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6G-EDGEDT-04-E6

Reference Model of the DT gNB

Abstract

This document presents a model to serve as a reference for future development of DT gNBs, describing necessities and challenges, and presents an architecture of functional blocks, detailing their interactions and interfaces. The model is designed to be aligned with the standard of a Network DT proposed by IETF. To finalize, deployment options over the are reviewed.

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List of Acronyms

3GPP: 3rd Generation Partnership Project

AF: Application Function

AI: Artificial Intelligence

API: Application Programming Interface

APP: Application

B5G: Beyond 5G

DT: Digital Twin

ETSI: European Telecommunications Standards Institute

FL: Federated Learning

gNB: next generation Node B

IETF: Internet Engineering Task Force

IoT: Internet of Things

KPI: Key Performance Indicator

LTE: Long Term Evolution

MEC: Multi-access Edge Computing

ML: Machine Learning

NEF: Network Exposure Function

NF: Network Function

NWDAF: Network Data Analytics Function

OAM: Operations, Administration, and Maintenance

RAN: Radio Access Network

UPF: User Plane Function

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Resumen Ejecutivo

Este entregable tiene por objeto definir un modelo de referencia para el DT gNB que se utilice de guía en el desarrollo de futuras instancias del mismo. Este complementa el entregable [3] de Ericsson, dónde presentan el modelo que van a utilizar para desarrollar el DT gNB, generalizándolo y mapeando con el modelo presentado por el IETF sobre el modelo de arquitectura para un Network DT genérico [1].

Este trabajo provee de una descripción detallada del DT gNB, identifica las funciones que necesita para satisfacer correctamente los casos de uso propuestos y presenta los retos que se deben afrontar a la hora de desarrollar este tipo de tecnología.

Por otro lado, el documento define una arquitectura base, con la descripción de cada uno de los bloques funcionales y sus interacciones.

Para terminar, el trabajo incluye un análisis del despliegue del DT gNB sobre el Edge, complementando el anterior entregable [4], en el que se presentan diferentes posibilidades para su despliegue.

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Executive Summary

The purpose of this deliverable is to define a reference model for the DT gNB that will be used as a guide in the development of future instances of it. It complements the Ericsson deliverable [3], where they present the model that they will use to develop the gNB DT, generalizing and mapping it with the model presented by the IETF on the architecture model for a generic Network DT [1].

This work provides a detailed description of the DT gNB, identifies the functions it needs to correctly satisfy the proposed use cases, and presents the challenges that must be faced when developing this type of technology.

On the other hand, the document defines a base architecture, with the description of each of the functional blocks and their interactions.

Finally, the work includes an analysis of the deployment of the DT gNB on the Edge, complementing the previous deliverable [4], in which different possibilities for its deployment are presented.

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1. Introduction

A reference model lays out the groundwork, rules, and steps necessary for achieving or constructing something. For instance, the draft [1] from Internet Engineering Task Force (IETF) where it is presented the Network Digital Twin (DT) concept, exemplifies this paradigm.

Our prior discussions have delved into the essence and significance of Digital Twins (DT) and its importance in future Beyond 5G (B6G) and 6G networks [3,4]. Specifically, Ericsson's work [3] took a deep dive into establishing a logical architecture for a DT of the Next Generation Node B (gNB), thoroughly exploring its potential use cases and essential requirements.

This document endeavours to establish a comprehensive reference model tailored specifically for constructing a DT gNB. Our aim is to encompass and integrate the insights from [3] while aligning with the recommendations proposed by the IETF in [1]. This unified approach seeks to streamline and optimize the development of DT gNBs, consolidating prior research findings into a cohesive and actionable framework. Within this analysis, specific required functions that must fulfil the DT gNB are identified and mapped to the list of use cases presented in [3], and the challenges that needs to be addressed when implementing it are exposed.

To finalize with the study, the document complements the deployment options presented in [4] with the presentation of standardized entities and procedures to deploy the DT gNB at the edge.

2. Definition

The purpose of a DT gNB is to analyse, diagnose, reproduce the behaviour, and control the physical gNB using data, models, and interfaces. A dynamic, real-time mapping between the tangible entity and its virtual counterpart is essential to achieve this objective.

