**3GPP TSG-SA5 Meeting #156S5-243547**

**19 - 23 August 2024, Maastricht, Netherlands**

**Source: Nokia**

**Title: pCR TR 28.915 Conclusions on automation use cases**

**Document for: Approval**

**Agenda Item: 6.19.5**

# 1 Decision/action requested

***The group is asked to discuss and agree on the proposal.***

# 2 References

[1] 3GPP TR 28.915: " Study on management aspects of Network Digital Twin"

[2] 3GPP TS 28.104: " Management and orchestration; Management Data Analytics (MDA)"

# 3 Rationale

The large quantity of ML training data set improves the probability to get a ML model with better performance (e.g., higher accuracy, etc.). General the ML training data is obtained through historical network management data. For instance, assuming that there is a ML model supporting MDA SLS analysis described in TS 28.104 [2] clause 7.2.2, the raw feature of training data could be the enabling data, such as UL/DL throughput, uplink/downlink delay, etc., as specified in clause 8.4.2 of [2]. The label of training data could be information elements specified analytics output, such as issue type, affected objects, etc.

The training data mentioned above is collected from historical network management data, which means only when an issue happened in actual mobile network, the training data set can be accumulated with a new record. The preparation of ML model training data in this way has two drawbacks:

- The quantity of issues happened in actual mobile network is limited.

- The variety of issues happened in actual mobile network is limited. There could be corner network issues cases that hardly happen in real life.

Therefore, NDT can simulate network issues (as training data label) and collect performance measurements (as training data raw feature) to enrich the ML training data set.

# 4 Detailed proposal

This document proposes the following changes in TR 28.915.

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| **1st Change** |

# 5 Use cases

## 5.1 Use case 1: Network management policy verification using NDT

### 5.1.1 Description

A typical example for policy verification is RAN energy saving policy verification as introduced below.

When configuring the energy saving for RAN, normally the policy is applied in execution with monitoring and optimization loop to minimize the influence on network service quality. That’s to say, there could be multiple ES policies executed iteratively in actual mobile network until the network performance, e.g., energy efficiency of NG-RAN, UE throughput in gNB, etc., meets certain requirements from operators.

This may bring two problems from network management perspective:

- Redundant ES policies configurations due to conservative adjustment on ES policy for each iteration.

- Risk of unexpected deterioration in actual mobile network performance.

The digital twin technology may be used to evaluate the impact of RAN ES policy while satisfying simulation performance requirements (e.g., precision, maximum run time, etc).

The consumer could request the NDT to verify the impact of behaviour (e.g., the configuration of RAN energy saving policies) and receive the report of simulated impact generated by NDT.

