



AINETUS – AI for safety-critical NEtwork infrastrUctureS

LF Energy Technical Advisory Council (TAC)

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AI4REALNET has received funding from European Union's Horizon Europe Research and Innovation programme under the Grant Agreement No 101119527, and from the Swiss State Secretariat for Education, Research and Innovation.



ai4realnet.eu



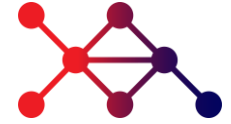
Why AI assistants for critical infrastructures?



- Critical infrastructures (power grids, rail, air traffic, water) are becoming more complex, demanding faster and more sophisticated decisions
- Humans remain accountable, but **AI is increasingly essential for decision support, turning large volumes of data into rapid, context-aware recommendations**
- Traditional control room tools enable robust physics-based decisions, but can be too slow for real-time actions (e.g., topology optimization) and struggle with partial observability and risk modelling
- Control rooms are a fragmented work environment with multi-screen applications, and increasing human cognitive load

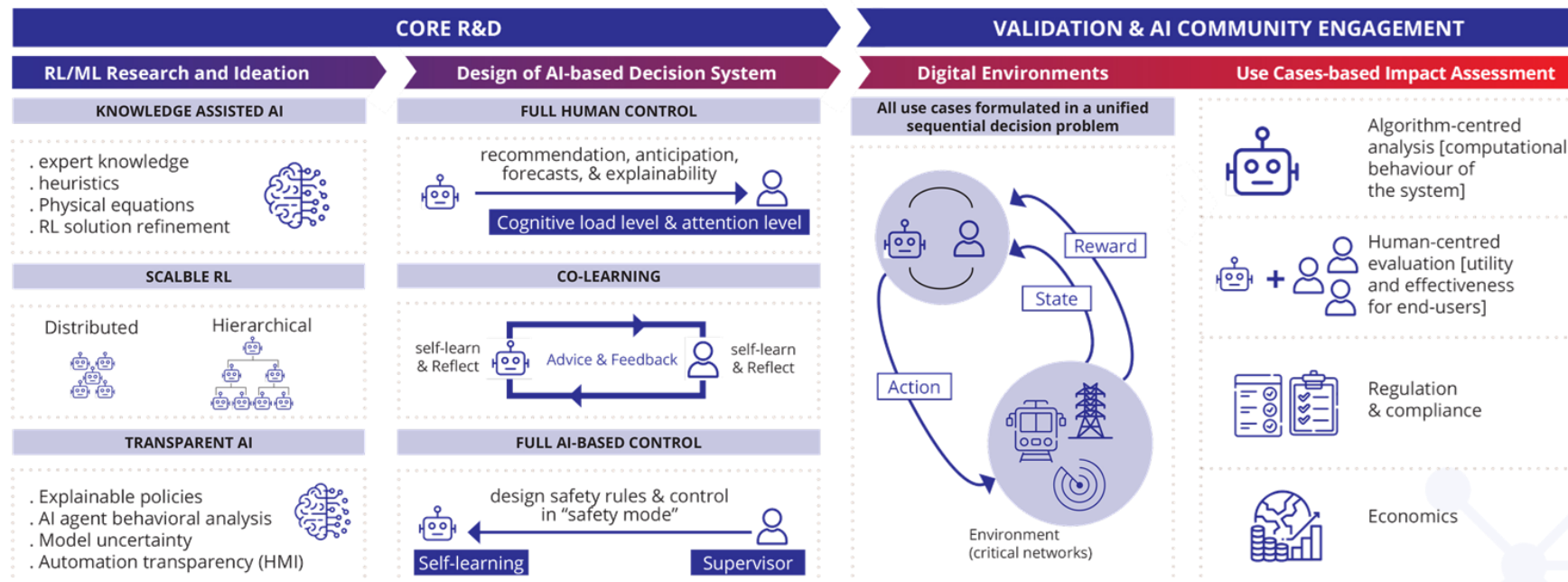


AI4REALNET in a nutshell



GOALS

- ❑ Develop the next generation of decision-making methods powered by supervised and reinforcement learning, which aim at trustworthiness in AI-assisted human control, human-AI co-learning, and autonomous AI
- ❑ Boost the development and validation of novel AI algorithms via 3 existing open-source AI-friendly digital environments