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```
+-------------+               +--------------+
|             |               |              |
|  Mapping    |               |  Interface   |
|             |               |              |
+-------------+---------------+--------------+
        |                          |
        |    Analyze, Diagnose     |
        |                          |
        | +----------------------+ |
        | | Digital Twin Network | |
        | +----------------------+ |
+------------+                +------------+
|            |  Emulate, Control  |            |
|   Models   |                    |    Data    |
|            |--------------------|            |
+------------+                +------------+
```

FIGURE 1: FUNDAMENTAL COMPONENTS OF A DT [1].

Drawing from DT characteristics in diverse sectors and networking specifics, four fundamental components—data, mapping, models, and interfaces—are fundamental to any DT related with networks, as depicted in Figure 1 from [1].

- **Data**: The DT gNB must uphold historical and real-time data (such as configuration, operational state, trace, metric, and process data) regarding its real-world counterpart. This data serves as the singular "truth," stored in a repository to support model development with timely and accurate data services.
- **Models**: Techniques involve collecting data from various sources within the real network and crafting comprehensive representations (e.g., systems, entities, processes) through specific models. These models serve as the basis for emulation and diagnosis, generating data used for decision-making about how the live network operates.
- **Interfaces**: Standardized interfaces ensure interoperability within the DT gNB. Two key types of interfaces include those between the DT platform and the actual network infrastructure, and between the platform and applications. These interfaces facilitate real-time data collection and control over the network, as well as application requests and utilization of platform capabilities.
- **Mapping**: Employed to identify the DT and its underlying entities, establishing a real-time interactive connection between the real gNB and its twin, or among multiple twin entities. This mapping can be one-to-one (pairing, vertical) for continuous synchronization or one-to-many (coupling, horizontal) for occasional data exchange. Such mappings provide visibility into the network's actual status, enabling analysis and optimization of the real network's performance and maintenance.

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Constructed on these four core technology elements, the DT gNB can analyse, diagnose, emulate, and control the entire lifecycle of the real network. Optimization algorithms, management methods, and expert knowledge aid in controlling the DT gNB environment and its elements. This control aims to derive desired system behaviour, providing the requirements listed in [3].

Notice that real-time interaction isn't universally necessary for all DT use cases. In scenarios like testing configurations or innovative techniques, DTs can function as simulation platform without real-time telemetry data. However, interactive mapping capability remains valuable for validating changes and testing them in the real network when needed. For most other cases like network optimization and fault recovery, real-time interaction between the virtual and real entity is crucial. This capability helps achieve the goal of an autonomous or self-driven network through the DT gNB.

2.1. Required functionalities

Previous discussion generalizes over the required functionalities that the DT gNB needs to satisfy, and now is time to deepen in them.

To this end, within this section, all use cases presented in [3] are revised, one by one, and analysed to determine the required functions that the DT gNB must accomplish.

Use Case 1: Configuration Proposal for Physical Twin

