Developing a 6G Data and ML Operations Automation via an End-To-End AI Framework: The 6G-DALI Context

Ioannis P. Chochliouros[1] (✉), Kostas Ramantas[2], Vasileios Theodorou[3], Christian Pinto[4], Takai Eddine Kennouche[5], Adlen Ksentini[6], Franco Minucci[7], Dimitrios Amaxiliatis[8], Giacomo Bernini[9], Luigi Briguglio[10], Rihan Hai[11], Anastasia S. Spiliopoulou[1], and Christos Verikoukis[12]

[1] Hellenic Telecommunications Organization (OTE) S.A., 99 Kifissias Avenue, 15124 Maroussi-Athens, Greece
ichochliouros@oteresearch.gr
[2] Iquadrat Informatica SL, Barcelona, Spain
[3] Intracom Telecom Solutions, Peania, Greece
[4] IBM Ireland Limited, Dublin, Ireland
[5] VIAVI Solutions France S.A., Saint-Étienne, France
[6] EURECOM, Sophia-Antipolis, France
[7] Katholieke Universiteit Leuven, Leuven, Belgium
[8] Spark Works Limited, Galway, Ireland
[9] Nextworks Srl, Pisa, Italy
[10] CyberEthics Lab Srls, Cardito, Italy
[11] Technische Universiteit Delft, Delft, The Netherlands
[12] Industrial Systems Institute (ISI)/Athenà Research Center, Athens, Greece

Abstract. One of the key enablers of 6G is the Native support of Artificial Intelligence (AI) and Machine Learning (ML) at all the system levels, components and mechanisms, from the orchestration and management levels to the low-level optimisation of the infrastructure resources including Cloud, Edge, RAN, Core Network, as well as a transport network. However, this integration presents significant challenges, primarily the need for relevant datasets to train AI models. The availability of high-quality 6G data is still limited, and even when new models are developed, testing and validation remain complex without adequate evaluation platforms. To address these challenges, the 6G-DALI project proposes a framework that harmonizes Data Management with AI development. Its approach is defined by two "key" pillars: (i) AI experimentation as a service via MLOps and; (ii) Data and analytics collection and storage via DataOps. The 6G-DALI DataOps pillar provides the mechanisms for preparing clean and processed data that are stored within a 6G Dataspace and are made available for training and validating machine learning models as a service, a part of the MLOps Pillar. The end-to-end framework also delivers continuous monitoring, drift detection and retraining of models. 6G-DALI revolutionises next-generation 6G networks by addressing the critical challenges of data availability, artificial intelligence integration and energy efficiency.

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1 Introduction

In the past few decades, Artificial Intelligence (AI) technology has experienced swift developments, changing everyone's daily life and profoundly altering the course of human society [1, 2]. The intention behind developing AI was and is to benefit humans by reducing labor, increasing everyday conveniences, and promoting social good [3–5]. AI provides numerous benefits such as reducing human errors, time saving capabilities, digital assistance and unbiased decisions.

More specifically, during the past decade there has been an explosion in the development and use of AI and Machine Learning (ML) techniques with a particular focus on the ML aspects of the AI field, where ML is generally seen as a sub-field of AI. The AI technologies have been evolved and matured and are now assessed as stable with state-of-the-art techniques being used to solve many types of hard problems. AI techniques excel in situations where there is inherent randomness and non-determinism, and where the complexity of capturing patterns and correlations in available data, sometimes based on very complex inputs, takes an inordinate amount of effort to be tamed by human expertise.

In the telecom domain, the increasing relevance of AI in several use cases has been observed for some years now [6, 7]. The telecom industry is embracing AI to improve customer experiences, automate processes, increase productivity and refine network operations. AI-driven technologies have been increasingly integrated into various facets of network operations, ranging from traffic management and resource allocation to predictive maintenance and anomaly detection [8]. By leveraging the predictive and adaptive capabilities of AI, telecommunication networks can dynamically adapt to changing conditions, optimise resource utilisation, and proactively address potential issues, ultimately enhancing the overall network performance and user experience.