### 5.1.2 Potential requirements

**REQ-NDT-FUN-01** The NDT shall have the capability to estimate the impact of network management policies.

**REQ-NDT-FUN-02** The NDT shall have the capability allowing the consumer to configure the network management policies.

**REQ-NDT-FUN-03** The NDT shall have the capability to report the simulated impact of network management policies.

### 5.1.3 Potential solutions

### 5.1.3.1 solution1



Figure 5.1.3-1: procedure of network management policy verification

1. MnS consumer requests MnS producer (the entity who provides the NDT for network simulation) to create/active an NDT with simulation requirements. Simulation requirements are used to specify the scope and time of the simulated network in NDT.
* Simulation scope: the area of actual mobile network or the managed object that needs to be simulated in NDT. For instance, a geography area, a network slice, etc.
* Simulation time: the timestamp indicates if the simulation is for the past, present, or future.
* Simulation data: the data that collected for NDT simulation, e.g., PM data as defined in TS 28.552/28.554, CM data as defined in TS 28.541/28.622, etc.
1. Based on the simulation requirements given in step 1, NDT collects the data from the managed entities within the specified simulation scope, time and data. If the Simulation time indicates the timestamp in the past, NDT collects the historical network data. If the Simulation time indicates the timestamp in the present, NDT collects the data from live network. If the Simulation time indicates the timestamp in the future, NDT collects the data based on prediction. In this step NDT is also fed with the performance data and/or KPI which can help to induce a particular network state to be simulated
2. MnS producer receives the simulation requirements for NDT and create/activate the NDT capability. MnS producer notifies MnS consumer that the NDT capability is ready.
3. MnS consumer makes analysis and generates network management policy. For instance, MnS consumer collects and analyses energy saving related performance measurements and notices that the energy consumption is too high. MnS consumer decides to lower the energy consumption and generates RAN energy saving policies. A simple example of RAN energy saving policy could be the configuration on certain NR capacity booster cells which specifies to enter the energySaving state or not.
4. MnS consumer requests NDT to verify the policy in the simulated network which synchronizes with actual mobile network. The request parameters may include:
* Policy: the relevant policy for a certain use case. For example, the policy for RAN ES policies verification use case could be the ES policy as described in TS 28.310.
* Impact detectors: specified performance metrics and/or alarm types that needs to be collected and reported by NDT after the behaviour happens in NDT.
* Performance requirements: the expected network simulation performance of NDT. For instance, the time spent for the network simulation, the expected proximity between the network simulation results and the actual network execution outcome.
1. NDT executes network management policy according to the performance requirements and collects its impact on the simulated network. The impact could be performance measurement or alarm reporting from simulated network.
2. MnS producer reports the simulated impact and result to MnS consumer. The report content may include the impact which is a key-value list where the keys contain the impact detectors specified in step5. Alarms are reported if any raised. Possibly an indicator, which shows whether the performance of the network simulation satisfies the performance requirements or not, is also reported.

Editor’s note: whether NDT can optionally reside outside of MnS producer is FFS.

### 5.1.3.2 solution 2

Introduce an IOC for an NDT, which may be called NDT. This may be name contained in a subnetwork or managed function to respectively represent a standalone NDT and an NDT contained in another function, e.g. in a SON function.

- The consumer can configure on to the NDT instance the network scenario to be modelled. The scenario can include the scope to be considered for evaluating ES policies.

* introduce a data type and an attribute on the NDT of the scope to be modelled or simulated by the NDT instance. This may be called nDTSimulationScope.

 The consumer can configure the parameters of the NDT instance, including the configurations indicating the ES policy

* Introduce a data type and an attribute on the NDT to represent a configuration plan. The datatype which may be called nDTConfigurationPlan indicates the parameter values to be applied by the NDT instance..

Note: the specific characteristics of RAN energy saving policy can be added as an attribute of the nDTSimulationScope and nDTConfigurationPlan

The NDT can provide output to the MnS consumer, the output including values on PMs and KPIs of all the objects that have been modelled by the NDT instance. These include the values indicating the impact of the configured ES policies.

* Introduce a data type and an attribute on the NDT to represent the output of the NDT instance. This may be called nDTOutput and will contain attributes similar to those of existining network objects like cells

Note: the specific characteristics of reports for RAN energy saving policy can be added as an attribute of the nDTOutput

### 5.1.4 Evaluation of potential solutions

In solution 1, the capabilities required for the MnS producer responsible for an NDT are the interactions in steps 1, 3, 5 and 7. These are supported by information elements described in solution 2. In principle, solution 1 describes the required interactions while solution 2 provides required information elements. Accordingly, solution 2 provides the NRM extension needed to support Network management policy verification using NDT. The normative work should progress following the outline in solution 2 while adding the information elements needed to fulfil the interactions in solution 1

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## 5.2 Use case 2: Signaling storm analysis

### 5.2.1 Description

Signaling storm refers to the situation where a large number of signaling messages suddenly surge in the mobile communication network, resulting in the network processing capacity overload, thus affecting the network performance and stability. Signaling storm may be caused because of big event happened that too many users request service at the same time, or by network failure, configuration error or malicious attacks. During this period, users will repeatedly try to establish the connection until reconnected, thus generating a large number of signaling messages surge suddenly, causing signaling storm.

To prevent potential signaling storm risks, the operator needs to effectively control the flow of each signaling control node on the network to avoid nodes working improperly caused by signaling storm. For example, as depicted in figure 1, AMF, SMF, and UDM in the 5G NDT might be all potential signaling storm impact points when network signaling storm happens. the signaling storm scenarios need to perform simulation and evaluation using NDT to find the optimal flow control parameters of each signaling impact point to avoid serious damage to the 5G network when it is affected by signaling storm.



By simulating various network scenarios such as network failure or large amount of user subscribes at the same time the network operator can determine whether the current network can defend against if signaling storm happened.