This use case aims to verify if the Physical Twin meets service performance requirements by utilizing the synchronized Digital Twin. The functions that the DT gNB must satisfy to achieve this use case are:

- Synchronization: the digital copy must mimic the current status/configuration of its physical counterpart.
- Replication: the DT must replicate the behaviour of the physical gNB if some changes (to the configuration or the environment) are applied.

Use Case 2: Configuration Implementation in Physical Twin

The DT gNB apply one given configuration to the Physical Twin, confirming successful application or reporting any implementation errors. The required functions are:

- Implementation: the DT gNB must be able to configure its physical twin.

Use Case 3: Performance Comparison (Physical vs. Digital Twin)

Users can compare the performance of the Physical Twin with the Digital Twin in either offline or online mode during a specific window time. By choosing the mode (offline/online) and duration, users receive a comparison of various performance metrics, showcasing the alignment between both twins. The functions, in this case, are:

- Synchronization: the digital copy must mimic the current status/configuration of its physical counterpart.

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- Replication: the DT must replicate the behaviour of the physical gNB if some changes (to the configuration or the environment) are applied.
- Monitorization: the DT gNB must receive the performance metrics that the real gNB is producing.
- Storage: the produced performance metrics must be stored and accessible by the DT.

Use Case 4: Physical Twin Health Check

This use case facilitates obtaining the current status of the Physical Twin by conducting a health check through the Digital Twin. Upon user request, the Digital Twin provides a status report, highlighting any issues, their potential causes, and recommended solutions. Needed functions are the following:

- Synchronization: the digital copy must mimic the current status/configuration of its physical counterpart.
- Monitorization: the DT gNB must receive the performance metrics that the real gNB is producing.

Use Case 5: Prevention of Physical Twin Degradation

Users can anticipate potential performance degradation in the Physical Twin at an upcoming time by leveraging the Digital Twin. By selecting a future time for supervision, the Digital Twin forecasts issues and offers preventive actions based on the system's status. In this use case, the required functions are:

- Synchronization: the digital copy must mimic the current status/configuration of its physical counterpart.
- Replication: the DT must replicate the behaviour of the physical gNB if some changes (to the configuration or the environment) are applied.

Use Case 6: Digital Twin Proposal for Edge Location

For a given service, this use case identifies edge environments meeting technical and economic requirements. Inputting specific service demands, the Digital Twin suggests the best-suited User Plane Function (UPF) considering various edge configurations, aiding decision-making for optimal UPF selection. The functions of this use case are:

- Synchronization: the digital copy must mimic the current status/configuration of its physical counterpart.
- Replication: the DT must replicate the behaviour of the physical gNB if some changes (to the configuration or the environment) are applied.
- UPF-awareness: the DT gNB must be aware of the possible UPF options and receive the needed information to fulfil this task.

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Table 1 summarizes the reviewed functions for all these use cases proposed in [3]. Notice that for more specific use cases – as Use Case 6 – the DT gNB needs to satisfy concrete functions.

TABLE 1: DT gNB FUNCTIONS PER USE CASE.

	Synchronization	Replication	Implementation	Monitorization	Storage	UPF-awareness