There are multiple drivers for the adoption of AI-based solutions in the telecom industry [9, 10] and this relevance is captured also, but not only, by standardisation, for example, the 3GPP specifications of 5G and 5G Advanced [11] where AI-based solutions are increasingly being used to improve network performance and enable intelligent network automation [12]. Numerous Telco functions have been improved by using AI [13]; examples include network automation, traffic monitoring, energy efficiency, fault or fraud detection and consumer plan optimisation/recommendation. The common theme in all these efforts has been that AI-enabled features or use-cases have been "bolted-on" as value-addition features to existing Telco systems.

In the telecommunication sector, AI has the capability to profoundly change the way future networks operate by enabling autonomous and predictive functionalities on multiple network layers. As such, AI has already been nominated as one of the major building blocks of future 6G networks by prominent standardisation bodies and associations [14, 15] while the vast majority of global telecommunications stakeholders are prioritising research into AI-based technological enablers [16], as 6G is expected to offer AI-native functionalities. The SNS-JU [17] has identified AI/ML as a “key” component of 6G, building on the recent projects supported by the European Commission and funded under the SNS (Smart Networks and Services) program. Indeed, through the flagship HEXA-X [18] and HEXA-X-II [19] projects as well as SNS-B phase 1&2 projects, like ADROIT6G [20] and 6G-INTENSE [21], novel 6G architectures are introduced towards natively integrating AI/ML as a core layer of the 6G system [22]. On the other hand, experimentation-oriented projects, such as 6G-BRICKS [23] and the flagship SUNRISE-6G [24], support AI/ML and MLOps (ML Operations) to help experimenters test and deploy AI/ML models. MLOps is a set of practices and tools that combine ML and AI development with operations (Ops) processes [25]. It aims to automate the process of developing, deploying and maintaining ML models. In particular, MLOps unifies ML application development (Dev) with ML system deployment and operations (Ops), ensuring smoother transitions from experimentation to production and more efficient and robust ML systems. The field of MLOps is emerging as a critical one, guiding the incorporation of ML algorithms into operational processes [26].

In general, this trend shows the vital importance of AI/ML in 6G networks [27, 28] where a clear framework is needed to build ML models [29] (i.e., generate data, train and test, tune hyper-parameters) and handle their life-cycle (e.g., benchmarking, drift detection, model customisation) through streamlined MLOps approaches [30, 31].

Meanwhile, the last decade has seen unprecedented developments in the AI/ML field, thanks to the increasing computing capabilities we are experiencing with newer generations of CPUs (Central processing Units) and (primarily) GPUs (Graphics Processing Units), which allowed the AI/ML research community to massively scale the computational resources devoted to AI model training. The (empirical) scaling laws [32] of ML along with theoretical breakthroughs have promoted advancements in many fields of AI/ML, such as supervised/unsupervised learning, distributed and federated learning, reinforcement learning with the multi-agent version, and more recently with Generative AI [33, 34] and Large Language Models (LLM) [35], such as GPT-4 [36], that powers ChatGPT [37], and the open model LlaMA [38] from Meta Research [39], which revolutionised and impacted all the ICT fields, including networking. All these advances will definitely contribute to accelerating the adoption of AI/ML in 6G and beyond systems and integrating it as a native component [40].

The paper is organised as follows: Sect. 1 serves as an introduction, by identifying AI/ML’s roles in the modern era. Section 2 discusses the native support of AI/ML in 6G. Section 3 introduces the 6G-DALI EU-funded project and presents its basic concept, together with its fundamental objectives. Section 4 briefly covers 6D-DALI’s Proofs of Concept (PoCs). Finally, Sect. 5 summarizes the work.

2 Native Support of AI/ML in 6G

One of the “key” enablers of 6G is definitely the native support of AI/ML [41] at all the system levels, components and mechanisms [42], from the orchestration and management levels to the low-level optimisation of the infrastructure resources, including Cloud, Edge, RAN (Radio Access Network), Core Network as well as a transport network.

