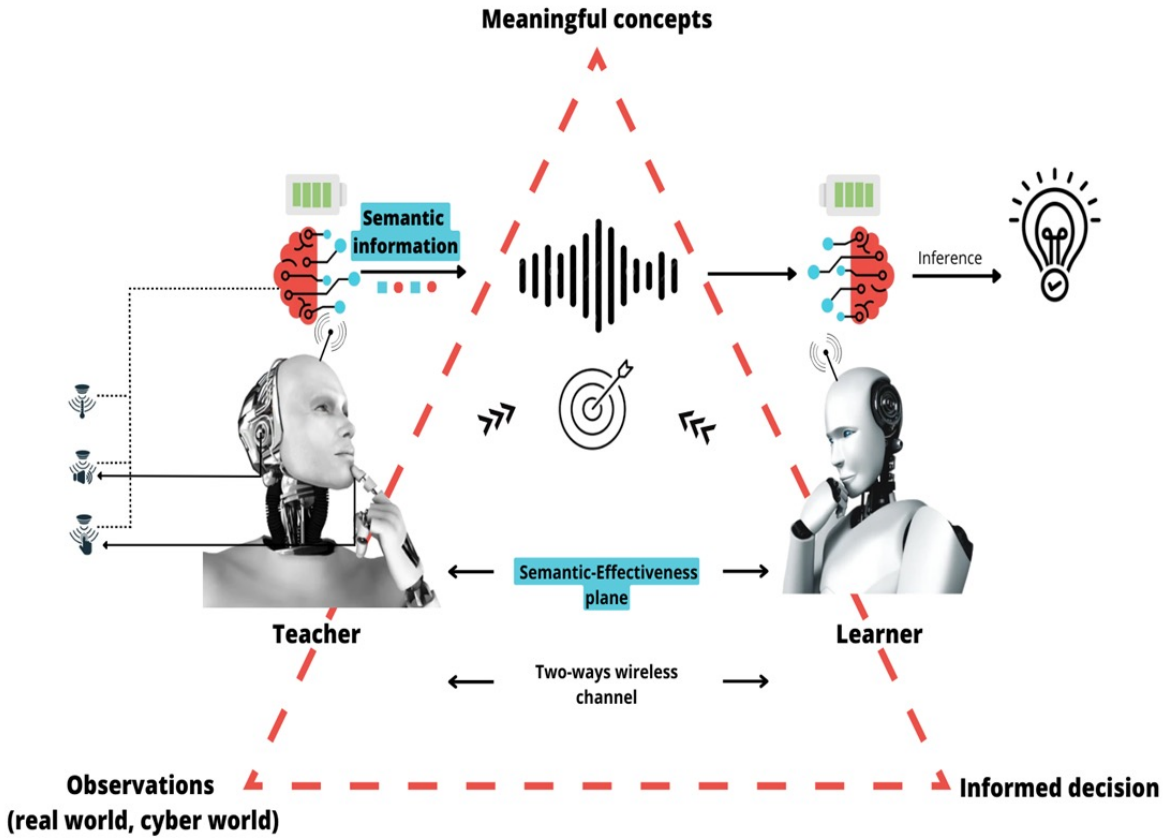


KEY PROJECT'S CONCEPTS

Understand-then-transmit

- **Move beyond the established sense-compute- connect- control models** towards **semantic** and **goal-oriented communications** based on AI-enabled architectures, protocols and services.

- Lay the **theoretical**, **algorithmic** and **operational foundations** of a novel communication and networking paradigm



Understand-then-Transmit

PARADIGM SHIFT #1: GOAL-ORIENTED COMMS

From: Spectral Efficiency of Data-oriented Communications

➔ **Send more data over the available spectrum to use it efficiently**

Send the maximum volume of data per second while maintaining a target QoS.

How to? Not just more antennas and/or network densification (interference issues)

(*Massive) MIMO*, *cell free*, *beamforming*, *new modulatoins*, *waveforms* & *coding schemes*, full-duplex, etc.

To: Effectiveness *per Goal* of transmission strategy outcome

➔ **Identify the relevant needed information to recover the meaning intended by the transmitter(s) and/or to attain the goal at the receiver(s)**

How to? Focusing rather on the actual effect that the received information has on performing an action →

Targeting inference/intelligence reliability rather than blind bit-fidelity

PARADIGM SHIFT #2: SEMANTIC COMMS

From: Moving (raw) data to feed ML & AI is all you need!