Use Case 1	✓	✓				
Use Case 2			✓			
Use Case 3	✓	✓		✓	✓	
Use Case 4	✓			✓		
Use Case 5	✓	✓				
Use Case 6	✓	✓				✓

2.2. Challenges

As per [5], constructing and sustaining DT present five primary challenges:

- Data acquisition and processing.
- High-fidelity modelling.
- Real-time, two-way communication between virtual and real twins.
- Unified development platform and tools.
- Environmental coupling technologies.

In the networking sphere, Network DTs have distinct traits, as [1] remarks. While data acquisition and virtual-real communication are relatively straightforward due to high digitalization levels, challenges arise from the diversity of network elements and typologies. Additionally, network size, marked by node and link quantities, doesn't pace up adequately to meet service demands, especially for end-

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to-end services spanning multiple administrative domains. In the case of the DT gNB, it has challenges from both worlds, because it replicates just a node of the network, and can be treated as any other twined physical element. These challenges are:

- Interoperability: Technical disparities and vendor-driven technologies hinder establishing a unified DT gNB system within a network domain. Proposing a unified architecture and defining standardized interfaces become imperative to ensure compatibility among them.
- Data modelling difficulties: Modelling large-scale network scenarios produce highly complex behaviours, in particular from the users' side, and demands not just accuracy but also flexibility and scalability. This complicates building efficient and hierarchical functional data models. For simpler scenarios, cloning the real network using virtualized resources might suffice, but for larger scales, mathematical abstraction or Artificial Intelligence (AI) algorithms and Machine Learning (ML) models become more viable solutions.
- Real-time requirements: Network services requiring real-time processing encounter latency when using DT for model simulation and verification. Maintaining sync between twins and the real elements becomes challenging. To manage this, designing simplified processes and defining real-time requirements for different applications are crucial.
- Security risks: Synchronizing data between digital and real entities increases the attack surface, raising information leakage risks. Implementing secure data mechanisms and limiting raw data requirements through innovative technologies such as Blockchain or Federated Learning (FL) becomes necessary.

In addressing these challenges, proposing a unified architecture for DT gNB, defining functional components and interfaces, is essential. Subsequently, ongoing research into enabling technologies like data acquisition, storage, modelling, interface standardization, and security assurance is imperative.

3. Reference model and Architecture

Derived from the definition of key technology elements within the DT gNB as outlined previously, Figure 2 illustrates the architecture of a DT gNB. This architecture consists of three tiers: the Application Layer, Digital Twin Layer, and physical gNB Layer. Notice that the DT gNB architecture is aligned with [1] and encompasses what is described by Ericsson in [3].

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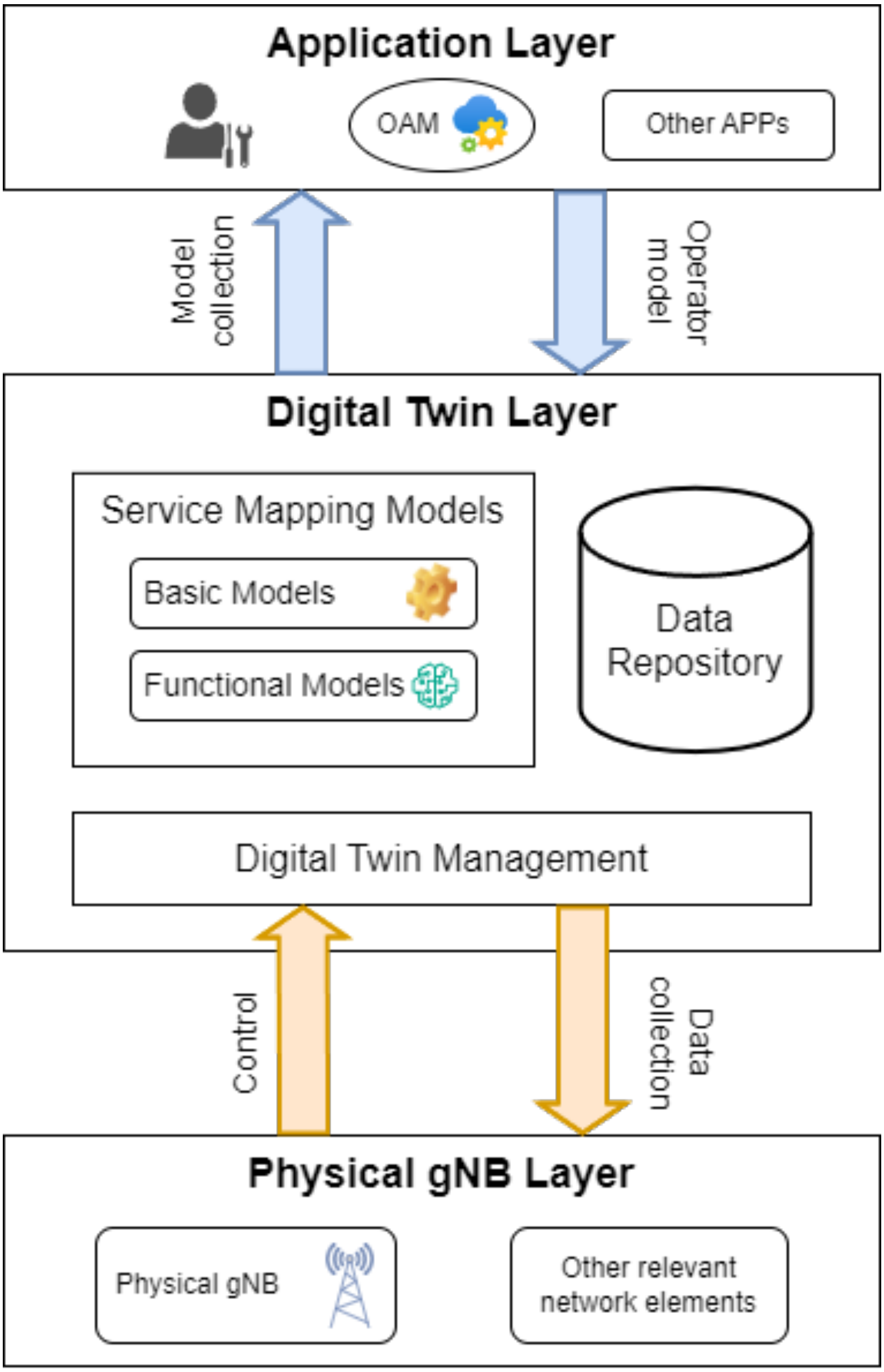

FIGURE 2: REFERENCE ARCHITECTURE OF A DT gNB.

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- Physical gNB Layer: This layer encompasses the real entities that are twinned (remember that the gNB may be split in several elements [2]) and involves the exchange of data and control messages between a DT instance and the network elements within the tangible network. The DT gNB also supports the exchange of information with entities that are not twinned but is not mandatory.

- Digital Twin Layer: It is the core of the DT and comprises the same three critical subsystems than those mentioned in [1]: Data Repository, Service Mapping Models, and Digital Twin Management.