AI native is the term for technology that has intrinsic and trustworthy AI capabilities [43]. AI is introduced naturally as a core component of every entity in the technology system, including its operations, functions, implementation & deployment and maintenance & optimisation [44]. An AI native technology ecosystem enables end-to-end (E2E) data-driven decision making using advanced AI capabilities and real-time contextual knowledge. Importantly, the AI systems are also dynamic [45] in nature: they do not follow fixed predefined rules, but adapt continuously. The underlying resources are built to scale. AI is pervasive across the ecosystem, built naturally from the ground up.

AI native is different from embedded AI. Embedded AI integrates AI functionality into an existing technology system. The goal of embedded AI is to enhance the functionality and improve performance of existing technology entities. Typically, this is achieved by replacing an existing technology component with one that enables AI capability. Another approach involves adding an AI-based component to the existing technology stack. In both cases, the existing systems do not involve legacy processes and technologies; a new AI component offers sufficient backward compatibility to realize business goals – whether operating as a standalone component or an API interfacing with an external AI service. A third type of embedded AI controls and optimises legacy systems and processes. In this use case, the AI component is engineered to interface with the legacy technology.

An AI-native concept [46] is characterised by the following key tenets: (i) related systems have AI capabilities that are intrinsic and trustworthy [47, 48]; (ii) AI is used as a natural part of design, deployment, operation, and maintenance; (iii) such a system will be adaptive and dynamic and will be driven by data and knowledge; (iv) The AI-native transformation will result in new AI functionality or augment existing ones or replace existing static rule-based systems with learning and adaptive AI; (v) An AI-native transformation refers to an AI-driven or AI-designed transformation rather than an AI feature or solution "bolted-on" an existing system.

The integration of AI/ML in 6G will impact not only the key stakeholders, i.e., network operators and telco manufacturers, but also verticals, which are more and more optimizing their applications and services running on top of the network using AI/ML-based algorithms. Knowing the huge potential of AI/ML for being a "key" enabler for 6G to automate the network configuration and resource management of the entire chain, several standardisation groups concentrated efforts towards standardizing activities around using AI/ML in 6G, such as ETSI through the ZSM [49] and ENI [50] Working Groups, 3GPP through NWDAF [51] and SA5 [52] working groups, and O-RAN initiative [53] via the Real-time Intelligent Controller (RIC) and Non-Real time Intelligent Controller activities. TM Forum, through its intent abstraction mechanisms and the IDAN Catalyst project [54], proposes an autonomous architecture that relies heavily on AI/ML to support zero-touch management [55, 56] and configuration of Next-Generation (NG) networks [57].

There are several remaining gaps that hinder the adoption of AI/ML in 6G, hence blocking the advantages that AI/ML can bring to all 6G actors, including verticals, in terms of increased efficiencies and business opportunities. On one hand, it is well established that AI/ML requires extensive datasets to train the models. Indeed, the amount and the quality of data have a critical impact on the accuracy of the AI/ML model, hence impacting the quality and efficiency of the AI/ML driven solutions. The generation and management of data is a critical concern that has been addressed in many International and European initiatives in various domains. Notably, the International Data Space [58] (IDS) and Gaia-X [59] initiatives aim to provide a secure and sovereign framework to make data available in data economies via efficiently sharing the data between stakeholders and exposing it to end-users and verticals to build ML models. However, while existing initiatives have focused on data generation and the creation of Data Spaces for Health, Agriculture, and Manufacturing, data generation efforts for 6G datasets are indeed very limited [60].

Even the scarce datasets available typically do not cover the RAN, the quantity of data is not enough to obtain accurate models, and the considered scenarios are typically non-realistic (e.g., due to a small number of UE (User Equipment), no mobility considerations, etc.). Although several projects funded by the European Commission are committed to producing datasets out of their testbed and PoCs, these efforts are fragmented and datasets are published on different platforms. Furthermore, several datasets are not complete or miss key features capturing the behavior of 6G components and systems and lack end-to-end vision. Definitely, what is missing for 6G and the telecom domain, in general, is an analogous approach that Gaia-X [59] is proposing to other fields (Healthcare, Transportation, Banking, etc.) applied for sharing and exploiting data for ML developers, data engineers and verticals in 6G.

