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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Telecommunication management;

Study on the Self-Organizing Networks (SON) for 5G networks (Release 16)

** 

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# Introduction

A 5G network is more complex than previous generations of mobile networks, which means that the need for automation is higher for 5G.

This study is evaluating SON functions in previous generations of mobile networks and is studying new SON functions, both for RAN and the core network.

# 1 Scope

The present document comprises management use cases, potential requirements and potential solutions of SON for 5G mobile networks.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 32.500: "Telecommunication Management; Self-Organizing Networks (SON); Concepts and requirements".

[3] 3GPP TR 32.501: "Telecommunication Management; Self-configuration of network elements; Concepts and requirements".

[4] 3GPP TS 28.525: "Life Cycle Management (LCM) for mobile networks that include virtualized network functions; Requirements".

[5] 3GPP TR 38.321 v0.0.0 "NR; Medium Access Control (MAC) protocol specification".

[6] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".

[7] 3GPP TS 32.511: "Automatic Neighbour Relation (ANR) management; Concepts and requirements"

[8] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2"

[9] 3GPP TS 28.628: "Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"

[10] 3GPP TS 28.551: "Performance Management (PM) for mobile networks that include virtualized network functions; Procedures"

[11] 3GPP TR 38.423: "NG-RAN; Xn Application Protocol (XnAP)".

[12] 3GPP TR 37.816: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Study on RAN-centric data collection and utilization for LTE and NR".

[13] 3GPP TR 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".

[14] 3GPP TS 32.541: "Telecommunication Management; Self-Organizing Network (SON); Self-healing concepts and requirements".

[15] 3GPP TS 28.550 v15.0.0 "Management and orchestration; Performance Assurance"

[16] 3GPP TS 28.530 v15.1.0 "Management and orchestration; Concepts, Use cases and Requirements"

[17] 3GPP TS 28.533 v15.1.0 "Management and orchestration; Architecture framework"

[18] TS 28.627 "Telecommunication management; Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP); Requirements"

[19] 3GPP TS 28.658 "Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"

[20] 3GPP TS 32.297 "Telecommunication management; Charging management; Charging Data Record (CDR) file format and transfer"

[21] 3GPP TS 37.320 Radio measurement collection for Minimization of Drive Tests (MDT); Overall description; Stage 2

[22] 3GPP TS 32.502: "Telecommunication Management; Self-configuration of network elements Integration Reference Point (IRP); Information Service (IS)".

[23] 3GPP TS 32.508: "Telecommunication Management; Procedure flows for multi-vendor plug-and-play eNode B connection to the network".

[24] 3GPP TS 28.310 "Management and orchestration; Energy Efficiency (EE) of 5G; Concepts, use cases and requirements".

[25] 3GPP TS 38.211: "NR; Physical channels and modulation".

[26] 3GPP TS 28.532: "Management and orchestration; Generic management services"

[27] 3GPP TS 28.545: "Management and orchestration; Fault Supervision (FS)"

[28] 3GPP TS 32.522: "Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"

[29] 3GPP TS 28.806: "Study on non-file-based trace reporting"

[30] 3GPP TS 32.421: "Telecommunication management; Subscriber and equipment trace; Trace concepts and requirements"

[31] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

## 3.2 Symbols

Void

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

AAS Active Antenna System

ANR Automatic Neighbour Relation

CCO Coverage and Capacity Optimization

LB Load Balancing

MRO Mobility Robustness Optimization

NR NR Radio Access

NSI Network Slice Instance

NSSI Network Slice Subnet Instance

OAM Operation, Administration and Maintenance

OPEX Operating Expenditure

PCI Physical Cell Identifier

PM Performance Management

RLF Radio Link Failure

# 4 Concept and background

## 4.1 SON concepts

### 4.1.1 Introduction

3GPP management system includes 3GPP Cross Management Domain and Management Domain.

Based on the location of the SON algorithm, SON is categorized into centralized SON (i.e. Cross Domain-Centralized SON, Domain-Centralized SON), distributed SON and hybrid SON.

