

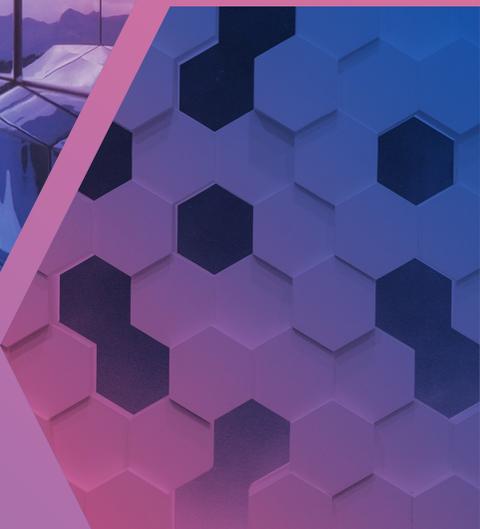
ICT-52 Workshop on 6G
January 19, 2023

AI-enabled services management and orchestration

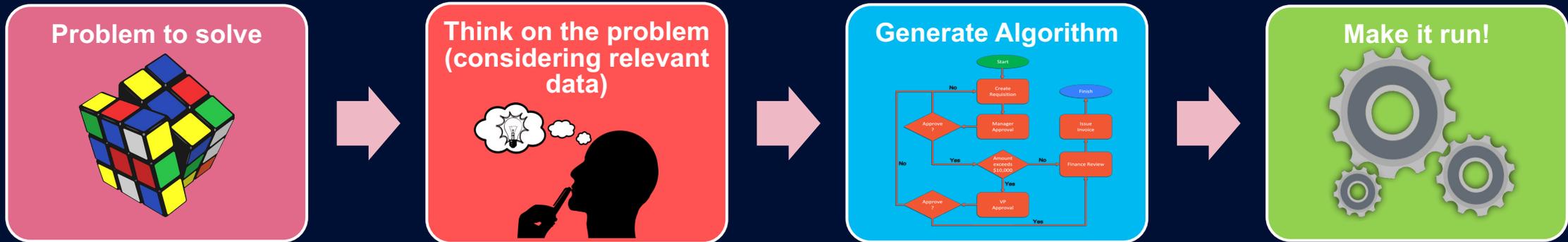
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Typical (simplified) software development workflow



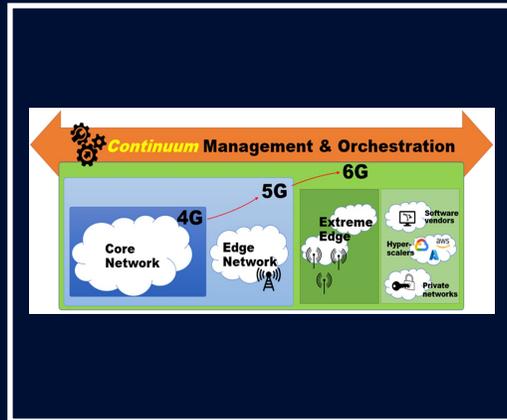
- But practical problems are not always easy to understand and to model
E.g., Natural language processing, handwritten characters recognition, weather forecast, stocks price evolution, images recognition...
- This can be because of different reasons:
huge amount of data, raw/unnormalized data, hidden variables, non-evident correlation among relevant variables...
- So, it is not always possible/easy for humans generate an algorithmic solution to the problem.

>> The regular SW development workflow is only applicable to easily explainable and parametrizable problems <<

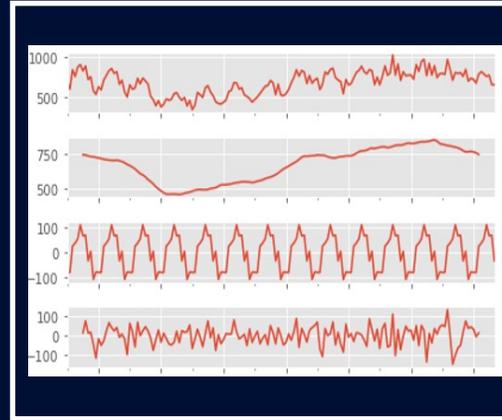
ML can provide algorithms able to efficiently address **more complex** problems, dealing with huge, incomplete, noisy, and/or unstructured data sets.

Why ML in Services M&O?