The data PARADOX: AI needs data but data needs AI.

ML/AI training, test and operation are known for insatiable appetite for data

The transmitter determines what to send

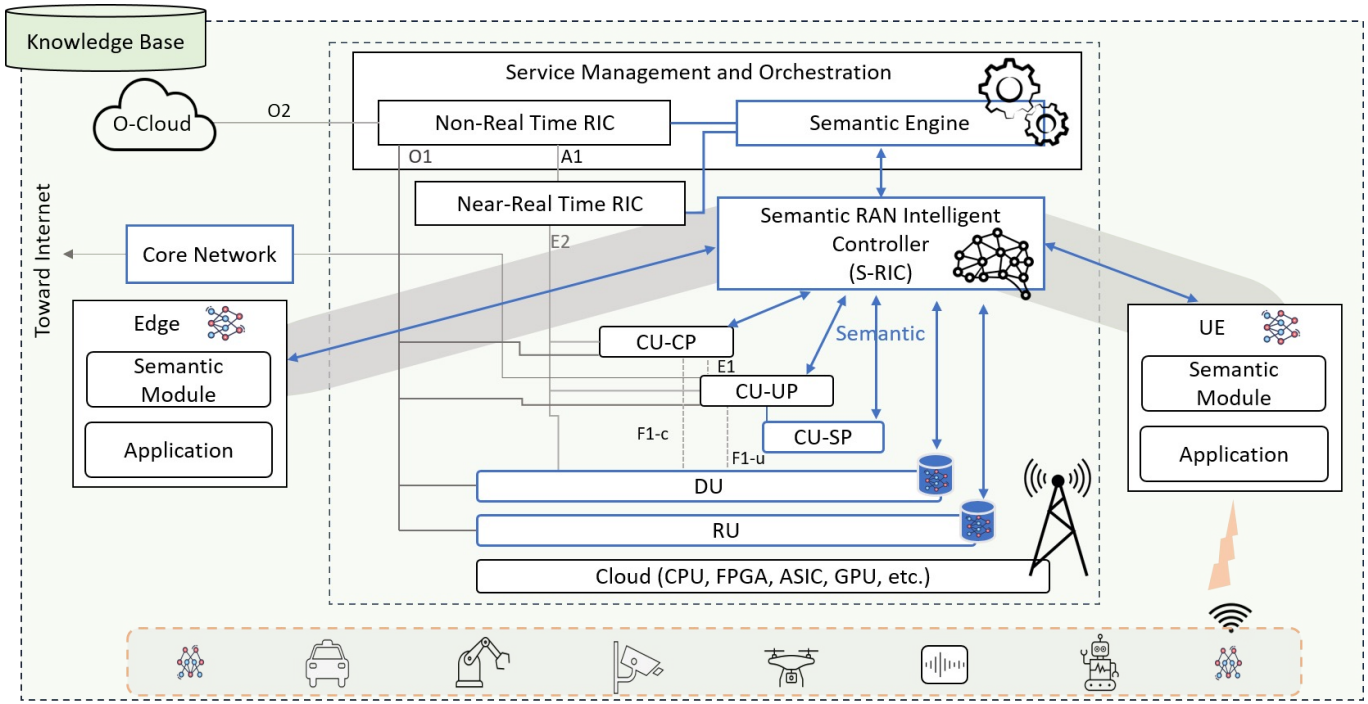
To: Understanding & Effectively Conveying the Intended Meaning

How to? Enabling more context-aware & meaningful interactions between Intelligent Agents.

Moving beyond the exchange of raw data towards communication that is context-aware, goal-driven, and capable of preserving and conveying the intended useful **meaning of information**

Share only knowledge that cannot be reliably deduced or inferred by the receiver (Generative) AI agent

