A Data Space for 6G Network Digital Twins: Challenges and Opportunities

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***Abstract*—The concept of Network Digital Twin (NDT) has emerged to deal with the increasing complexity of mobile network management and optimization. NDTs replicate the real network state and behavior to act as a sandbox detecting anomalies, optimizing the overall system performance, and automating processes. Data is the fuel of any DT. It notably helps in monitoring and building a future vision of the system. Beyond the volume of data, there is the question of governance, regulation, and ensuring data exchange between various stakeholders. The concept of Data Space (DS) arises as a potential governance solution for NDT data exchange – already used in several verticals, but poorly in networking. In this poster, we aim to foster discussion around DS and the related challenges and opportunities underlying NDT data exchange, in view of future 6G systems.**

I. NDT DATA EXCHANGE CHALLENGES

A Data Space (DS) [1] offers the standards and infrastructure to enable a data marketplace. This functions as a data ecosystem, enabling data providers to commercialize their data as products for data consumers. In contrast to an open data repository, a DS emphasizes data ownership, regulated access, and secure transactions between providers and consumers.

The implementation of data-space standards for optical network stakeholders, without considering NDT, has already been demonstrated [2]. Unlike optical networks, which are usually national infrastructure, mobile networks are mostly run by private companies. If technological solutions exist, we encounter practical and organizational challenges. The first lies in **NDT governance** , which is of critical importance due to the complexity of the ecosystem involving private operators. The second is **data and model harmonization**, induced by the heterogeneity of devices and providers.

II. ROLE, RESPONSIBILITY, AND ORCHESTRATION

First, we have to answer: who is in charge of the NDT(s)? In most cases, each Mobile Network Operator (MNO) will manage its own NDT, exchanging information with other MNOs' NDTs when necessary. MNOs will also be responsible for sharing relevant information to regulatory authorities, virtual operators (MVNO), and application providers. This exchange of data is regulated through the DS, which governs interactions among MNOs as well as with other stakeholders, as illustrated in Figure 1. Related domains also influence the NDT (e.g., building information, transportation, etc.), which could be exploited as a federation of heterogeneous NDTs. The challenge is then to define a specific governance scheme for orchestrating data flow, in and out, of this **NDT federation** according to the roles of NDTs and actors involved.

As part of the ongoing work in the *6G-TWIN project*, we are defining the governance of 6G NDT DS, specifying data access

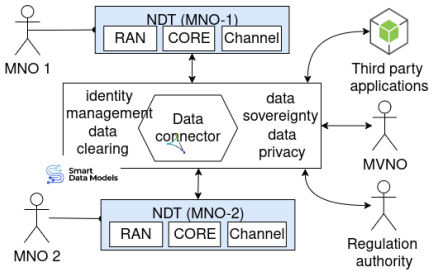

Figure 1. Data Space Architecture for NDTs

control to ensure regulatory and legal compliance. This includes establishing a governance board composed of associations of MNOs and national regulatory authorities, responsible for identifying and managing NDT-DS stakeholders.

III. HARMONIZATION AND EVOLUTION CHALLENGES

Semantic harmonization [3] is a critical challenge within the context NDT-DS, particularly when network infrastructure providers relying on different standards. Even when stakeholders adopt a common standard, discrepancies in semantics can still arise. For data consumers, such as third-party applications, it is essential to accurately interpret the meaning of the data being provided. To reflect real-world complexity, the NDT federation will need to support data exchange with digital twins from other domains, as detailed earlier. Building on our previous work [4], which demonstrated a first implementation of such models extracted from 3GPP standards, we are building a common semantic data model smart-data model in FIWARE ecosystem [5] as an open standard, tailored to 6G networks and their interconnected domains. In addition, we plan to explore semantic alignment techniques (e.g., [6]) to address heterogeneity and support interoperability across domains.

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