The 3GPP progress of Network Digital Twins

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Content

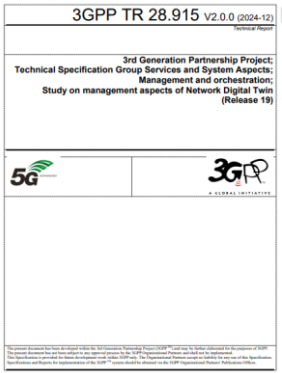
- 3GPP NDT introduction
- R19(5GA) working progress
- R20(5GA/6G) work planning

3GPP NDT Standardization

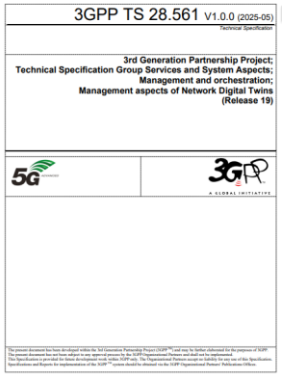
3GPP SA5 has initiated the study on R19 (5GA) “Network Digital Twin Management” in December 2023, which has been completed by December 2024, followed by the start of R19 normative work.

For R19 (5GA), TS 28.561 specified the requirements of network-level scenarios, reaching a consensus on terminology, concepts and key technologies to support the launch of new network services and the optimization of operation and maintenance management.

For R20 (5GA/6G), SA5 continues to promote the study on NDT to optimize the network management system.



Study on management aspects of Network Digital Twin (R19) (2023.12-2024.12)



Management aspects of Network Digital Twins (R19) (2024.12-2025.09)

R19 NDT Concept

NDT Definition

Network Digital Twin (NDT): virtual replica of mobile network or part of one, that captures its attributes, behaviour and interactions.
NOTE 1: Mobile network includes both RAN and Core.
NOTE 2: NDTs can interact with other NDTs during simulation or emulation activities, and dynamically adapt their internal behavior based on such interactions.

NDT Concept

- Network Digital Twin (NDT) is used as a replica of a mobile network, in order to learn how an actual mobile network would behave in certain scenarios, without causing any changes to the actual mobile network.
- To provide meaningful results, NDT needs to model the behaviour of the mobile network, so that the result of the operations on the virtual replica are good approximations to similar operations on the actual network.
- The implementation of an NDT can rely on simulation, emulation, AI-based modelling, or any other technique that enables the NDT to mimic the behaviour of the network.

R19 NDT Use Cases

1. Usage of control and Life-cycle management of NDTs

- ✓ Life cycle management of NDT instances
- ✓ Control of NDT instances
- ✓ Synchronization with network

2. NDT support for network automation

- ✓ General capabilities on NDT support for network automation
- ✓ Support for evaluation of high-risk network operations
- ✓ Support for evaluation of failure events including signalling storm
- ✓ Network issue inducement

3. NDT support for verification

- ✓ General verification
- ✓ Verification of network response to events
- ✓ Verification of network configurations
- ✓ Verification of automation-function configurations

4. NDT support for data generation

- ✓ General use case on NDT support for data generation
- ✓ Using NDT to generate ML training data
- ✓ Using NDT to generate user experience data

5. Advanced NDT capabilities

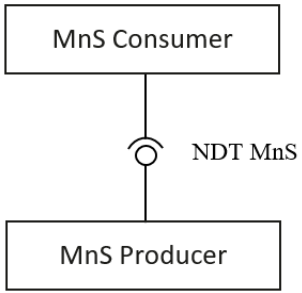
- ✓ Collaboration between NDTs

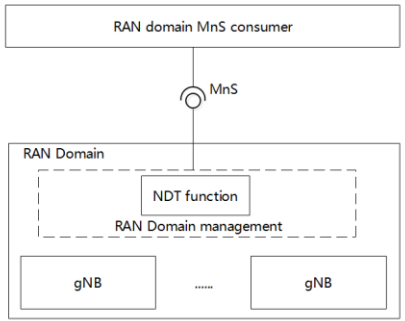
Ref TS 28.561

R19 NDT Management Service

NDT Management Service

The NDT MnS can be requested by the NDT MnS consumer to model the behaviour of the network and generate the simulation/emulation output. The simulation/emulation capabilities provided by NDT MnS Producer can be invoked by the network intelligence and automation management functions (e.g. MDAF, AIML Inference Function, Intent Handling Function, etc.) playing the role of NDT MnS Consumer to support their intelligence and automation functionality.