  The Data Repository subsystem is responsible for collecting and storing diverse information to build models. It collects and updates real-time operational data through the twin's southbound interface, providing data services and unified interfaces to the Service Mapping Models subsystem.
  Service Mapping Models engage in data modelling, providing instances for various applications, enhancing service agility and programmability. These models include basic and functional types, characterizing the physical gNB and data used for analysis, emulation, diagnosis, and more.
    - Basic models: englobes the physical elements models based on their configuration and the environment information. We can highlight the <u>gNB configuration model</u>, which characterizes the link between the gNB and the users; and the <u>air model</u>, as it highly influences the performance of radio communications; but these are not the only ones.
    - Functional models: these are data models with a higher level of abstraction that tackles more specific applications and are expanded through multiple dimensions: the architecture of the gNB, the functionality of the model, etc. For example, the <u>user performance model</u>, that represent the user flows using Key Performance Indicators (KPIs), as the rate, latency, jitter, etc; and the <u>traffic models</u>, capturing the stochastic and dynamic behaviour of real-world network traffic.

  New applications requiring new models trigger the Service Mapping Models subsystem to create models based on retrieved data.
  Last, the Digital Twin Management subsystem satisfies the management function of the DT gNB, recording life-cycle transactions, monitoring performance and resource consumption, and controlling various elements of the DT, including security management. By other hand, it is also in charge of accomplishing the required modifications to the physical entities, derived as output from any application of the DT.
- Application Layer: Diverse applications, such as Operations, Administration, and Maintenance (OAM), efficiently operate over the DT gNB platform to execute traditional or innovative operations with minimal service impact on the tangible networks. Also, network operators may employ the DT gNB to accelerate their maintenance and control. These applications request services addressed by the DT, exchanged through a northbound interface, and applied via service emulation at suitable twin instances.

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3.1. Interfaces

Communication across the three layers involves distinct interaction points:

- Southbound interfaces: connecting the Physical Twin and Digital Twin. The Control interface facilitates adjustments to network setups or the transmission of commands to diverse elements. Simultaneously, the Data Collection interface serves to disclose configuration specifics and network metrics to the Data Repository.
- Northbound interfaces: between the Digital Twin and Operator Layers. The Operator Model interface allows users to specify their service requirements within the DT setup. Conversely, the Model Collection interface consolidates DT data, presenting it in the operator layer for user access, facilitating their comprehension.

3.2. Security considerations

Security considerations within the DT gNB encompass safeguarding the integrity of the DT itself and ensuring data privacy protection, as any other Network DT [1].

The objective of securing the DT gNB is to establish operational security by implementing robust security measures and adhering to security best practices. Within the context of the DT gNB, these measures and practices entail data verification, model validation, and authenticated and authorized user-based mapping operations between the tangible and digital entities.