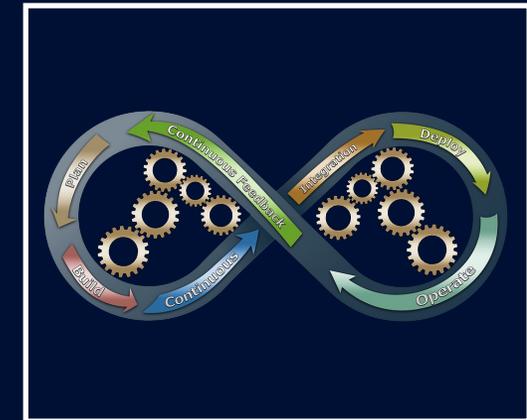
Where is *complexity* in our scope?



**E2E MULTIDOMAIN
INTEGRATION**



**TIME SERIES
PROCESSING**

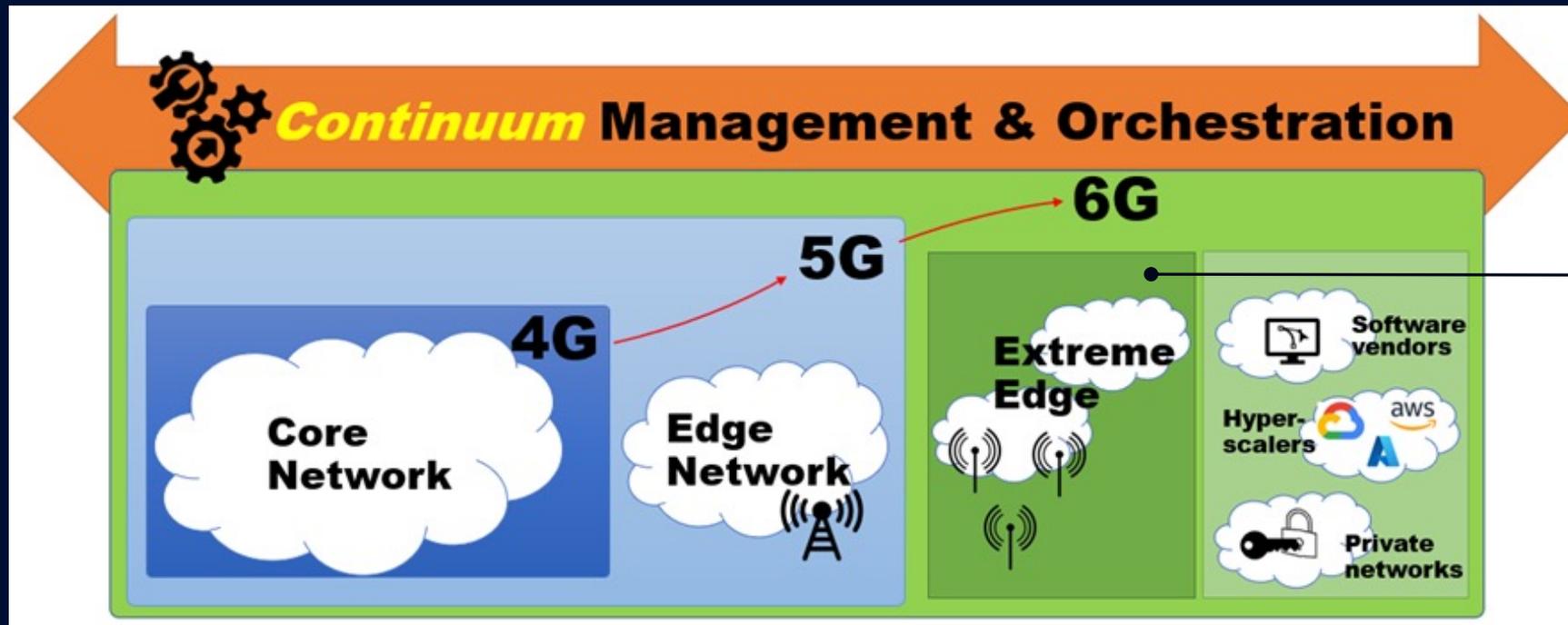


**OPERATIONS
MANAGEMENT**

Why ML in Services M&O?

E2E Multi-domain integration

- A major challenge for the upcoming 6G networks would be to integrate the Extreme Edge domain (together with the edge and core network domains) and other external networks in the M&O workflows.
- All those devices “beyond” core and edge will be available as an additional source of computing, networking, storage and information resources.