6G GOALS PROPOSED ARCHITECTURE



Coexistence & **inter-operability** with semantic-agnostic systems

Semantic plane that enhances both the user plane and the control plane

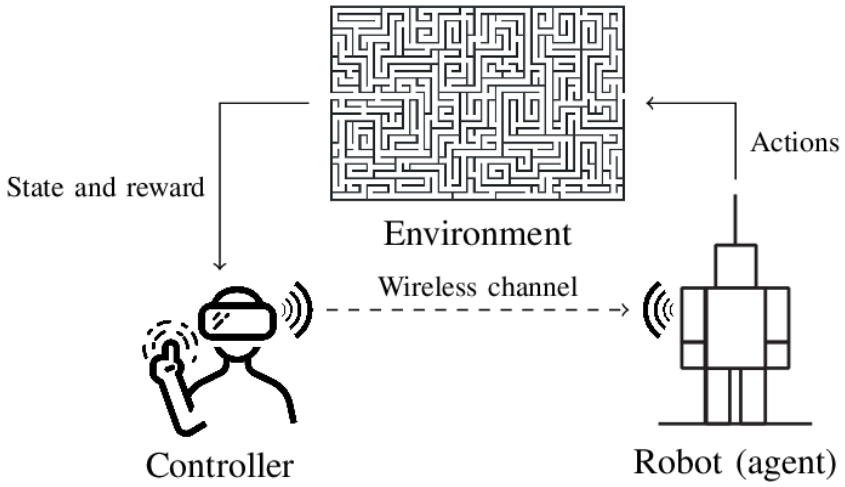
Open RAN to effectively handle semantic communications on a large scale

New intelligent semantic network functions responsible for semantic communication and resource management

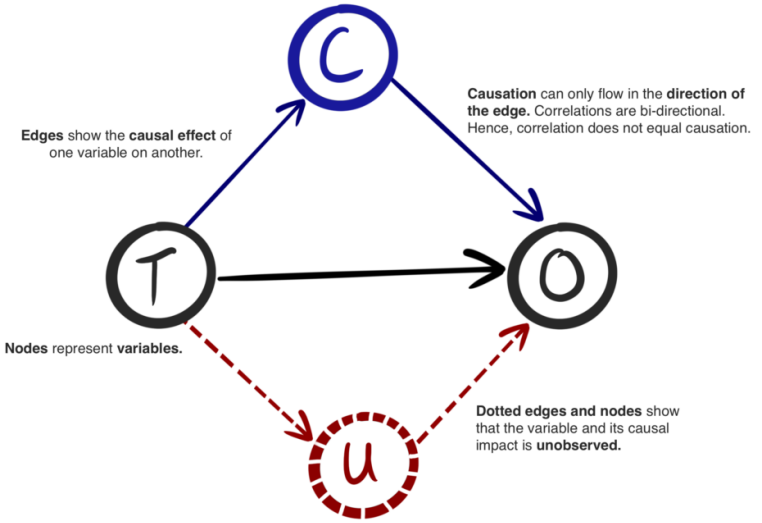
AI-native 6G system tailored for semantic and goal-oriented communications

6G GOALS STUDY NEW FUNDATIONAL PRINCIPLES

Pragmatic communications



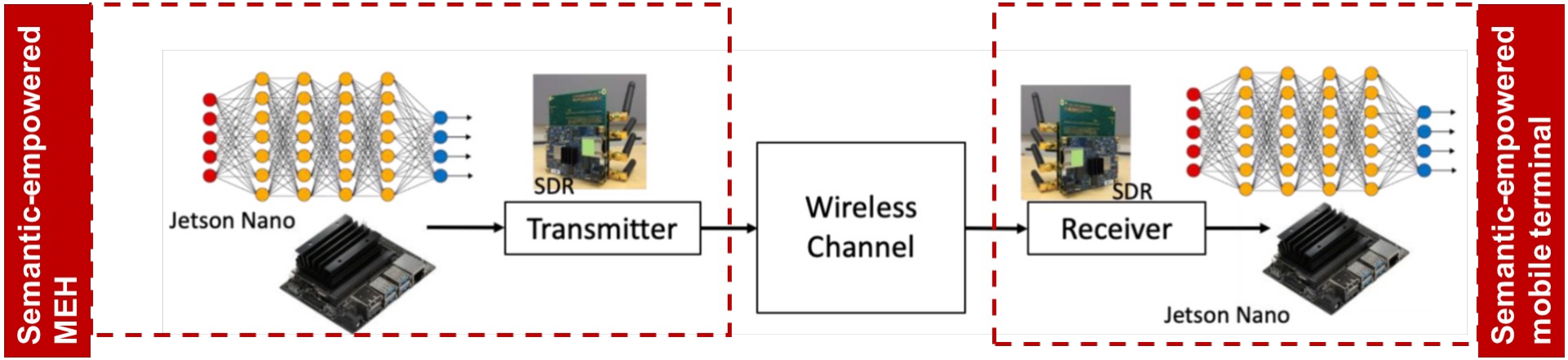
Causal representations



6G-GOALS : enable learning and reasoning via pragmatic communications, incorporating causal semantic data representations, and considering mismatches of languages and semantic rules between sender(s) and receiver(s) & ensuring backward compatibility with legacy (data-driven) systems.