The SON algorithm is not standardized by 3GPP.

Following figure illustrates the overview of SON Framework.

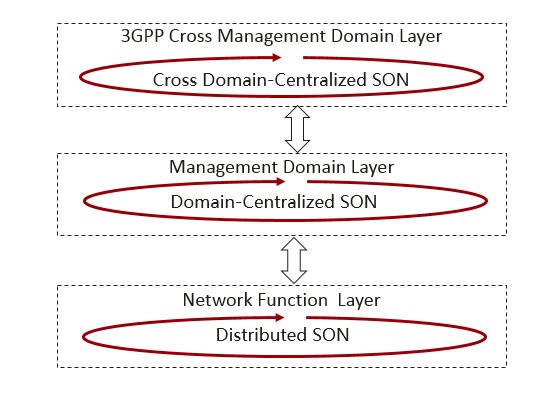


Figure 4.1.1-1: SON Framework

### 4.1.2 Centralized SON

#### 4.1.2.1 Introduction

3GPP management system includes 3GPP Cross Management Domain and Management Domain.

The centralized SON (C-SON) means the SON algorithm is located in the 3GPP management system. The centralized SON concept has been defined for LTE in TS 32.500 [2].

For centralized SON, the 3GPP management system monitors the networks via management data (see NOTE), analyses the management data (i.e., by management data analytics), makes decisions on the SON actions, and executes the SON actions towards the networks.

NOTE: The management data may vary for different the SON cases. For example, for automated creation of NSI, NSSI and/or NFs related cases, the management data may be SLA requirements received from service management layer; for automated optimization related cases, the management data may be performance measurements of the networks; for automated healing related cases, the management data may be alarm information of the networks. The management data is to be specified case by case.

The monitoring, analysis, decision and execution process also applies to monitoring the result of already executed SON actions, evaluating the results (by analysing the historical and current management data), making decisions on new SON actions (which may move forward or backward of the prior actions), and the executing the new SON actions.

As presented at the Figure 4.1.2-1, 3GPP management system is monitoring and executes SON actions in and across multiple network domains such as RAN and Core.



Figure 4.1.2-1: C-SON view

Centralized SON has two variants:

- Cross Domain-Centralized SON: SON solution where SON algorithms are executed at 3GPP Cross Management Domain Layer.

- Domain-Centralized SON: SON solution where SON algorithms are executed at Management Domain layer.

#### 4.1.2.2 Cross Domain-Centralized SON

The Cross Domain-Centralized SON means the SON algorithm is located in the 3GPP Cross Management Domain layer.

For Cross Domain-Centralized SON, the 3GPP Cross Management Domain monitors the networks via management data, analyses the management data, makes decisions on the SON actions, and executes the SON actions.

#### 4.1.2.3 Domain-Centralized SON

The Domain-Centralized SON means the SON algorithm is located in the Management Domain layer.

For Domain-Centralized SON, Management Domain monitors the networks via management data, analyses the management data, makes decisions on the SON actions, and executes the SON actions.

3GPP Cross Management Domain is responsible for management and control of the Domain-Centralized SON Functions. The management and control may include switching on/off a Domain-Centralized SON function, making policies for a Domain-Centralized SON function, and/or evaluating the performance of a Domain-Centralized SON function.

### 4.1.3 Distributed SON

The distributed SON means the SON algorithm is located in the NFs. The distributed SON concept has been defined for LTE in TS 32.500 [2].

For distributed SON (D-SON), the NFs monitors the network events, analyses the network data, makes decisions on the SON actions and executes the SON actions in the network nodes.

The 3GPP management system is responsible for management and control of the D-SON functions. The management and control may include switching on/off a D-SON function, making policies for a D-SON function, providing supplementary information (e.g. the value range of an attribute) to a D-SON function, and/or evaluating the performance of a D-SON function.