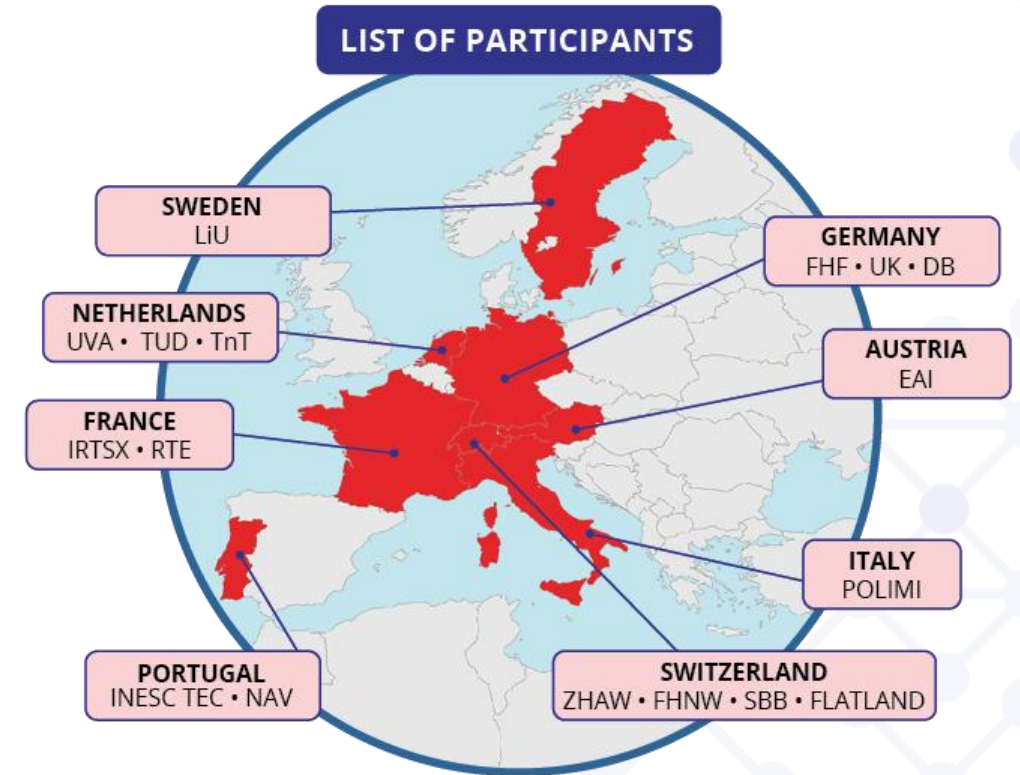


Project information and partners



AI4REALNET – AI for REAL-world NETwork operation

- Oct/2023 – Mar/2027
- **Type of action:** Research and Innovation Action (RIA)
- **Budget:** € 3 999 976,25
- **Project coordination:** Ricardo Bessa (INESC TEC)
- **Project officer:** Stefano Foglietta (HaDEA)



Open-source software (GitHub)



All results will be released in open-source (GitHub page already with several OSS results)

AI4 REALNET OSS

AI4REALNET has received funding from European Union's Horizon Europe Research and Innovation programme under the Grant Agreements No 101119527 and from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Flatland

Project Website

Multi-purpose environment to tackle problems around resilient resource allocation under uncertainty.

Railway **flatland**

Top OSS Repositories

- flatland-rl 0 ☆
- flatland-scenarios 0 ☆
- flatland-book 0 ☆

[See repositories](#)

Grid2Op

Project Website

Cutting-edge machine learning research and applications for industrial use cases.

Energy **grid2op**

Top OSS Repositories

- pypowybl2grid 0 ☆
- grid2op-scenario 0 ☆
- grid2op 0 ☆

[See repositories](#)

AI4REALNET

Overview Repositories 24 Projects Packages AI Teams People 23 Insights Settings

You only have a single verified email address. We recommend verifying at least one more email address to ensure you can recover your account if you lose access to your primary email.

AI4REALNET - AI for REAL-world NETWORK operation

AI-based solutions addressing critical infrastructures: power grid, railway, and air traffic management