Extreme Edge main features:

- Volatile resources with random behavior uncontrolled and asynchronous environment.
- Unpredictable mobility patterns
- High heterogeneity of devices.
- Massive in scale ecosystem can exceed human scale regarding operations.

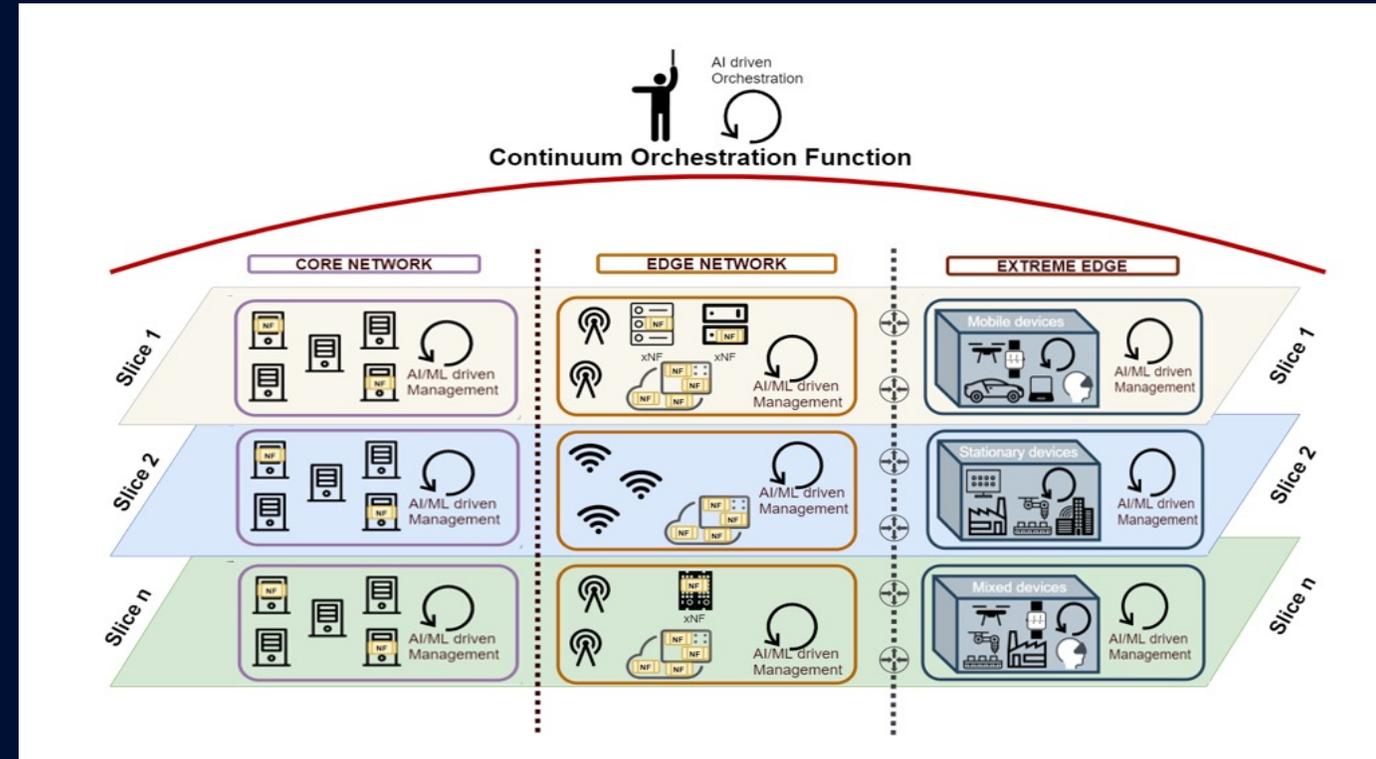
Why ML in Services M&O?

E2E Multi-domain integration

Possible uses of ML:

In general, having access to the high diversity of data sources in the core, edge, extreme-edge, and external networks makes it possible to collect and correlate a rich variety of heterogeneous data, which allows implementing new M&O strategies. E.g.:

- Automation algorithms integrating heterogeneous information from all the different domains (core, edge, extreme-edge and 3rd party networks).
- Generate models able to work with UE raw/unstructured data to trigger orchestration actions based on that.
- Support for big data analytics.
- Volatility management for the extreme-edge (e.g., by means of algorithms to predict future state of devices or their energy requirements).
- Optimization algorithms for the NFs placement (NP-hard problem) considering the *continuum* of the network.