On the other hand, when a model is developed, testing and validating its performance in a representative environment (by emulation or real deployment) is still difficult. While model validation platforms, such as AI Gym, may help to validate a model, they have a strong limitation when it comes to representing real and complex environments like 6G systems. To this end, the industry has adopted the MLOps paradigm as a set of reproducible workflows for the development, deployment and testing of ML models and to deploy staging (i.e., pre-production) environments for performance benchmarking of models prior to deployment. In the context of 6G, MLOps should evolve to support testing, evaluating, and validating ML models in real or emulated 6G staging environments (i.e., 6G testbeds or 6G Network Digital Twins [61] respectively) before deployment in production. This is particularly important when it comes to reinforcement learning, which needs to be trained and validated while ensuring that all actions are executed as expected and do not break functionality, security, nor privacy rules before deployment on an operational system.

Such a step is essential to ensure that an ML model is well-performing and not drifting or realizing an action that it does not have the right to do, which hence guarantees building a trustworthy AI system.

3 6G-DALI: Basic Concept and Fundamental Objectives

6G-DALI [62] aims to build a novel E2E AI framework that intends to connect 6G data with verticals and ML developers and experimenters, while relying on 6G testbeds selected from the flagship SNS-C phase 2 (SUNRISE-6G) project [24]. To this end, 6G-DALI is bringing together 3 communities, that is: (i) Experts on the design and experimentation on 6G systems; (ii) experts on AI and MLOps with a good mix of industry and academic experience, and; (iii) experts on DataOps [63] and the Gaia-X community. These will collaborate for the first time to build an efficient, realistic and trustworthy framework for E2E AI/ML experimentation for 6G [64, 65].

The envisioned framework shall be open and enable all functionalities needed by ML developers and third parties that do not own data to train and validate their ML models for 6G, covering all the layers and components of the 6G system, i.e., the RAN (including Physical layer), Core Network, Edge and Cloud computing. To this end, 6G-DALI ambitions to embrace the data management and mechanisms adopted by Gaia-X [59] and IDS approaches [58, 66] for handling data life-cycle, which will be collected from 6G testbeds and a Digital Twins Testbed (DTT). The objective here is definitely to build a data space dedicated to telecom data and actors. To fulfil this vision, 6G-DALI aims to deliver an E2E AI framework for 6G structured in two interdependent pillars: (i) AI experimentation as a service via MLOps, and; (ii) Data and analytics collection and storage via DataOps. The 6G-DALI DataOps pillar provides the mechanisms for preparing clean and processed data that are stored within the 6G Dataspace and are made available for training and validating machine learning models as-a-service, a part of the MLOps Pillar. The latter, in turn, ensures that the models trained or fine-tuned with this data can be deployed efficiently and reliably into testbed infrastructures. It also involves continuous monitoring, drift detection and retraining of models with new data, which may require ETL (Extract Transform Load) pipelines [67] to be run repeatedly to supply the latest data, through adapters and connectors that link the framework with the 6G testbed APIs and Dataspace.

The 6G-DALI project is structured around fulfilling 7 measurable objectives along with well-defined outcomes, which, combined together, permit to reach of these objectives constituting the two Pillars of the project: (i) AI experimentation as-a-service via MLOps and; (ii) Data and analytics collection and storage via DataOps. Objectives 1, 4, 5 and 6 "build" the AI framework components and the Digital Twins of the project, which enable both pillars. Objective 2 is on the support of pillar 2, while objective 3 is dedicated to pillar 1. Finally, objective 7 concerns the support of the societal sustainability of 6G-DALI. These objectives are briefly discussed below:

Objective 1: *Deliver a user-friendly E2E AI framework structured in two interdependent pillars*, that is: a DataOps pillar that provides the clean, processed data that are stored in the 6G Dataspace and are available for training and validating ML models a part of an MLOps pillar. Deliver high-level user interfaces (graphical and application programming interface- (API-) based) to interact with the 6G-DALI's DataOps and MLOps systems, offering AI experimentation as-a-service (AIaaS) as well as intent-based approaches and Large Language Models. The envisioned interfaces will allow to: (i) discover available datasets following the Gaia-X approach; (ii) express data request as intent; (iii) "run" data generation and quality improvement; (iv) "trigger" the test of trained ML models, and; (v) test and validate the ML model by deploying it on top of the existing testbeds, including the 6G-DALI Digital Twin Testbed (DTT).