21 followers <https://cordis.europa.eu/project/id/10...>

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Repositories

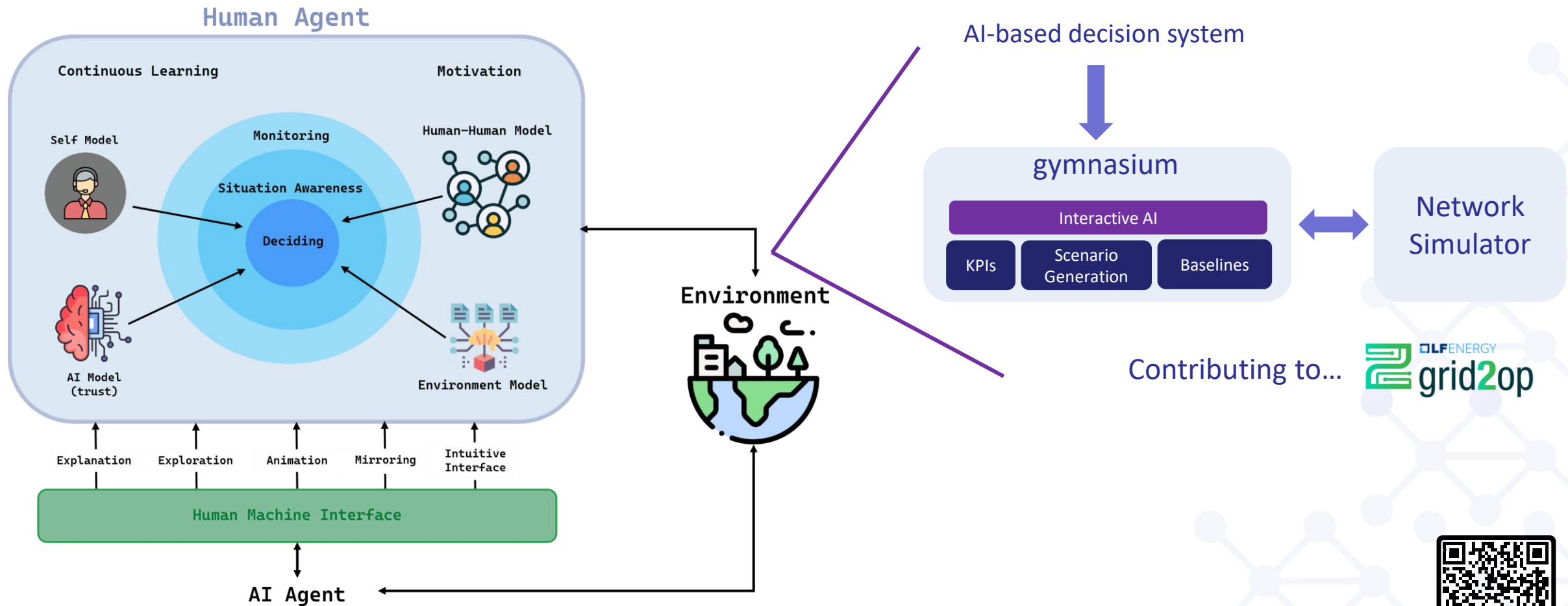
- ai4realnet-orchestrators**
Forked from flatland-association/ai4realnet-orchestrators
Python Updated 1 hour ago
- Human-Assessment-Module**
Python Updated 3 days ago
- grid2evaluate**



ai4realnet.eu



Conceptual framework for human-AI interaction



Contributing to... 



Use cases



UC1

AI assistant supporting human operators' decision-making in managing power grid congestion

AI ROLE Provide a human operator with remedial action recommendations aimed at safely managing overloads on the electrical lines and easing the workload of the human operator.

7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

FULL HUMAN CONTROL

recommendation, anticipation, forecasts, & explainability

Cognitive load level & attention level

UC2

Sim2Real, transfer AI-assistant from simulation to real-world operation

AI ROLE Provide a human operator with remedial action recommendations, considering a transfer from training (digital) to real-world environments.

7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

FULL HUMAN CONTROL

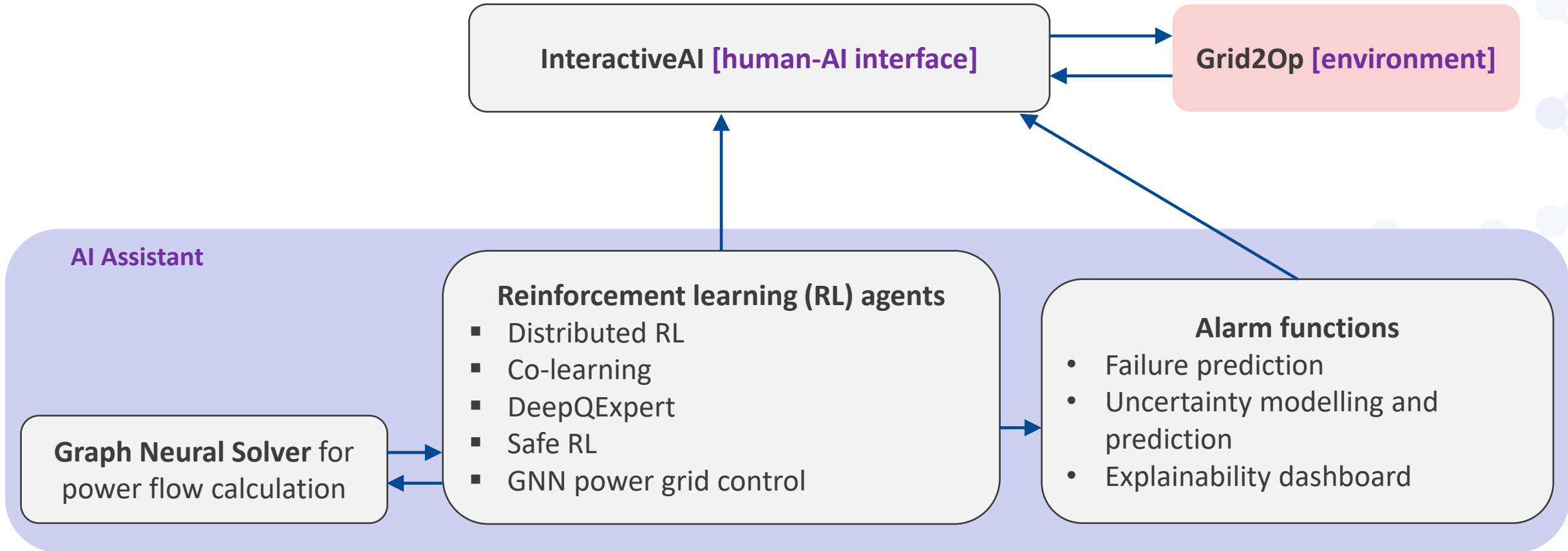
recommendation, anticipation, forecasts, & explainability