Figure 4.1.3-1: D-SON view

### 4.1.4 Hybrid SON

The hybrid SON (H-SON) means the SON algorithm is partially located in the 3GPP management system and partially located in the NFs. The hybrid SON concept has been defined for LTE in TS 32.500 [2].

The 3GPP management system and NFs work together, in a coordinated manner, to build up a complete SON algorithm. The decisions on SON actions may be either made by 3GPP management system or NFs, depending on the specific cases.

As presented at the Figure 4.1.4-1, the centralized SON component is monitoring and executes SON actions in and across multiple network domains such as RAN and Core.



Figure 4.1.4-1: H-SON view

4.1.5 Management Data Analytics Service and SON functions

Management data analytics for 5G networks have already been defined in [15] and also by other specifications including [16] and [17]. It utilizes both management and network data collected through management services and from network functions (including e.g. service, slicing and/or network functions related data) and makes the corresponding analytics based on the collected information. These analytics services (i.e., MDAS) can be made available and consumed by other management and SON functions. Figure 4.1.5-1 gives a high level illustration of potential interaction and utilization of the MDAS.



Figure 4.1.5-1: Management Data Analytics Service and SON functions

It is therefore important that the following concept is observed and considered for the development of use cases and requirements, i.e.

- SON functions may utilize the services provided by the management data analytics (i.e., MDAS) to conduct their functionalities and control actions.

Note: Other potential interactions between the entities are not shown in the diagram in Figure 4.1.5-1 above.

## 4.2 Human intervention of SON

### 4.2.1 Introduction

The full automation of SON is desirable to maximally reduce the operating expenditure (OPEX) of the networks, and to achieve the fastest reaction to the network issues.

However, any improper SON action (e.g. modification of the networks) may cause significantly negative impact to the networks, for instance downgrade of the user experience. Therefore, the consumer (e.g. network operator) may need to build the confidence about the SON functions step by step before allowing the SON process to run fully autonomously, thus human intervention of the SON process needs to be allowed.

Based on whether the SON process is intervened by the consumer, the SON process is categorized to open loop process and closed loop process.

### 4.2.2 Open loop

The SON process with human intervention is the open loop process (see TS 32.500 [2]). Therefore, the open loop SON process is semi- autonomous.

In the open loop SON process, the consumer (e.g. network operator) may pre-define some stop points and the SON process will stop at each pre-defined stop point. Based on the status of the SON process at each stop point, the consumer may decide to resume the SON process or cancel the SON process. The consumer may also make some adjustment to the networks, besides the resumption or cancellation of the SON process.

### 4.2.3 Closed loop

The SON process without human intervention is the closed loop process (see TS 32.500 [2]) and thus fully autonomous. Human intervention is only possible in case of exceptions.

### 4.2.4 Open loop and closed loop transition

The consumer may need to transit a SON process from open loop to closed loop if sufficient confidence has been built; vice-versa, the consumer may transit a SON process from closed loop to open loop if the human intervention is required to gain more trust.

## 4.3 Legacy SON Functions

### 4.3.1 Self-establishment of 3GPP NF, including automated software management

For LTE, the self-establishment SON function has been defined for eNB in TS 32.501 [3].

This concept may be applicable to 5G: the 3GPP NF or its components (e.g. gNB-DU) including NG-RAN and 5GC NFs, is automatically established, when it is powered up and connects to the IP network. As a part of self-establishment, the 3GPP NF or its components is also automatically connected to the network and provided with initial configurations.

For 5G, some phases of the self-establishment (e.g. self-configuration, Multi-Vendor Plug and Play eNB connection to network) may be implemented in other types of 3GPP NFs (not only the Base Stations).

### 4.3.2 Automatic Neighbour Relation (ANR) management (including automatic X2 and Xn setup)

The neighbour relations, including intra-5G neighbour relations and inter-RAT neighbour relations, are automatically established by the gNB and the management system.

The ANR management concept defined for LTE in TS 32.511 [7] may be applicable to 5G.

For NG-RAN, the ANR functionality is specified in TR 38.300 [13], TS 38.331 [6] and TS 38.423 [11].The ANR management concept defined for LTE in TS 32.511 [7] may be applicable to 5G.