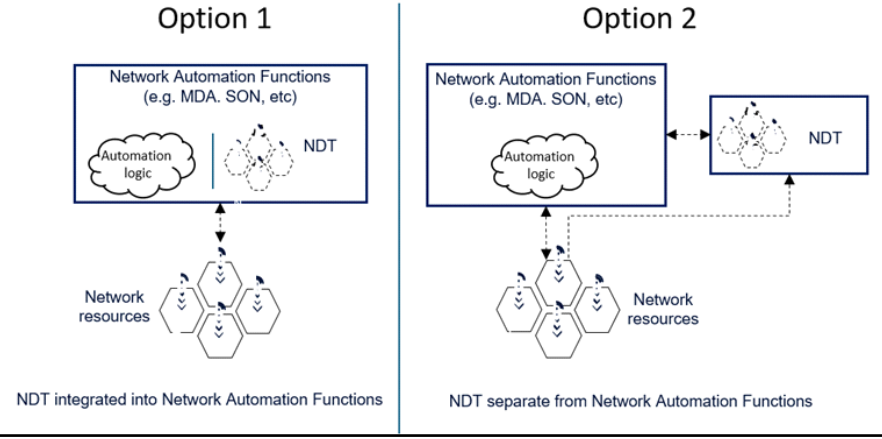




Example: NDT function in RAN domain management

NDT relations

The Network Digital Twin adds the ability to model the behaviour of a mobile network. It can provide modelling capabilities that are used by the network automation functions (e.g. MDA, SON, etc.) to accomplish their automation functionality. When the network digital twin provides modelling capabilities for the network, it can be integrated inside or outside of existing network automation functions.



R19 NDT Life-cycle Management

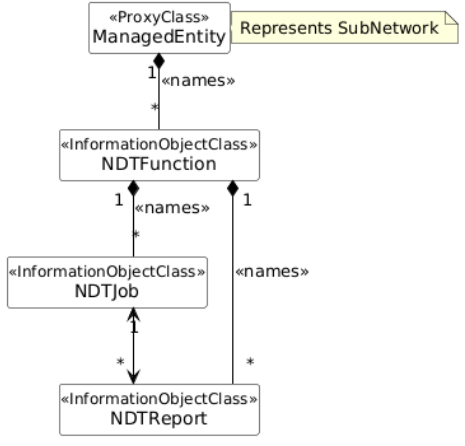
An NDT is an analytical function that can provide simulation/emulation capabilities to be used by the network automation functions to obtain information useful in operation decision-making. An NDT may have multiple simulation/emulation jobs (here called NDT jobs) each considering a different network scenario and use case. **The NDT is an object that can be managed, the LCM includes two aspects: the LCM of the NDT function instance and the LCM of the NDT job instances.** Accordingly, the following capabilities are included:

- **NDT Creation:** The MnS producer who provides the NDT simulation/emulation capabilities creates an NDT function instance that is capable to model a specific scenario.
- **NDT job instantiation**: NDT MnS producer receives the request to create a task instance or job. The NDT MnS producer instantiates and executes the simulation/emulation. The NDT job instance can be configured by the MnS consumer at any time.
- **NDT job suspension:** NDT MnS producer receives the request to pause or suspend a session task instance or job.
- **NDT job deletion:** NDT MnS producer receives the request to delete a simulation/emulation task instance/job. The NDT MnS producer stops the execution of the simulation/emulation and deletes the NDT job instance.
- **NDT Deletion:** the MnS producer may delete an NDT Function instance that is not active.