Cognitive load level & attention level

AINETUS platform



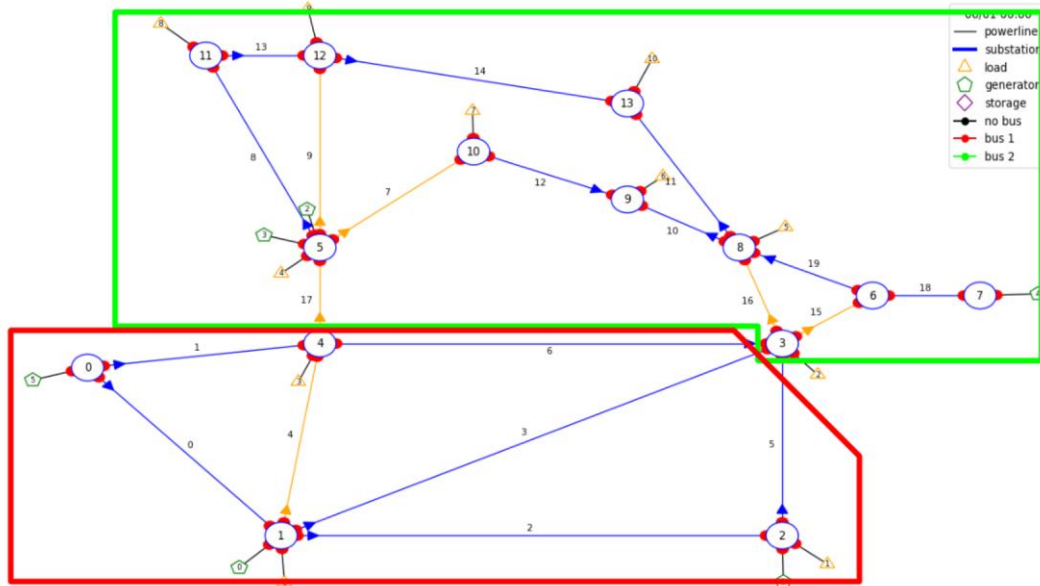
OSS license: MPL-2.0



OSS highlight 1: Distributed reinforcement learning

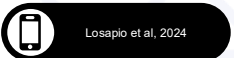


GOAL: Divide into subproblems that can lead to distinct learning processes with less computational and data requirements

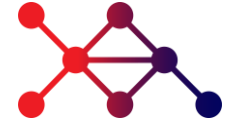


s0	1	1	1	0	0	0	0
s1	1	1	0	0	0	0	0
s2	1	1	1	1	0	0	0
s3	1	1	1	0	0	0	0
s4	1	1	1	0	0	0	0
s5	0	0	1	0	0	0	0
s6	1	1	1	1	0	1	0
s12	0	0	0	1	1	0	0
s7	0	0	0	0	1	0	0
s8	0	0	0	0	1	1	1
s9	0	0	0	0	1	1	0
s15	0	0	0	1	0	1	0
s17	0	0	0	0	0	1	0
s18	0	0	0	1	0	1	1
s11	0	0	0	0	1	0	1
s13	0	0	0	0	0	0	1
s14	0	0	0	1	1	0	1
s19	0	0	0	0	0	0	1
s10	0	0	0	0	0	0	0
s16	0	0	0	0	0	0	0
	sub1	sub4	sub2	sub3	sub12	sub5	sub8