AI/ML techniques could be applied on both:

- Within each domain (core, edge and extreme-edge), even in a very granular way, at the level of individual devices.
- Globally, through the *continuum* orchestration function, integrating data from the different domains.

Why ML in Services M&O?

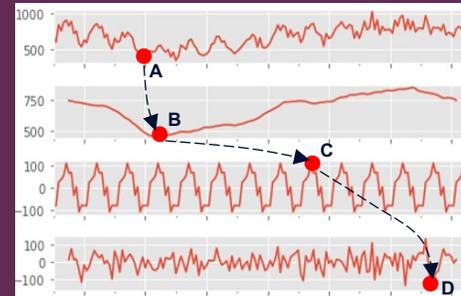
Time series processing

Possible uses of ML:

Certain ML algorithms have demonstrated a good performance in dealing with time series. In general, the variation of certain metrics over time can be treated as a time series. In our scope, these metrics would be taken from any network domain, including also the service layer, to allow correlating data from different sources to extract valuable information and trigger more accurate M&O actions. This could be used for:

- Hidden patterns discovery related to non-evident causal relationships on multiple time series.
- Implementing proactive elasticity M&O algorithms to anticipate the enabling/disabling/scaling of network functions.
- To support proactive NFs placement decisions.
- To proactively optimise the network resources usage.

ML-driven M&O system



If this sequence of events happen (infrastructure metrics)



... and road traffic flow increases in certain areas (service layer data)



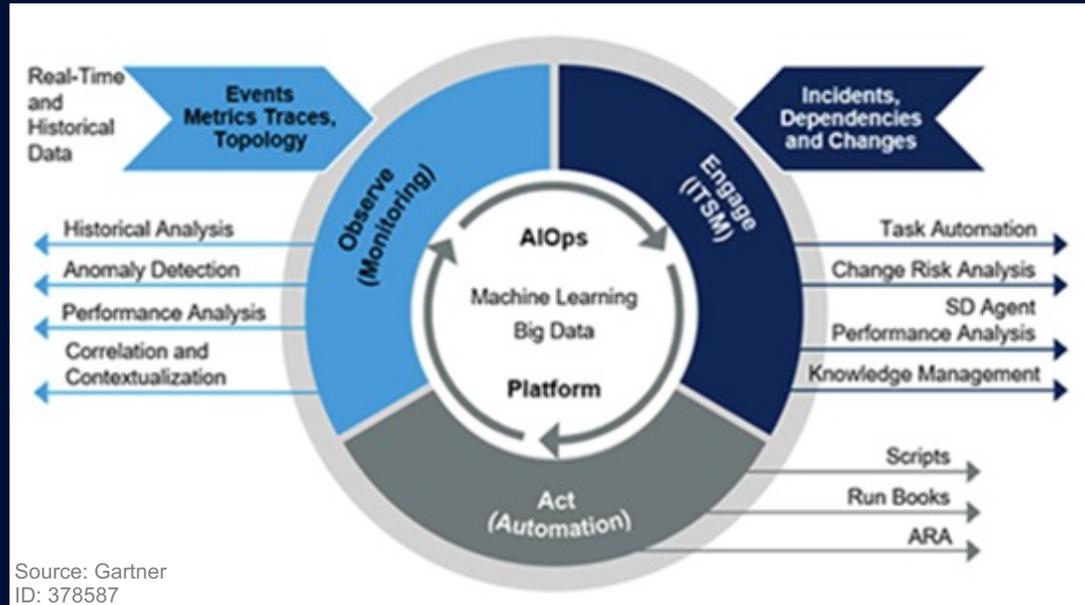
... and there is a football match this weekend (info. from a web service)