### 5.2.2 Potential requirements

**REQ-SIMULATION\_NDT-01:** NDT should have the capability to simulate the behaviour ofsignaling storm.

**REQ-SIMULATION\_NDT-02:** NDT should have a capability enabling the MnS consumer to configure the network scenario to be modelled for a signaling storm

**REQ-SIMULATION\_NDT-03:** NDT should have the capability to report the results for signaling storm analysis.

**REQ-SIMULATION\_NDT-04:** NDT should have a capability enabling the MnS consumer to configure the parameters of the NDT instance of the objects to be modelled for a signaling storm

### 5.2.3 Potential solutions

### 5.2.3.1 solution 1

This solution addresses the following issues of use case 2. Signaling storm simulation should be made by using NDT. The NDT utilizes network related information on signaling storms from the MnS producer to generate a report of simulation and validation results for defending against signaling storms with the following approach:

Figure 5.2.3: NDT for signaling storm simulation and validation

Editor’s Note: Figure will be provided later.

1. The MnS consumer sends a request to NDT as the MnS provider for signaling storm simulation, including the simulated network objects(e.g., network functions, S-NSSAI, etc) and optional optimization actions(e.g. setting the maximum rate of traffic received at a network node, flow control rules).
2. The NDT as the MnS provider provides a response to MnS consumer indicating the status of the request based on a feasibility check (success or failure).
3. The NDT as the MnS consumer synchronizes the network related information from MnS providers for network simulation and validation. The network related information may include network capability related information, network slicing information regarding the resource aspects and/or other relevant data (e.g., the number of current subscribers,traffic collected in recent and historical periods) for simulation and validation of the behaviour of signaling storm.
4. The NDT executes the network simulation and validation for signaling storm, and generates the report.
5. The NDT as the MnS provider sends the report including the results signaling storm to MnS consumer. The report can include:

- Simulated behavior: Use of network simulation to analyse the behavior and impacts of signaling storms based on current and historical data.

- Validation Results report the evaluation results, such as the effective PM, KPIs and alarms related to the signaling storm.

### 5.2.3.2 solution 2

Introduce an IOC for an NDT, which may be called NDT. This may be name contained in a subnetwork or managed function to respectively represent a standalone NDT and an NDT contained in another function, e.g. in a SON function.

- The consumer can configure on to the NDT instance the network scenario to be modelled. The scenario can include the scope to be considered for evaluating a signaling storm.

* introduce a data type and an attribute on the NDT of the scope to be modelled or simulated by the NDT instance. This may be called nDTSimulationScope.

 The consumer can configure the parameters of the NDT instance, including the configurations indicating a signaling storm.

* Introduce a data type and an attribute on the NDT configuration plan . The datatype which may be called nDTConfigurationPlan indicates the parameter values to be applied by the NDT instance.

Note: the specific characteristics of Signaling storm analysis can be added as an attribute of the nDTSimulationScope and nDTConfigurationPlan

The NDT can provide output to the MnS consumer, the output including values on PMs, KPIs and alarms of all the objects that have been modelled by the NDT instance. These include the values indicating the impact of the signaling storm.

* Introduce a data type and an attribute on the NDT to represent the output of the NDT instance. This may be called nDTOutput and will contain attributes similar to those of existining network objects like cells

Note: the specific characteristics of reports for Signaling storm analysis can be added as an attribute of the nDTOutput

### 5.1.4 Evaluation of potential solutions

In solution 1, the capabilities required for the MnS producer responsible for an NDT are the interactions in steps 1, 2 and 5. These are supported by information elements described in solution 2. In principle, solution 1 describes the required interactions while solution 2 provides required information elements. Accordingly, solution 2 provides the NRM extension needed for the NDT to provide modelling of network behavior that supports analysis including for signalling storms. The normative work should progress following the outline in solution 2, while adding the information elements needed to fulfil the interactions in solution 1

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## 5.3 Use case 3: Emergency preparedness

### 5.3.1 Description

A natural disaster (e.g. earthquake, tsunami) can cause major impacts to the services provided by a mobile network. The disaster may directly impact the network by causing loss of connectivity, and can also cause indirect effects such as a flood of calls to emergency services. It is important for a network operator to be able to estimate how the mobile network will be impacted by a natural disaster, and to optimize the network configuration (e.g. redundancy and routing) to reduce the impact to services.