R19 NDT MnS provisioning

NDT provisioning framework

The generic NDT provisioning MnS, including NDT function management, NDT job management and NDT report management. The NDTFunction, NDTJob, NDTReport instances can be treated as Managed Object instances.



Relationship UML diagram for NDT management

NDTFunction

- An NDTFunction may have multiple simulation/emulation NDTJob instances each considering a different network scenario and use case.
- The NDTFunction includes a reference to one or more NDTFunction instances which act as component NDTs contributing to the functionality of the NDTFunction.

Attribute Name
supportedNDTCapabilities
nDTFunctionScope
Attribute related roles
ndtRef

NDTJob

- The NDTJob instance is an object that can be managed by the 3GPP management system.
- The NDTJob instance represent different network scenario and use cases.

Attribute Name
NDTCapability
nDTJobSynchScope
ndtJobScenario
ndtJobExecustionRequirements
collaboratingNDT
Attribute related roles
ndtReportRefList

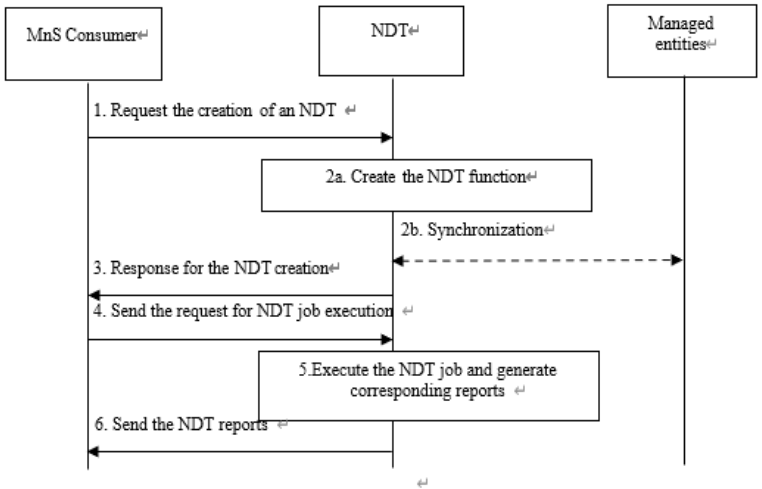
NDTReport

- This IOC represents the properties of an NDT report corresponding to an NDT job.
- An NDT job may run more than one task at the same time, e.g., a network configuration task and a network response task. The NDTReport contains an output for each task that is executed by the NDT job.

Attribute Name
NDTJobOutputData
Attribute related roles
ndtJobRef
ndtFunctionRef

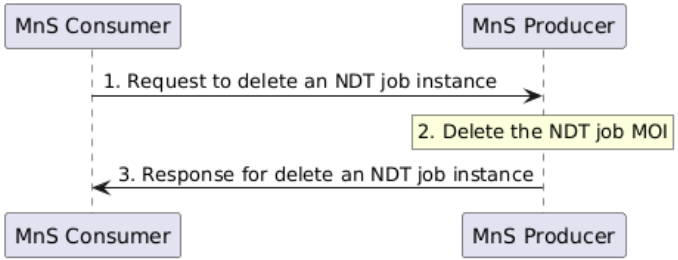
R19 Procedure for consuming NDT service

Generic procedure

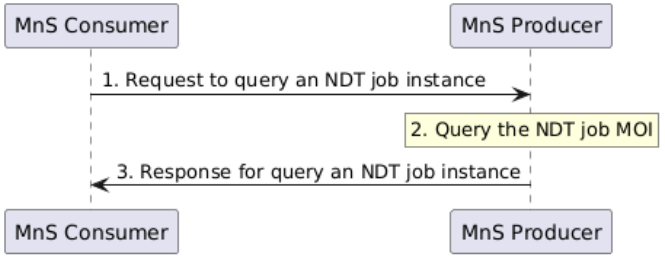


The NDT MnS can be requested by the NDT MnS consumer to model the behaviour of the network and generate the output. The simulation/emulation capabilities provided by NDT MnS Producer can be invoked by the network intelligence and automation management playing the role of NDT MnS Consumer to support their intelligence and automation functionality.