6G-GOALS Proof of Concepts #1 :

IN-LAB DEMOS FOR SEMANTIC-ORIENTED COMMUNICATION



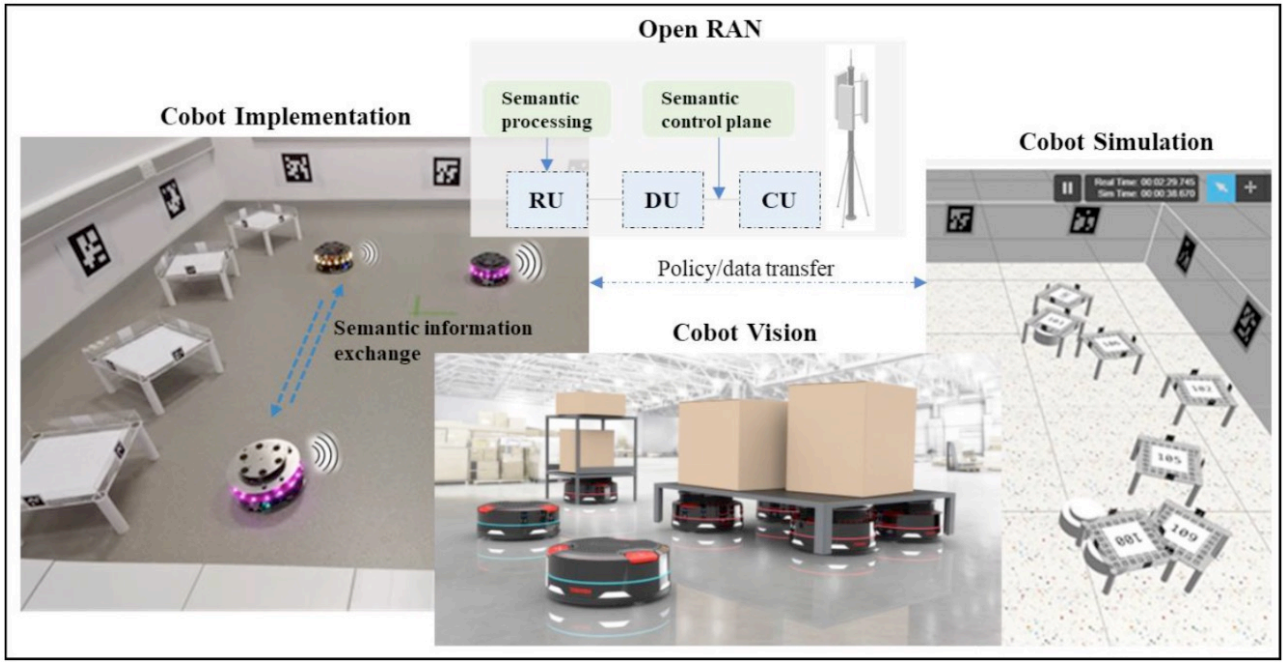
PoC implementation of the **delivery of large deep neural network** models over wireless links

- **Point-to-point scenario**:
  - the **transmitter** models the **edge server wherein the trained model is available**
  - the **receiver** (a **mobile terminal**): requests to download the model on-demand to carry out inference tasks locally within desired latency & energy budgets
- The In-LAb PoC will bring technology to a **TRL 4 maturity**

Goal: the recovered model can still serve its intended inference goal with high accuracy (robustness)

6G-GOALS Proof of Concepts #2 :

SEMANTIC & GOAL-ORIENTED ENABLED COLLABORATIVE ROBOTS



Goal: To develop E2E robot control techniques that **use semantic communication to exchange sensing data**, and allocate tasks with a Goal-Oriented approach

Target: to reduce communication overhead while improving energy efficiency

The demo trial will bring technology to a **TRL 5 maturity**

Get in touch

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Thank you!

Take a look at our first consortium paper

Goal-Oriented and Semantic Communication in 6G AI-Native Networks: The 6G-GOALS Approach

On Arixiv : http://arxiv.org/abs/2402.18271