Network Digital Twin allows the possibility to apply the effects of a natural disaster in a replica network without risk of impacts to the mobile network. This allows the network operator to evaluate how the replica network responds to the natural disaster. If the response is not acceptable, the network operator may repeatedly reconfigure the replica network and replay the natural disaster until the response is acceptable. The network operator may then decide to apply the best-performing configuration to the mobile network.

As an example, the impact evaluation of a natural disaster (e.g. earthquake, tsunami) is explored in more detail as follows:

1. The network operator wishes to check how a proposed network configuration will react to a natural disaster.

2. The network operator synchronizes the replica network with the mobile network to ensure that the replica network is up to date.

3. The network operator applies the proposed network configuration to the replica network.

4. The network operator applies the effects of the natural disaster (e.g. loss of connectivity, flood of calls to emergency services) to the replica network.

5. The replica network simulates the behaviour of the mobile network.

6. The network operator measures the reaction of the replica network, by observing performance measurements and alarms from the replica network.

7. The network operator may optionally decide to apply the reconfigured parameters to the mobile network.

By using the replica network as described above, the network operator may proactively check how a proposed network configuration will react to a natural disaster.

### 5.3.2 Potential requirements

**REQ-NDT-01:** NDT should have a capability enabling the MnS consumer to configure the network scenario to be modelled for evaluating emergency preparedness

**REQ-NDT-03:** NDT should have a capability enabling the MnS consumer to configure the parameters of the NDT instance of the objects to be modelled for evaluating emergency preparedness

**REQ-NDT-02:** NDT should have a capability to provide the results of network simulation for evaluating emergency preparedness.

### 5.3.3 Potential solutions

### 5.3.3.1 solution 1

Introduce an IOC for an NDT, which may be called NDT. This may be name contained in a subnetwork or managed function to respectively represent a standalone NDT and an NDT contained in another function, e.g. in a SON function.

- The consumer can configure on to the NDT instance the network scenario to be modelled. The scenario can include the scope to be considered for evaluating Emergency preparedness.

* introduce a data type and an attribute on the NDT of the scope to be modelled or simulated by the NDT instance. This may be called nDTSimulationScope.

 The consumer can configure the parameters of the NDT instance, including the configurations indicating the actions of a natural disaster.

* Introduce a data type and an attribute on the NDT configuration plan . The datatype which may be called nDTConfigurationPlan indicates the parameter values to be applied by the NDT instance.

Note: the specific characteristics of Emergency preparedness can be added as an attribute of the nDTSimulationScope and nDTConfigurationPlan

The NDT can provide output to the MnS consumer, the output including values on PMs and KPIs of all the objects that have been modelled by the NDT instance. These include the values indicating the impact of the actions of a natural disaster.

* Introduce a data type and an attribute on the NDT to represent the output of the NDT instance. This may be called nDTOutput and will contain attributes similar to those of existining network objects like cells

Note: the specific characteristics of reports for Emergency preparedness can be added as an attribute of the nDTOutput

### 5.3.4 Evaluation of potential solutions

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## 5.4 Use case4: Network failure and risk prediction

### 5.4.1 Description

Each operations for network optimization and maintenance on mobile network may cause potential network failures and risks, especially high-risk operations, such as potentially dangerous configuration modification, policy modification, software version upgrade, and board switching, which may cause network congestion and network breakdown. To avoid any impact on the physical network, we can’t carry out the potential high-risk network operations in the physical network directly without concerning any consequences, and we can’t use the physical network to evaluate possible network optimization strategy and solution directly. Therefore, it is the better way that these network operations and possible network optimization solutions can be simulated and evaluated using network digital twin.

Using NDT, high-risk operations can identify whether these operations may cause potential network failures and risks by performing necessary digital twin related operations, e.g. simulation, verification and evaluation. The NDT can also optimize, verify and evaluate possible network policies and solutions for the further risk avoidance. After simulating and evaluating by the NDT, the results of high-risk operations prediction and evaluation should be notified back to 3GPP network system.

In addition, SLA degradation and failure of single node in mobile network can also be predicted using the NDT. When it is predicted that the network resources in the network domain are not enough to maintain the SLA or hardware resources failure at some time in the future, the NDT should warn 3GPP management system to take actions for network failure and risk avoidance.