Objective 2: *This is about delivering Gaia-X and Extract Load Transform (ELT) approaches for DataOps in 6G environment.* The purpose is to deliver procedures to satisfy user requests, either for "cold data" (i.e., available datasets at the local or data space catalogues) or "hot data" via the AI experimentation as-a-service using the 6G testbeds as well as DTs that collect and construct the needed datasets [68]. The process will be about adopting the Gaia-X approaches [59] for cold data search (service catalogue) and data security (trust and security) and integrating these procedures to the user interface (i.e., as in Obj.1). Regarding hot data, the process will be about devising and implementing ELT pipelines to collect datasets if they are not available in the 6G data space. The ELT process, specifically the Transform phase, will be improved by novel data augmentation and cleaning algorithms devised in 6G-DALI. Here one of the "key" criteria that guarantees an accurate and performing ML model is the quality of the used dataset.

Objective 3: *Streamline 6G testbed's trustworthy AI/ML operations via MLOps and AutoML.* The expectation is about delivering efficient, automated and trustworthy MLOps for 6G via AutoML [69] and AutoRL [70] workflows, covering the entire life cycle of AI and ML models (i.e., training, validation, fine-tuning, hyper-parameter optimisation, and performance benchmarking, an approach termed as AIaaS for 6G experimentation [71]). The proposed 6G-DALI AIaaS framework will target an easy-to-use approach, leveraging Dashboards, Open APIs and AutoML approaches to fully expose and ease the learning curve of MLOps for 6G testbeds and ML experimentation. The AIaaS framework offers a set of components that cover a wide set of scenarios [72] that allow a unified approach to searching, serving, optimizing, fine-tuning and testing the performance of ML models. In this context it is also expected to incorporate Reinforcement Learning (RL) operations (RLOPS) [73] as well as Federated Learning (FL) operations (FLOps) on top of 6G testbeds [74] and Digital Twins. The target is to devise a meta-orchestration solution encompassing heterogeneous MLOps/RLOps software stacks, covering all the steps constituting the life cycle of development of ML/RL/FL-based models.

Objective 4: *Deliver plug-able adapters to easily integrate 6G testbeds from future calls.* Among 6G-DALI's objectives is to allow ML developers (including verticals) to collect data and train ML/RL models for 6G systems via DataOps and MLOps. To achieve this, it is important to rely on existing 6G testbeds and additional testbeds constituted of Digital Twins [75, 76] (DT) and emulation approaches. Although 6G-DALI has identified testbeds participating in the SUNRISE-6G federation [24] as "*the initial testbeds for developing the experimentation facility*", the project aims to deliver an E2E AI framework that easily integrates new testbeds and additional enablers (e.g., THz) from future European calls. Consequently, 6G-DALI aims to implement and release as open source two "key" innovations to ease the integration of the testbed: (i) the adaptation layer at the AI framework level that allows having a common set of Northbound MLOps & DataOps APIs, and; (ii) a set of adapters deployed at testbeds to translate the Northbound APIs to Southbound 6G testbed (and DT) APIs, and to the 6G Data space through Dataspace Connectors.

Objective 5: *Building and integrating a Digital Twin testbed to generate representative datasets for 6G.* The envisioned DT will allow the running of experiments and, therefore, dataset generation for scenarios that require a high-scale deployment running a high number of mobile UEs, several gNB cells, different RAN configurations, etc. Although several existing 6G testbeds propose RAN experiments, they cannot support more than a small number of UEs, which generally are connected to one or two gNB, hence limiting scenarios involving mobility. Such limitation is mainly due to the geographical location covered by the testbed, which, most of the time, covers a small area. In this objective, in complement to the existing 6G testbeds, 6G-DALI will develop one reference Digital Twin Testbed (DTT) to allow running tests and create datasets [77, 78] including scenarios that require, for instance, large-scale deployment, such as connecting a number of cells to test mobility or generate a high amount of traffic via the connection of thousands of UEs. Such a scenario is difficult to deploy today in existing 6G testbeds, which lack scalability.