There is related study TR 37.816 [12].

### 4.3.3 PCI Configuration

The PCI is to be automatically assigned to an NR cell by the gNB DU and the management system.

The framework for PCI selection defined for LTE in TS 36.300 [8] (see clause 22.3.5) may be applicable to 5G.

There is related study TR 37.816 [12].

### 4.3.4 Automatic Radio Network Configuration Data Handling

The concept of automatic radio configuration data (ARCF) handing for eNB defined in TS 32.501[3], including ARCF data preparation, ARCF Data Transfer and ARCF Data Validation, may be applicable to 5G. Whether the detailed ARCF data for eNB can be applied for gNB needs to be revisited.

### 4.3.5 Load Balancing Optimization

The objective of LB is to automatically distribute cell load evenly among cells or to transfer part of the traffic from congested cells, by means of optimizing the intra-RAT and inter-RAT mobility parameters.

The LB concept and mechanism defined for LTE in TS 28.628 [9] and TS 36.300 [8] may be applicable to 5G.

There is related study TR 37.816 [12].

Actions undertaken through the LB mechanism may have impact on the Virtual Network Functions’ and/or network slices’ load and resources. The LB mechanism defined for LTE with its uni-dimensional perspective on resources needs to be enhanced in 5G to address or account for such effects.

### 4.3.6 Inter-Cell Interference (Interference coordination)

Inter-cell interference coordination is to optimize use of radio resources to ensure that inter-cell interference is kept under control. ICIC mechanism defined for LTE in TS 36.300 [8] includes a frequency domain component and time domain component. ICIC is inherently a multi-cell RRM function that needs to take into account information (e.g. the resource usage status and traffic load situation) from multiple cells.

The ICIC concept defined for LTE in TS 36.300 [8] may be applicable to 5G.

### 4.3.7 RACH Optimization (Random Access Optimization)

The RACH parameters, for example listed in the following, are optimized automatically to achieve a better performance for UE random access:

- RACH configuration (resource unit allocation);

- RACH preamble split;

- RACH back-off parameter value;

- RACH transmission power control parameters.

The RACH optimization concept defined for LTE in TS 36.300 [8] may be applicable to 5G.

There is related study TR 37.816 [12].

### 4.3.8 Centralized Capacity and Coverage Optimization

The CCO is to automatically optimize the coverage and capacity for radio networks, with the consideration of trade-off between them. The CCO concept was defined for LTE in TS 28.627 [18] with the targets and parameters to be optimized specified in TS 28.628 [9] and the NRM support in the TS 28.658 [19].

The concept may be applicable to 5G, however the functions specific to 5G radio technology (e.g. beam management) need to be taken into account.

### 4.3.9 Self-healing

The concept of Self-healing for LTE NE described in TS 32.541[14] may be applicable to 5G NE (including 5GC and NG-RAN NE).

### 4.3.10 SON coordination

Some SON functions eventually affect the same network parameters, thus these SON functions need to be coordinated to prevent or resolve the conflicts.

The SON coordination concept defined for LTE in TS 28.628 [9] may be also applicable to 5G, however the new 5G SON functions and the 5G specific network parameters affected by the 5G SON functions need to be taken into account.

The SON coordination (as defined for LTE) does not account for multiple network aspects e.g. virtualization or slicing. Functionality for multi-aspect views of the network requires new services to be defined.

### 4.3.11 SON for AAS-based Deployments

SON for AAS-based deployments was specified for LTE and is documented in TS 28.627 [18] and TS 28.628 [9]. Its purpose was to create a framework for splitting and merging cells, as well as for changing cell configuration (cell shaping.)

The NR beamforming will be able to take over the role of cell splitting and cell merging. Cell shape changes, in LTE SON for AAS-based deployments manifested by changing handover and similar parameters, is in NR primarily handled by the SON function CCO.