Another scenario of network slice risk prediction is described in clause 5.2[1]. Using the NDT to predict risks, the ZSM framework can identify risks of specific service or network slice profile parameters not being met due to changing traffic and network conditions (e.g. a MD not being able to provide the network slice latency it committed for) and the NDT supports the ZSM framework to take actions before these risks materialize and therefore before the committed SLA/SLS are broken.

Therefore, 3GPP network system has needs to use network digital twin to predict and evaluate potential network failures and risks based on operator’s requirements, such as predict possible network failures and risks posed by the high-risk operation. 3GPP management system can also use the NDT to evaluate and verify possible network policies and solutions to minimize the impact of high-risk operations.

### 5.4.2 Potential requirements

**REQ-NDTN\_Failurerisk-1:** The NDT should have the capability allowing the consumer to request evaluation of the risk level for high-risk operations.

**REQ-NDTN\_ Failurerisk-2:** The NDT should have the capability to provide the results of a simulation, including evaluation of risk level for high-risk operations.

**REQ-NDT-01:** NDT should have a capability enabling the MnS consumer to configure the network scenario to be modelled for evaluating a Network failure

**REQ-NDT-02:** NDT should have a capability enabling the MnS consumer to configure the parameters of the NDT instance of the objects to be modelled for evaluating a Network failure

### 5.4.3 Potential solutions

### 5.4.3.1 solution 1

Introduce an IOC for an NDT, which may be called NDT. This may be name contained in a subnetwork or managed function to respectively represent a standalone NDT and an NDT contained in another function, e.g. in a SON function.

- The consumer can configure on to the NDT instance the network scenario to be modelled. The scenario can include the scope to be considered for evaluating Network failures and risks.

* introduce a data type and an attribute on the NDT of the scope to be modelled or simulated by the NDT instance. This may be called nDTSimulationScope.

 The consumer can configure the parameters of the NDT instance, including the configurations indicating the Network failure

* Introduce a data type and an attribute on the NDT configuration plan . The datatype which may be called nDTConfigurationPlan indicates the parameter values to be applied by the NDT instance.

Note: the specific characteristics of Network failure and risk prediction can be added as an attribute of the nDTSimulationScope and nDTConfigurationPlan

The NDT can provide output to the MnS consumer, the output including values on PMs and KPIs of all the objects that have been modelled by the NDT instance. These include the values indicating the impact of the Network failure which included the expected risks.

* Introduce a data type and an attribute on the NDT to represent the output of the NDT instance. This may be called nDTOutput and will contain attributes similar to those of existining network objects like cells

Note: the specific characteristics of reports for Network failure and risk prediction can be added as an attribute of the nDTOutput

### 5.4.4 Evaluation of potential solutions

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## 5.5 Use case 5: NDT support to network automation

### 5.5.1 Description

NDTs may be used to support many automation use cases. An NDT may be integrated into a network automation function, or it may be external to the network automation function. In the case where the NDT is external to the network automation function, it should be possible for the network automation function to define and configure into the NDT the scenario that should be modelled and simulated by the NDT. Then the NDT should implement the defined scenario, simulate it, and subsequently provide an output representing the statues of different network metrics for the simulated scenario.

### 5.5.2 Potential Requirements

REQ-NDT-1: The NDT should support a capability to model the behavior of the network and provide the outcomes of such modelling to consumers.

REQ-NDT-2: The NDT should support a capability enabling an Mns consumer to define the network scenario that should be modelled and simulated.

REQ-NDT-3: The NDT should support a capability to provide an output representing the statues of different network metrics for the simulated scenario.

### 5.5.3 Potential Solutions

* introduce an information object class representing an NDT, say called NetworkDigitalTwin
* introduce a data type representing the network scenario to be modeled and simulated, say called nDTSimulationScope
* introduce a data type representing the output of modelling and simulating a specific network scenario. The datatype may be called nDTSimulationOutput
	+ the NDT may have 1 or more nDTSimulationOutput objects wit
* introduce a data type representing the performance data and/or KPI that are computed by the NDT for the simulated scenario.