Objective 6: *Developing ethical data sets, validation methodologies and legislative compliance*. 6G-DALI will adopt a methodology to embed ethics into the design and implementation of a trustworthy E2E AI framework [48, 79, 80] aiming to ensure the societal acceptance, especially for the usage as well as the compliance of data sets and validation methodologies with the rules of current and forthcoming data legislation (e.g., GDPR [81], Data Governance Act [82], Data Act [83], AI Act [84]). Ethical AI is the practice of using AI with good intention to empower employees and businesses and fairly impact customers and society. Responsible AI enables companies to engender trust and scale AI with confidence. Moreover, 6G-DALI aims to provide final policy options for policy makers to cover eventual gaps as well as final recommendations for future endeavors in the 6G field. 6G-DALI will adopt an ethics-by-design approach [85, 86] based on the so-called ETHAI Model [87] with a specific focus on how society will adopt and accept this technology via the embedding of ethics values, principles and rules in the AI model design process. They will be based on [48] (including the seven "key" ethics requirements such as: human agency and oversight; technical robustness and safety; privacy and data governance; transparency; diversity, non-discrimination and fairness; societal and environmental well-being, and; accountability) and the EU AI Act [84], as well as further relevant EU regulatory framework (e.g. Data Act [83], GDPR [81]) into each implementation phase of the 6G-DALI AI technology.

Objective 7: *Maximise the impact expected to be created by the project* to a great number of potential "actors"/recipients through wide means of dissemination, communication, standardisation and exploitation activities.

4 Proofs of Concept

6G-DALI proposes three PoCs, where each PoC has two experiments: PoC1 focuses on DataOps; PoC2 focuses on MLOps, using a vertical service (i.e., Content Delivery Network (CDN), and; PoC3 covers both pillars. Each PoC has a leader-member of the 6G-DALI consortium, who will coordinate all activities related to that PoC. All enablers' providers will assist and support the PoC leaders based on their expertise.

In the following we briefly discuss each one among the PoCs.

PoC 1: Data management and experiment on demand

6G-DALI addresses the lack of datasets on 6G to unleash the full capacity of AI and ML models to improve and optimize 6G systems and services. Even though some datasets exist here and there, no framework exists that ensures that the data is clean and interoperable and shared with a broader public, hence monetizing the existing dataset. Meanwhile, Gaia-X is a novel initiative from the European Commission that aims to regulate data sharing of existing Data Spaces [88] through service catalogues and novel procedures for trust and security [59]. Many societal fields are taking advantage of Gaia-X systems to share data [89], such as the transportation field, where different key actors (airports, aerial companies, cities, etc.) share data to improve user mobility. However, in the field of communication (including telecommunication and computing), no such Data Space exists, which definitely will help shape upcoming next generations systems by integrating advanced AI and ML models to optimize these systems efficiently. In this PoC, the aim is to "fill this gap" by shedding light on the 6G-DALI framework to organize and share 6G data by federating the existing datasets and generating new ones.

The aim of this PoC is to showcase the capabilities of the 6G-DALI AI framework to satisfy users' requests for 6G data by building the concept of the 6G Data Space. This PoC's objectives are to: (i) Demonstrate the integration of the AI framework with 6G Data Space and Gaia-X service catalogue, authorisation and trust; (ii) demonstrate the AI framework's ability to translate user requests to data sets to experiments via LLM technologies, and; (iii) demonstrate the ETL pipeline to populate, transform and load to the data space for data analytic collection and storage.

PoC 2: AIaaS for CDN apps via cross-testbed decentralised MLOps

While MLOps is not a novel approach for automating ML workflows and lifecycles, still for most cases (especially in production environments) ML model lifecycle management has to go through a few manual steps and processes to satisfy constraints and solve interoperability issues at different phases, including training, deployment, inference, etc.