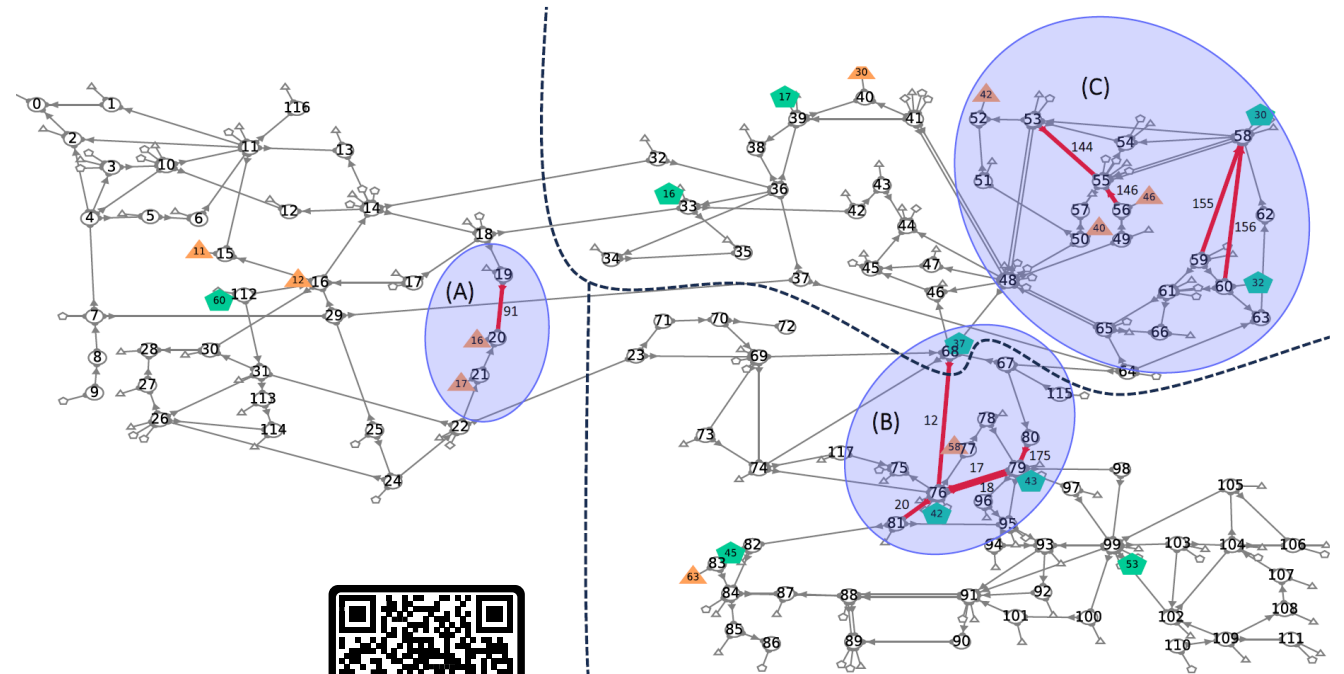
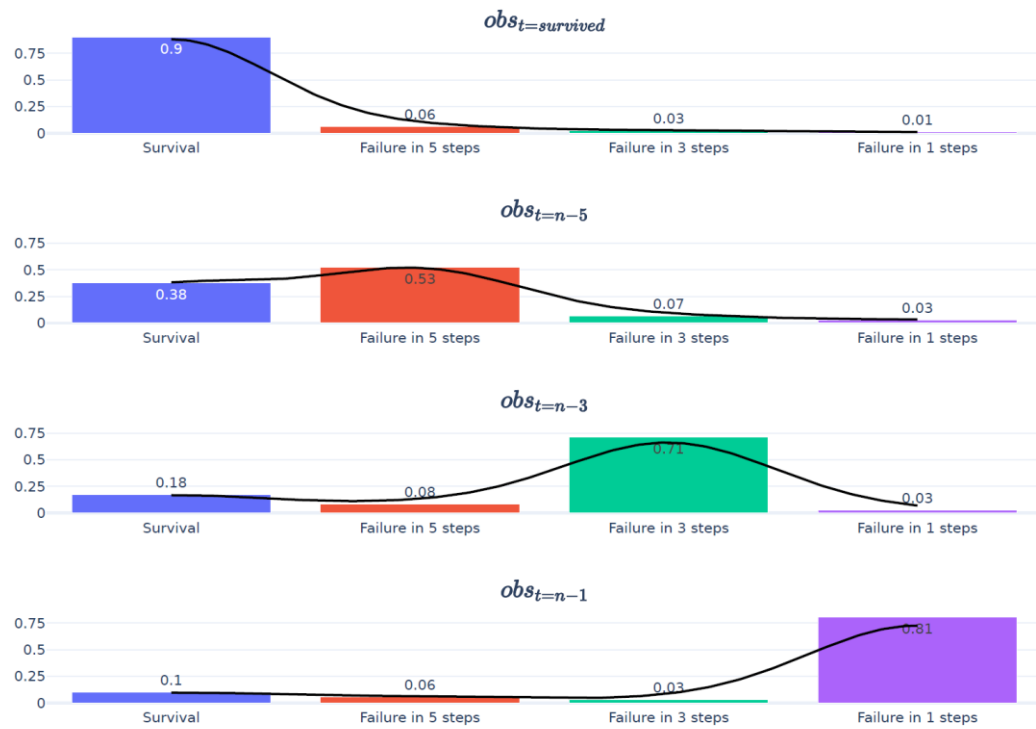
Highly correlated state-action pairs are grouped together to create simpler