Proactively migrate certain NFs to certain Edge and Extreme-edge resources

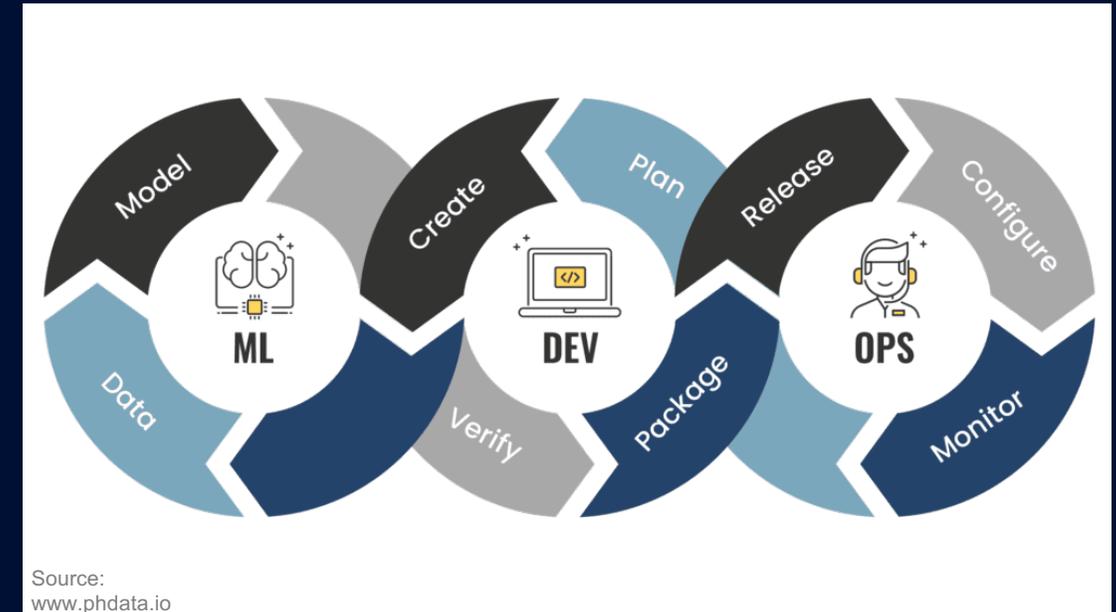
Why ML in Services M&O? Operations Management

AI Ops



- It represents the application of ML to DevOps.
- The target is to efficiently “operate” already deployed services
 - the activity focuses the DevOps’ “Ops” side.
- Operated services can be AI/ML-based or not.
- The focus is on monitoring, automation and service desk.
- Complexity (justification for using AI) is in the huge/diverse amount of information to be processed.
- Also, on integrating information from different operational tools.
- Intent-based service management can be also considered in this scope.

MLOps



- It represents the application of DevOps to ML
- Targeting to “develop and deploy” AI/ML-based services
- In short, we can understand MLOps as a kind of DevOps specialized in developing and operating AI/ML-driven service components.
- Each AI/ML-based service manages complexity on its own context (e.g., images recognition, network metrics processing, data clustering...).
- Different approaches for the different ML paradigms (supervised, unsupervised, reinforced...).

Main challenges associated to using ML for the services orchestration



1. The learning stage

a) Computational complexity

- Artificial intelligence models often require long processing times for the training stage.
- Also, once trained, they may require special HW resources if agile real-time responses are required.
- This can be solved using specific hardware resources (e.g., GPUs or FPGAs), which helps to reduce training and execution times (although increasing infrastructure costs).
- In the telco-grade env., depending on the ML paradigm this can affect only the MNO, the SW Vendor, or both.

b) Training data availability

- Supervised and unsupervised approaches (or other approaches similar to them) can need huge amount of data from the different network layers, or even from external data sources (e.g., non-public networks, 3rd party infrastructure nodes). The lack of adequate data sets for addressing certain type of problems can be challenge by itself.
 - A possible method to address the lack of datasets is to use rely on Generative Adversarial Networks (GAN) systems (based on a small dataset, a GAN could produce a larger dataset made of plausible data).
- Integration of heterogeneous data from different technical and administrative domains (including 3rd parties).

c) The way the learning stage is introduced in the regular MNO workflows (rel. to MLOps).

- In the telco-grade environment network services are typically designed and developed outside the MNO scope □ could lead to data privacy and security issues.
- ML paradigms where learning happens directly on the MNO premises (e.g., FL or RL) could help to deal with this challenge in some cases.
- In other cases encryption techniques could be applied (e.g., homomorphic encryption techniques).

d) To what extent is it acceptable for a service to run in a production environment without the training being fully completed?

- Could be addressed by really activating the service once it is considered the training stage is completed (or at least, completed to an acceptable level).
- But perhaps this is not valid in all cases (e.g., RL models need to actually interact with the real environment to be trained).
- Probably there is no general solution for this. The solution will depend on the criticality of each particular service.