The PoC will validate the 6G-DALI unified approach for managing and executing ML tasks and processes with full automation, streamlining the various steps and taking autonomous decisions related to AI/ML models training, deployment, placement, hyper-parameter optimisation and transfer learning/quantisation as a service [90, 91]. Moreover, the PoC aims at assessing the capability of an E2E AI framework to rely on heterogeneous testbed infrastructures with different MLOps software stacks, demonstrating a solution that is independent from the underlying computing technologies (meta-Orchestration concept) and from the user and ML model constraints (e.g. in terms of AI/ML model techniques and library used for development).

PoC 3: DTT and RLOPS for large and medium-scale experiments

The growing need to build models for 6G is limited by the lack of representative datasets, particularly if we consider building models for RAN and CN. Such limitation is not only due to the low number of available data sets but also due to the scenarios used to generate these data sets. Indeed, most of the available datasets contain insufficient data to "reflect high-scale deployment, such as a high number of UEs per cell, a high number of cells to enable mobility and handover scenarios [92], etc.

This UC showcases 6G-DALI capabilities to run large-scale experiments using the AI framework and the DT, with two-fold objectives: First, datasets are generated and integrated into the 6G dataspace by using 6G-DALI ETL; second, realize RLOps to test and validate trained RL agents.

Digital Twins for networks are expected to enable the development of rich network applications and provide means to realize new data-driven management and control concepts for networking. The envisioned DT will allow the running of experiments and, hence, dataset generation for scenarios that require a high-scale deployment running a high number of mobile UEs, several gNB cells, different RAN configurations, etc.

5 Discussion

The intersection of 6G and AI represents a convergence of two "cutting-edge" technologies [93], set to redefine the landscape of wireless communication. AI's capability for real-time data analysis and decision-making complements 6G's high-speed, low-latency network, enabling smarter, more efficient connectivity [94]. In addition, AI enables 6G networks to optimize themselves in real-time, enhancing network performance, reliability and energy efficiency. It allows for predictive maintenance, intelligent resource allocation, and personalised user experiences, setting the stage for a highly adaptive communication ecosystem [95]. To comply with the trend of ubiquitous intelligence in 6G, native AI wireless networks are proposed to orchestrate and control communication, computing, data, and AI model resources according to network status, and efficiently provide users with quality-guaranteed AI services [96, 97].

6G-DALI is very well aligned with the technological and business realisation of the 6G vision, targeting massive digitisation of societal and business processes, promoting and easing the native integration of AI within the cloud-to-device continuum (including RAN and CN [98]) and helping achieve the targets of UN SDGs [99]. The 6G-DALI project aims to: (i) Design and evaluate a revolutionary approach that embraces the data management and mechanism adopted by Gaia-X and IDS concepts for handling data life-cycle, which will be collected from 6G testbeds and Digital Twins; (ii) deliver an E2E AI framework for 6G, which is structured in two interdependent pillars, that is: (a) AI experimentation as-a-service via MLOps, and; (b) Data and analytics collection and storage via DataOps. The 6G-DALI DataOps pillar will provide the clean, processed data that are stored within the 6G Data Lake and are available for training and validating machine learning models as a service, a part of the MLOps pillar.6G-DALI will broad the scope of MLOps and apply it as a comprehensive solution in support of AI-native 6G networks and services, considering it is as a powerful and innovative toolbox to facilitate the development, testing and validation of ML models and, in general, AI software artefacts targeted at collaborative 6G research.

The E2E AI framework acts as an intermediary between end-users composed of ML developers (i.e., expert users), who define models for 6G systems to improve, for example, the infrastructure performance or the management systems to enable zero-touch management procedure using closed-control loop relying on ML models and vertical users that aim to develop ML models to be used to optimize their services for 6G. On the other hand, the AI framework is connected to a set of 6G testbeds that integrate all the technological domains composing a 6G system, i.e., RAN, CN, and computing platforms (edge and cloud resources). The AI framework of 6G-DALI will connect data consumers to data producers by building the first Dataspace to store, reference existing datasets, and generate new datasets per demand for 6G networks and technologies. Further, the 6G Dataspace has the ability to share the existing and collected datasets with different 6G stakeholders (including ML developers, verticals, network operators and vendors).

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