OSS highlight 2: Predicting AI agent failure



GOAL: prediction approach to detect AI agent failures beforehand



Lehna et al., 2024

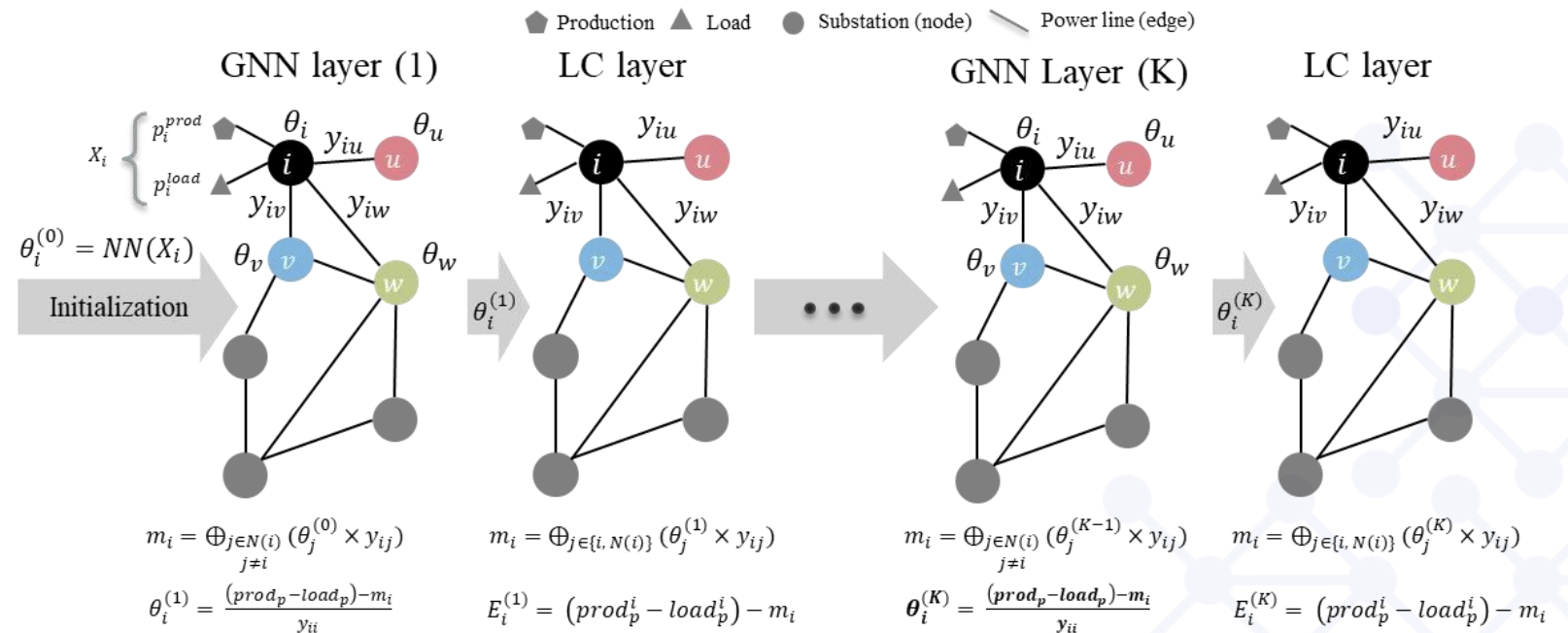
OSS highlight 3: Graph neural solver



GOAL: ML assisted (informed) by physics knowledge for compliance with physical constraints imposed in a power grid that enables the prediction of active powers at power lines from the injections in the substations

$$p_i^{prod} - p_i^{load} = (\theta_i \times y_{ii}) + \underbrace{(\theta_u \times y_{iu})}_{\text{message from node } u} + \underbrace{(\theta_v \times y_{iv})}_{\text{message from node } v} + \underbrace{(\theta_w \times y_{iw})}_{\text{message from node } w}$$

Compliance with physics laws by integrating the local conservation as the optimization criteria (non-supervised learning)



OSS highlight 4: Interactive AI



GOAL: Experimentation of bi-directional virtual assistants for joint decision-making

notifications about risks and events

Alerts

Overload on line 5_10_7

Warning: the line 7 connecting nodes 5 and 10 is overloaded by 112%

Security ⚡

Risk of N-1 contingency on line 9_10_12

Security ⚠

real-time view of the environment with tools like zooming

Context

Network diagram showing nodes (1-13) and lines with load percentages. Node 5 is highlighted in red, indicating an overload.