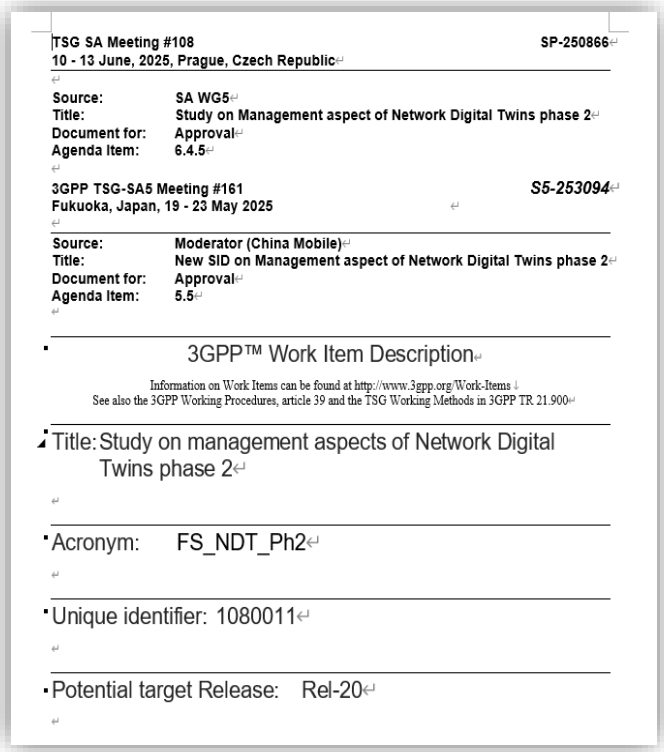
Procedure for delete an NDT job



Procedure for query an NDT job



R20(5GA) SID on NDT Phase 2



TSG SA Meeting #108 SP-250866
10 - 13 June, 2025, Prague, Czech Republic

Source: SA WG5
Title: Study on Management aspect of Network Digital Twins phase 2
Document for: Approval
Agenda Item: 6.4.5

3GPP TSG-SA5 Meeting #161 *S5-253094*
Fukuoka, Japan, 19 - 23 May 2025

Source: Moderator (China Mobile)
Title: New SID on Management aspect of Network Digital Twins phase 2
Document for: Approval
Agenda Item: 5.5

3GPP™ Work Item Description

Information on Work Items can be found at http://www.3gpp.org/Work-Items
See also the 3GPP Working Procedures, article 39 and the TSG Working Methods in 3GPP TR 21.900

Title: Study on management aspects of Network Digital Twins phase 2

Acronym: FS_NDT_Ph2

Unique identifier: 1080011

Potential target Release: Rel-20

Objective

WT-1: Investigate the detailed interaction and collaboration between NDT and network functions/automation functions.

WT-2: Investigate new use cases that require multiple NDT collaborations (e.g., interactions within and between management domains).

WT-3: Investigate use cases and requirements for potential additional data collection requirements to support NDTs.

Note: the solution for data collection is out of scope of this study.