The synchronization of data between the tangible gNB and its DT may elevate the risk of sensitive data and information exposure. Thus, stringent controls and security measures are imperative to prevent any potential data breaches.

4. Possible deployments over the Edge

Once is determined all necessities to successfully develop a DT of the gNB, this document analyses possible deployment options, leveraging the elements, interfaces and interactions defined in the standards. Authors in [4] highlight some potential possibilities to deploy the DT gNB as a Network Data Analytics Function (NWDAF) – or more than one instance of it – inside the 5G core, or directly connected to the OAM. Hence, the document focuses on the opportunities offered by the Edge Computing.

Edge Computing is a paradigm based on moving the applications closer to the end user, by deploying servers at the edge of the network. Applications within this edge servers can offer some services and capabilities that are nearly impossible to achieve by its homologous, i.e. the cloud. For example, being that close to the end user allows to extremely reduce the latency in communications, and even being deterministic under the right circumstances. However, not all are advantages, as the cloud is likely to have more powerful, efficient and cheaper computational resources.

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3GPP defines in [6] the architecture, procedures and flows necessaries for enabling Edge Computing to end user applications. In the same line, [7] presents the enhancements by the 5G architecture to support Edge Computing. To satisfy all requirements from the DT gNB, additional interfaces are needed to receive the mandatory metrics and information that the DT consumes [4]. In a scenario where the DT gNB belongs to a 3rd domain, it will access the core through the Network Exposure Function (NEF), as any other untrusted Application Function (AF).

The Multi-access Edge Computing (MEC) initiative, an Industry Specification Group within the European Telecommunications Standards Institute (ETSI), strives to create a standardized, open environment enabling seamless integration of applications across diverse MEC platforms. It's a collaborative endeavour benefiting mobile operators, developers, and various vendors, uniting telecommunication and IT-cloud capabilities within the Radio Access Network (RAN). MEC enables applications to sit 'on top' of mobile network elements, leveraging proximity to end-users and local radio-network data. The ISG's comprehensive work spans normative specifications, reports, and white papers.

The integration of MEC into 5G networks is a significant leap from its deployment in Long Term Evolution (LTE) networks [9]. In LTE, MEC was added as an enhancement to deliver edge services, requiring a self-contained system design specific to 4G. However, 5G marks a different starting point. Edge computing is identified as a pivotal technology supporting low latency, mission-critical, and future IoT services, fundamentally shaping the initial design to efficiently support Edge Computing. The 5G system architecture by 3GPP caters to various use cases, demanding significant architectural changes in both the RAN and the core network. [10] focuses on aligning the service-based architecture option for 5G, where network functions interact through services, with the principles outlined by ETSI MEC. This framework facilitates service exposure, authentication, authorization, and efficient service consumption. From the viewpoint of the 5G core, MEC has the role of an AF, so their interactions are defined within that framework through the Naf interface, using the NEF in the necessary cases. The deployment, depicted in Figure 3, assumes MEC deployment on the N6 reference point in the 5G data network, enabled by flexible UPF location.

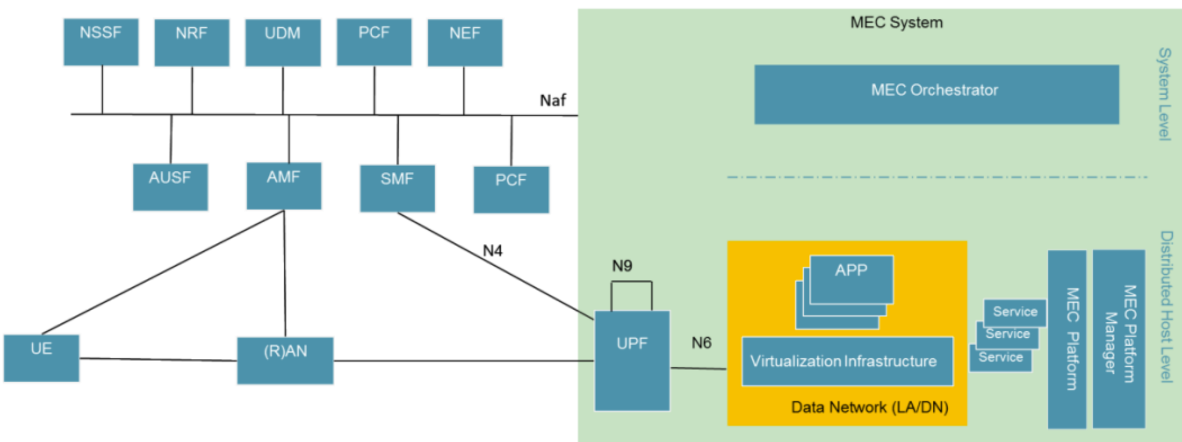

FIGURE 3: MEC INTEGRATION WITHIN 5G NETWORK FROM [10].