Main challenges associated to using ML for the services orchestration

2. Explainability

- a) Data structures generated by AI/ML models come typically in the form of collections of huge rational number's matrices.
- b) Unlike traditional software programs, this makes it difficult to understand the inherent logic in these models, which are commonly seen as sorts of black boxes
 - In case of a relevant event or failure the operational logic could not be easily explainable.

The challenge could be addressed using the so-called eXplainable AI (XAI) paradigm, which can be used to find the underlying rules behind the AI/ML algorithms.

3. Possible failures

Even our human intelligence cannot properly classify real-life patterns sometimes:



SIX or ZERO?



FORK or SPOON?(1)



YOUNG or ELDERLY?(2)

- But we need to build practical systems able to take real-life M&O decisions, which could impact on the Service Provider reputation.
- It should be considered that the application of AI/ML techniques may not be suitable in a general way, for every network service. Human should always be in the loop for those services that are considered critical (3).

(1) From the movie "WALL-E". Disney-Pixar. 2008.

(2) "My Wife and My Mother-in-Law". W.E. Hill, Puck Magazine. 1915.

(3) European Commission. Assessment List for Trustworthy Artificial Intelligence (ALTAI) for self-assessment. 2020.

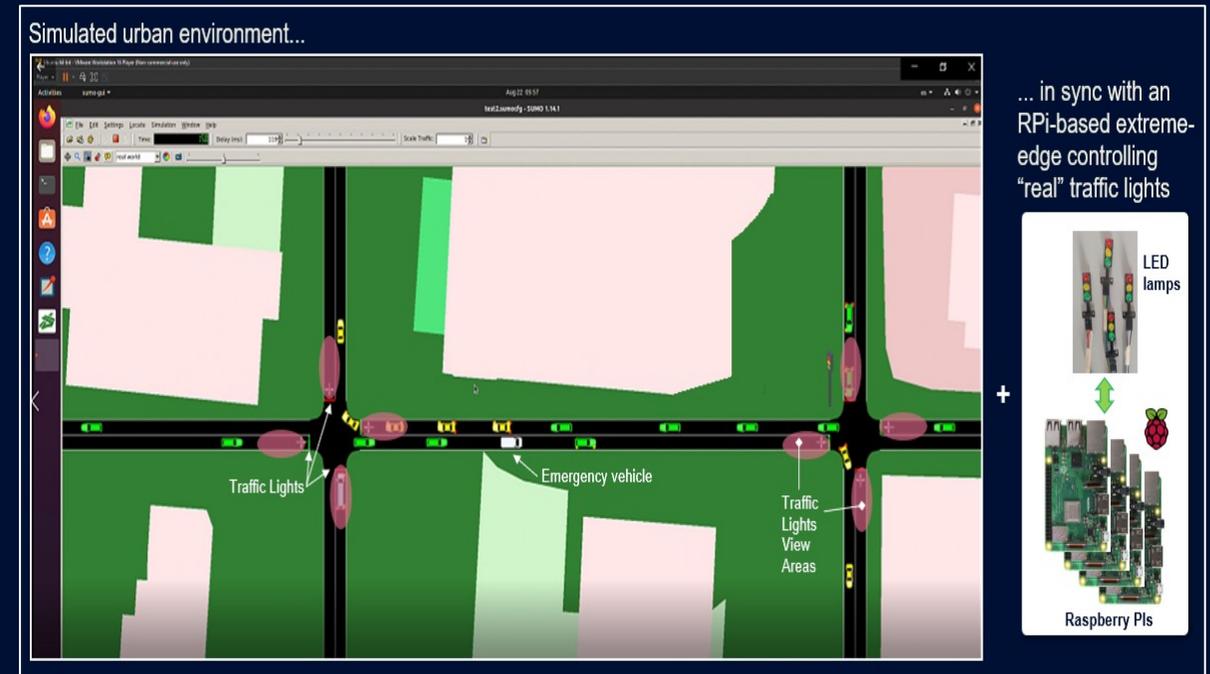
Proofs of concept (work underway)

Demo #4: Handling unexpected situations in industrial contexts



- Unified orchestration across the Cloud – Extreme edge continuum
- Functionality allocation with closed-loop control mechanisms.
- Predictive orchestration and maintenance

Demo #5: Data-driven device-edge-cloud continuum management



- Continuum orchestration of AI/ML-driven traffic light control service.
- Prediction-based URLLC service orchestration and optimization.
- Security.
- MLOps.



**Any
questions?**

Thank you!

HEXA-X.EU



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101015956.