AI-based suggestions that operators can adopt

Recommendations

Topological change

Switching to the scheme at substation 5

Redispatch

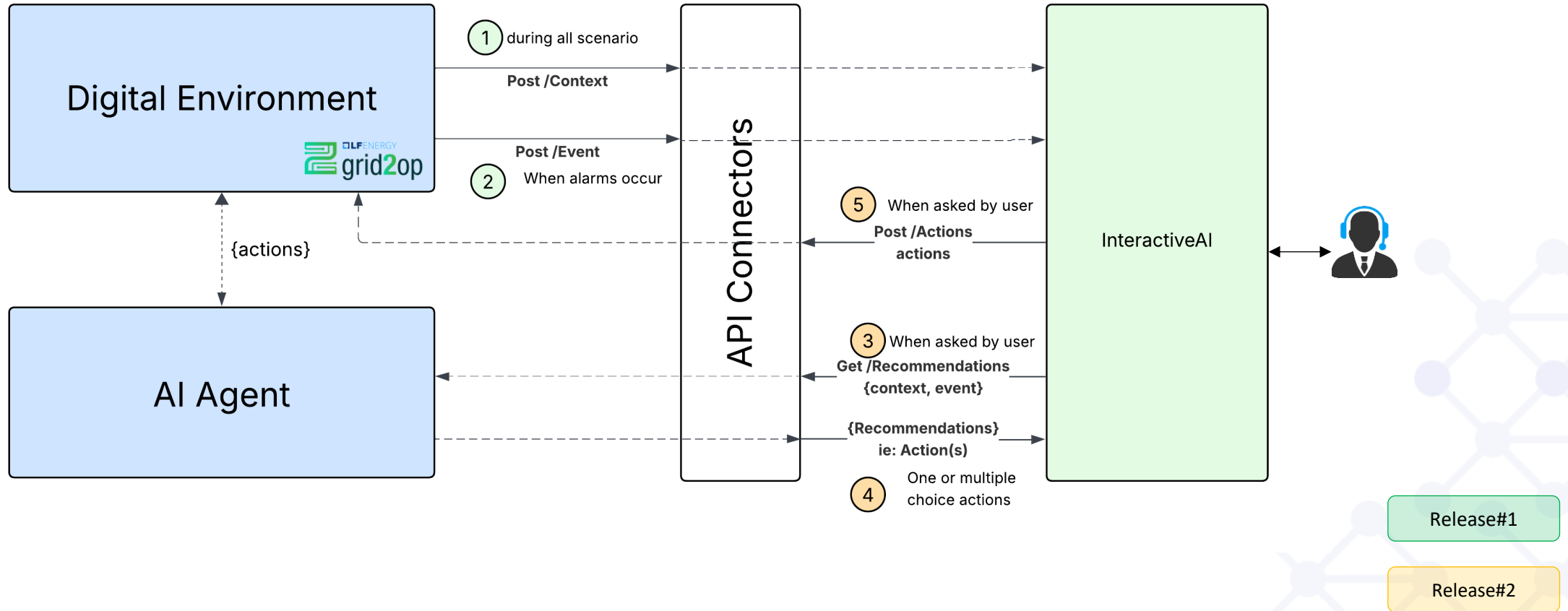
Reduce the generator 2 by 3 MW

Timeline

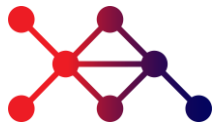
Timeline showing event history for analysis. The event 'Overload on line 5_10_7' is marked at 16:10:15.