### 5.5.4 Evaluation of solutions

The solution described in clause 5.5.3 provides the NRM extension needed for the NDT to provide modelling of network behavior that supports network automation. The solution is a general solution for any kind of automation functionality and should be adopted for general support to network automation. The normative work on NDT support to network automation should progress following the outline in solution in clause in 5.5.3.

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## 5.6 Use case 6: Using NDT to generate ML training data

### 5.6.1 Description

For many use cases, ML training requires large amounts of data to guarantee good performance of the ML models. In general, the ML training data for network related use cases is obtained through historical network management data. For instance, assuming that there is a ML model supporting MDA SLS analysis described in TS 28.104 [2] clause 7.2.2, the raw feature of training data could be the enabling data, such as UL/DL throughput, uplink/downlink delay, etc., as specified in clause 8.4.2 of [2].

However, obtaining data from the network has two limitations:

* The quantity of issues happened in actual mobile network is limited.
* The variety of issues happened in actual mobile network is limited. There could be corner network issues cases that hardly happen in real life.

Sufficient ML training data plays a key role to a useful ML model. The more training data provided, the better performance of ML model. To overcome, these challenges, an NDT can be used as simulated data generation entity that simulates the network and its characteristics including problems to generate configuration and performance measurements data which can be used to enrich the ML training data set.

### 5.6.2 Potential requirements

**REQ-NDT-FUN-01** The NDT MnS producer should have the capability to allow an authorized MnS consumer to request generation of simulated network data to be used for ML training.

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## 5.7 Use case 7: Nested NDTs

### 5.7.1 Description

An NDT may use or rely on other NDTs as layered/nested components. For example, an NDT that simulates load prediction, e.g., for the RAN energy saving purposes may rely on 2 NDTs - “DT-1” that models network traffic but relies on another DT that models user movement “DT-1” and “DT-2” that models the active equipment of the cell. And “DT-2” may also be composed of other DTs as illustrated by Figure 5.A.1-1. The MnS consumer relying on the simulation services of NDT “A” should be enabled get information on the structure of the DT relations and configure the characteristics of DTs.

 

Figure 5.A.1-1- An example of nested NDTs for load prediction

### 5.7.2 Use cases

### 5.7.2.1 Traceability of NDT composition

The DTs that are components of the NDT are composed in a particular way to provide a specific modelling service. Due to the dependency and nested characteristics of NDTs, any errors, malfunctions, or degradation of service may propagate and effect the services of overall NDT. Therefore, it is necessary to have the NDT's capabilities information .

An MnS consumer consuming the services of an NDT may need to configure or modify the composition of the NDT or the mapping and relationship of the DTs with respect to each other. Any modifications in these characteristics would change the context of the NDT resulting in a need for performing validation and feasibility checks. Any modification to the connected nested NDTs should be assessed and a report shall be provided on the validity and conformity with guaranteed services and feasibility of the new composition.

As an example, the MnS consumer may want to know whether the NDT models traffic for a city or for a village, i.e., whether the NDT has capabilities for a city or for a village. An NDT with city capabilities an then be requested to simulate a specific city.

### 5.7.3 Potential requirements

**REQ-NDT-1** The management system should have a capability enabling an authorized NDT MnS consumer to request information about the NDT capabilities.

**REQ-NDT-3** The management system should have a capability enabling an authorized NDT MnS consumer to subscribe to receive information about any modifications in the characteristics of a NDT capability supported by the MnS producer.

**REQ-NDT-4** The management system should have a capability enabling an authorized NDT MnS producer to inform the consumers of the validity and feasibility of the modifications in NDT capabilities.

### 5.7.4 Potential Solutions

introduce on the NDT <IOC>

* an attribute that lists the ids of the NDT capabilities composing the (N)DT. It may be named dTComponentIds. The ids of DTs in this attribute indicate the reliance of the NDT on the included DTs to provide its services.
* an attribute that describes the compositional information required to compose the components in dTComponentIds to provide a meaningful operational NDT service. It may be named nDTContext. An NDT may be associated to more than one NDTContexts indicating multiple potential compositional relations. The may NDTContext may contain:
	+ An identifier of the nDTcontext to be used to differentiate the multiple NDTContexts associated to one NDT.
	+ A map or graph describing the relations among the components, i.e. which component can provide input to which other component.