The MEC orchestrator and platform interact with 5G network functions, enabling the possibility of extracting all data required to deploy the DT gNB, and provide the actions and operations that its services require.

5. Summary and Conclusions

The document serves as a blueprint for creating DT gNBs, outlining their significance in upcoming network generations like Beyond 5G (B6G) and 6G. It builds upon prior work, notably Ericsson's exploration of DT gNBs [3], to define a comprehensive model for constructing them, adhering to IETF recommendations [1].

The document elaborates on key functionalities that must fulfil any implementation of a DT gNB, reviewing different use cases presented in the literature; and challenges faced in constructing and maintaining DTs, focusing on interoperability, data modelling difficulties, real-time requirements, and security risks. Proposing a unified architecture and advancing enabling technologies like data acquisition, storage, modelling, and security assurance are crucial in overcoming these challenges.

The reference model presents a three-layered architecture: Physical gNB Layer, Digital Twin Layer, and Application Layer. Each layer serves distinct purposes, such as managing physical entities, housing crucial DT subsystems like Data Repository and Service Mapping Models and facilitating various applications in the DT gNB platform.

Detailed exploration of interfaces—Southbound and Northbound—reveals their role in connecting the Physical and Digital Twin, as well as linking the Digital Twin and Operator Layers, respectively. Security considerations emphasize the need to safeguard the DT's integrity and ensure data privacy protection, highlighting the importance of robust security measures and controls during data synchronization.

The document ends exploring the deployment of DT gNB using Edge Computing advantages. The MEC initiative by ETSI unifies telecom and IT-cloud capabilities within the RAN, offering a standardized environment for seamless application integration across various MEC platforms. The integration of MEC into the 5G network facilitates the interactions between MEC platform and 5G NFs, accomplishing the DT gNB deployment and operational functionalities.

In summary, the document contributes a comprehensive model for constructing DT gNBs, acknowledging the functionalities, challenges, architectural layers, essential interfaces, and critical security aspects essential for robust and efficient DT deployments.

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6. References

[1] Zhou, C., Yang, H., Duan, X., Lopez, D., Pastor, A., Wu, Q., ... & Jacquenet, C. (2021). Digital twin network: Concepts and reference architecture. Internet Engineering Task Force: Fremont, CA, USA.

[2] 3GPP, NG-RAN; Architecture Description, Radio Access Network working group, Technical Specification (TS) 38.401, Release 17, 2022-09-23.

[3] "6G-EDGEDT-04-E8 Informe de análisis sobre necesidades y requisitos para la realización del B5G gNB DT".

[4] "6G-EDGEDT-04-E5 Abstractions for the DT gNB".

[5] Hu, W., Zhang, T., Deng, X., Liu, Z., and J. Tan, "Digital twin: a state-of-the-art review of its enabling technologies, applications and challenges. Journal of Intelligent Manufacturing and Special Equipment, Vol. 2 No. 1, pp. 1-34", 2021.

[6] 3GPP, Architecture for enabling Edge Applications, Service and System Aspects working group, Technical Specification (TS) 23.588, Release 18.

[7] 3GPP, 5G System Enhancements for Edge Computing; Stage 2, Service and System Aspects working group, Technical Specification (TS) 23.548, Release 18.

[8] European Telecommunications Standards Institute, https://www.etsi.org/technologies/multi-access-edge-computing

[9] European Telecommunications Standards Institute, MEC Deployments in 4G and Evolution Towards 5G, White Paper 24, 2018.

[10] European Telecommunications Standards Institute, MEC in 5G networks, White Paper 28, 2018.

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