tracking time steps and event history for analysis

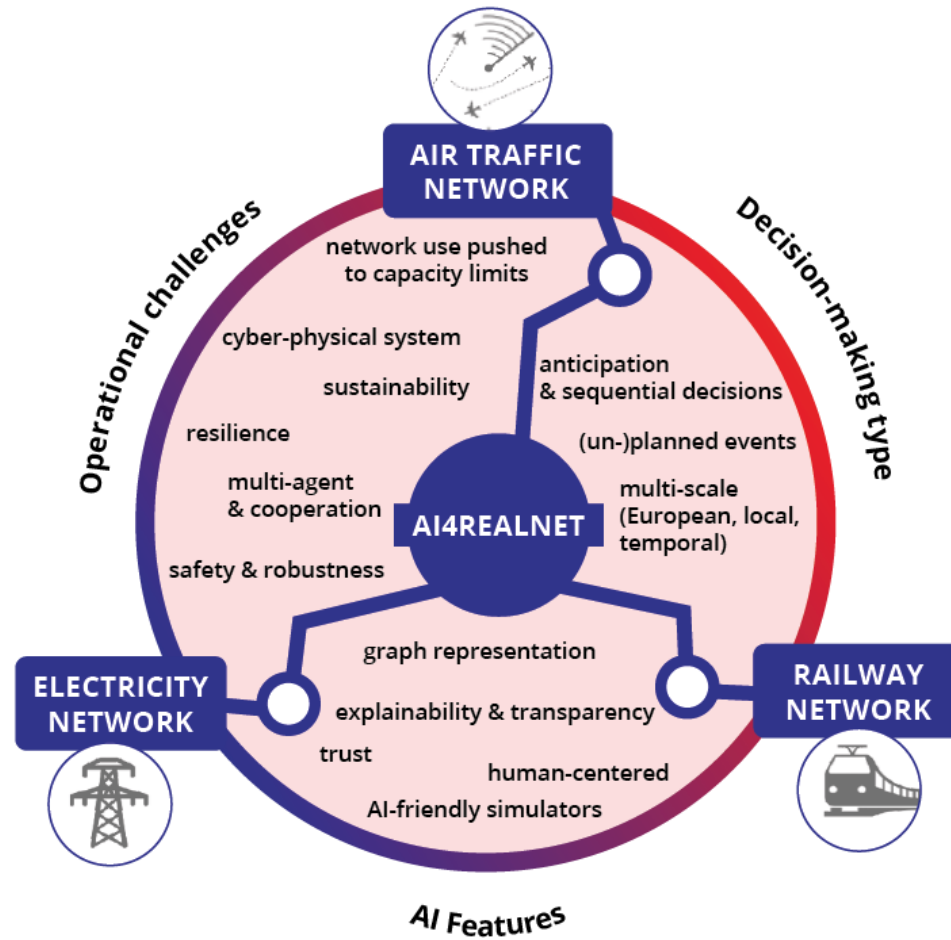
AINETUS interactions



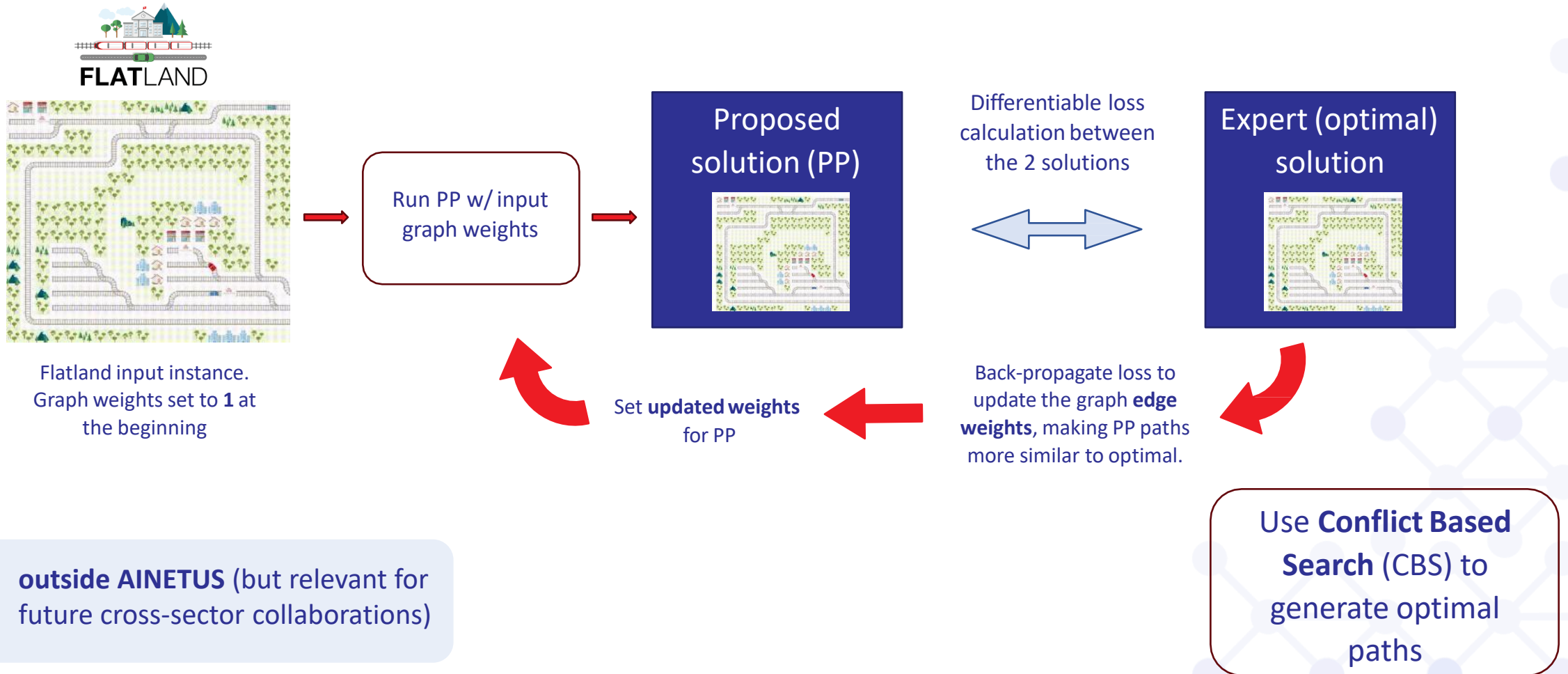
Short demo



Cross-sector dimension



Cross-sector example: railway



outside **AINETUS** (but relevant for future cross-sector collaborations)

Why LF Energy?



- Opportunity for collaborative improvement of an end-to-end stack for AI assistants (algorithms → HMI)
- Synergies with other LF Energy projects: Grid2Op and OperatorFabric
- Encourage co-creation with TSOs, DSOs, and vendors
- Increase awareness for the development and human-in-the-loop testing of AI solutions aligned with the EU AI Act
- Facilitating continuous improvement of RL agents & HMI (towards agentic AI)
- Open-source to accelerate adoption and impact
- Linking to other similar efforts beyond Europe & exploring potential for cross-sector collaboration

Community



- INESC TEC (RTO)
- Politecnico di Milano (University)
- Fraunhofer IEE (RTO)
- IRT SystemX (RTO)
- University of Amsterdam (University)
- RTE (TSO)
- TenneT (TSO)
- enliteAI (SME)

Code quality



- All code on Github: <https://github.com/AI4REALNET>
- Documentation is being improved
- Code is being tested in the AI4REALNET project & integration of the different components is planned for April 2026 (VM at RTE)

Releases



- The components have been developed and tested in the project
- New releases are planned for
 - March 2026
 - September 2026
 - March 2027
- The partners have an interest in keeping the effort alive and expanding it, and potentially exploring it as a development and testing stack for human-centric AI assistants
- Collaboration with a testing and experimentation facility (AI-EFFECT) and possibility of additional EU-funding

AI4 REALNET



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