### 5.7.5 Evaluation of solutions

The potential solution described in clause 5.7.4 is a fully NRM-based approach that extends the existing NRM to realise Traceability of NDT composition in nested NDTs. The solution allows NDT MnS consumer to request information about the NDT capabilities, subscribe to and receive information about any modifications in the characteristics of a NDT capability as well as enabling NDT MnS producer to inform the consumers of the validity and feasibility of the modifications. The solution involves simple extensions to the NRM which are implementable. Therefore, the solution described in clause 5.7.4 is a feasible solution for enabling traceability of NDT composition in nested NDTs.

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## 5.8 Use case8: Visualization of network topology and traffic

### 5.8.1 Description

The visualization of the network is helpful in some management capabilities for the network operators. For example, the visualization of network shows the network topology and information of each contained NFs including the overall performance statistics information (including, the number of simutaneous UEs and PDU sessions), this helps to knowledge the real time status and performance related information of the network. Another example is that based on the visualization of user or signaling traffic, it helps to quickly detect abnormal traffic and root cause of a service failure.

By collecting and the synchronizing real time data from the mobile network, the management system can create a network digital twin. The created network digital twin can provide the capability of network visualization, which not only shows the topology of the network, but also displays the simulation image of the real network which includes both network elements (e.g., 5GC NFs or gNB) information and infrastructure resource information.

The consumer could request the NDT for the supported capability of visualization of network topology and traffic and may further receive the detail information (e.g., the location information) for the consumer to obtain the visualization information of the network.

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### 5.8.2 Potential requirements

**REQ-VISUAL\_NDT-01:** NDT should have a capability to indicate its support visualization of network topology and traffic.

**REQ-VISUAL\_NDT-01:** NDT should have a capability to reportthe visualization information of the network.

### 5.8.3 Potential solutions

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## 5.9 Use case 9: Configuration verification

### 5.9.1 Description

When operating a mobile network, various configuration and software/hardware modifications (are required to achieve or preserve an efficient operational state (e.g., software updates, launching new instances, terminating instances, etc.). It is difficult to predict the impact of the configurations and operations because mobile network is built by many components. Unintended network failures can occur because of the new or updated settings and operations.

For example, 5GC is responsible for managing and controlling the mobile network, such as processing call requests and session connections from UEs. Incorrect configuration (e.g., conflict IP address setting at NFs, wrong TAC setting at AMF and etc.) may increase the risk of network failure. In the worst case, it may cause network interruptions and impact the user experience, this may also cause economic loss to the service providers. Therefore, to ensure the correct configuration, especially when updating some of the parameters of 5GC NFs is very important. The digital twin technology may be used to evaluate the impact when updating configuration of one or more 5GC NFs and check whether the new configuration has any side effects of the network (e.g., cause performance degradation or failure).

In another example, when the wireless coverage of a RAN base station cannot meet the performance requirements, updating the RAN base station configuration or creating a new RAN base station may be required. By using NDT, the RAN network performance can be simulated with the new changes and evaluate the result to check whether the network performance can met network coverage goal.

By using NDT, consumer can investigate potential impact in the network operation when new settings are applied (e.g., in which NF does congestion or service disruption occur and how many subscribers are impacted, etc.).

As an example, the impact of the configurations and operations is verified using NDT as follows:

1. The network operator wants to introduce new configurations or do some operation.
2. The network operator synchronizes the replica network to ensure that the replica network is up to date.
3. The network operator applies new configuration or operation to the replica network.
4. The replica network simulates the behavior of the mobile network.
5. The network operator observes and analyses the behavior of the replica network.
6. The network operator decides to apply new configuration or operation.

Consumers can request NDT to simulate various configuration settings and operations and analyze potential impact on the operation of the real network as a result.

### 5.9.2 Potential requirements

**REQ-NDT-FUN-01:** The NDT shall have the capability allowing the consumer to submit provisioning MnS operations to the NDT.

**REQ-NDT-FUN-02:** The NDT shall have the capability to report the result of applied configuration changes.

### 5.9.3 Potential Solutions

The solution described in clause 5.5.3.can be reused for the verification of configurations, with no extra additions. In particular,

* the configurations to be verified are part of the nDTConfigurationPlan
* the outcomes of the configurations are part of the PMs and KPIs in the nDTOutput

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| **Next Change** |

# 6 Conclusions

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| **End of change** |