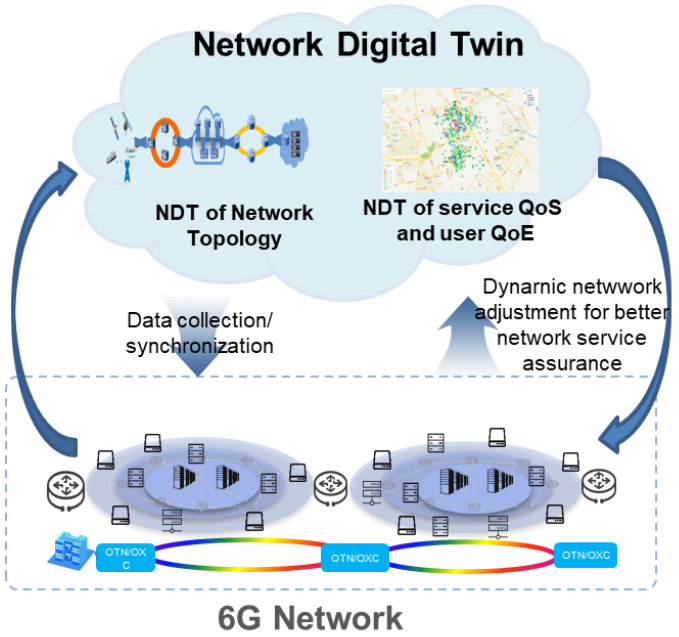
WT-4: Investigate new use cases and requirements that require enhancement of NDT in 3GPP management system.

Prospect on R20(6G) Network Digital Twin

Summarized from SA5 6G Workshop

6G NDT is expected to enhance its capabilities in the following dimensions:

- Study on **NDT autonomy capabilities** to enable network optimization and user experiences.
- Study **NDT enhancements** to support new 6G use cases, e.g., modeling security threads.
- Study **Multi-Domain & Cross-Domain Simulations**: Supports complex interactions across different domains, allowing for accurate planning.
- Study the service pre-evaluation based on **dynamic environment modeling** with new data.
- Study on **finer-grained modelling** from the network level to the user level, allowing for more precise analysis and optimization.
- Study on **how to support specific network services** (e.g., AIoT, UAV, Satellite), including exposure mechanisms of digital twin services (APIs, data) and the collaboration of digital twins for various verticals.
- … …



	Company	6G Potential work tasks from SA5 6G Workshop		Company	6G Potential work tasks
1	CMCC	1. Study on NDT autonomy capabilities, including self-discovery (analysis), selfresolution (self-healing), self-configuration (generation), and self-close loop (validation) to enable network optimization and user experiences. 2. Expand NDT scenarios to support specific network services(e.g., AIoT, UAV, Satellite)	**7**	China Unicom	Low-altitude service assurance
2	FiberCop	1. Management & Automation: Enhances real-time monitoring and automated operational processes, reducing human error and improving responsiveness. 2. Multi-Domain & Cross-Domain Simulations: Supports complex interactions across different domains, allowing for accurate planning and proactive issue resolution. 3. CAPEX Optimization & OPEX Reduction: Enables strategic investment planning and effective resource management, optimising capital expenditures and operational costs	**8**	ZTE	1. Self-organizing and self-optimizing NDT: 1) GranularDigital Replication; 2) Automatically update of NDTcomponents according to requirements; 3) Cross-domain NDTCollaboration, including RAN,TN, and CN. 2. Intelligent Evolution of NDT: 1) Enhanced Perception of NDT; 2) Advanced Analysisin NDT.
3	NTT DOCOMO	Study new use cases of NDT: 1) Use case about NDT for modeling security threads 2) Use case about NDT for NTN	**9**	Verizon	Digital-twin assisted netw. mgmt. (UC considerations for realistic deployment needs)
4	Huawei	1. Act as a predictive sandbox for agents to test, learn, and optimize decisions 2. Enable the pre-evaluation for services/user group based on dynamic environment modeling with new data, such as sensing, external data (e.g. weather, electronic map, camera), etc. 3. Support data service exposure to 3rd party, e.g., data generation supporting embodied agent training	**10**	Orange	Network digital twin(with semantic based knowledge management)
5	Lenovo	An enhanced framework that enables MnS consumers to dynamically manage and automate sensor data traffic characteristics—including frequency, priority, and latency	**11**	Rakuten	NDT and data-as-service
6	AsiaInfo	NDT data management, Integration of NDT and AI, new usecases of NDT for network	**12**	CATT	Real-time Digital Twins

Thank You !