### 4.3.12 Trace and MDT

Trace and the reporting of Trace data as it refers to subscriber tracing and equipment tracing. Trace also includes the ability to trace all active calls in a cell or multiple cells. Trace records control signalling information for specified interfaces.

The trace function is specified in Rel-15 for NR.

MDT is collecting UE measurements either when the UE is in active or idle mode. Information can be collected either on individual basis or for UEs in a specified area.

The concept of MDT, defined in the TS 37.320 [21], may be applicable to 5G.

There is related study TR 37.816 [12].

### 4.3.13 Mobility Robustness Optimization

The MRO is to automatically detect and solve the problems relate to the intra-5G and inter-RAT mobility, which include (but not limited to):

- Too early handover;

- Too late handover;

- Handover to wrong cell;

- Unnecessary handover;

- Ping-pang handover.

The MRO concept and mechanism defined for LTE in TS 28.628 [9] and TS 36.300 [8] may be applicable to 5G.

There is related study TR 37.816 [12].

### 4.3.14 Energy Saving Management

#### 4.3.14.1 General

There is related study TR 37.816 [12].

#### 4.3.14.2 Intra-5G Energy Saving in 5G networks

For energy saving purpose, in an off-peak-traffic situation, some functions of an NR cell or a NF are powered-off or restricted in resource usage in other ways, whereas the cell or NF is still controllable, and the coverage or capacity of the energy saving cell or NF is taken over by other NR cells or NFs.

The intra-RAT Energy Saving scenarios defined for LTE in TS 32.551 [10] are is also applicable to 5G, with the consideration that the RAT is for 5G instead of LTE.

#### 4.3.14.3 Inter-RAT Energy Saving

For energy saving purpose, in an off-peak-traffic situation, some functions of an NR cell or a NF are powered-off or restricted in resource usage in other ways, whereas the NR cell or NF is still controllable, and the coverage or capacity of the energy saving cell or NF is taken over by the cells or NFs of another RAT.

The inter-RAT Energy Saving scenarios defined for LTE in TS 32.551 [10] are is also applicable to 5G, with the consideration that the cell for energy saving is of 5G instead of LTE.

### 4.3.15 (Distributed) Capacity and Coverage Optimization

There is related study TR 37.816 [12].

# 5 Use cases

## 5.1 NSI resource allocation optimization

### 5.1.1 Goal

The goal is to enable the authorized consumer to optimize resource utilization performance of NSI.

### 5.1.2 Pre-conditions

- The NSI(s) have been deployed.

- The NSI management service producer is in operation.

### 5.1.3 Steps

1. (Optional) For shared NSIs, NSI management service provider may need to check policies and resource requirements of several services sharing the NSI.

2. Unless there are policies already determining configurations, SON service provider determines thresholds to trigger NSI optimization (e.g. scale in/out, configure policy), such as network traffic loading, a network resource usage percentage, and available bandwidth, based on policies and requirements of services using the NSI.

3. SON function collects the performance data (related to the data volume, the number of registered UEs, the number of PDU sessions, UE behaviour statistics based on Charging Data Records information (TS 32.297 [20] ]), QoS parameter notifications and UE mobility event notifications from the 5GC … etc.), and utilizes the historical performance data to identify the traffic patterns for the NSIs, and predict the demand for network resources per every NSI for a given time and location. This information is analysed, for example, with assistance of the MDAS, and the information may include data from NSI constituents’ data analytics entities, such as NWDAF, e.g. regarding the load of some network functions.

4. Based on analytics reports, current situation, and the performance optimization targets, the SON function adjusts the resource allocation (e.g. addition, reduction) for the NSIs. If the NSI needs to be adjusted to optimize performance, e.g. configure policies, scale in or out resources, network slice management systems checks the feasibility of the change requirements and initiates the provisioning of changes

5. SON function continues monitoring NSIs to validate the actions being taken, and may perform additional adjustments if necessary.

### 5.1.4 Post-conditions

The resource utilization for the NSI is optimized based on the indicated aspect.

## 5.2 Self-establishment of 3GPP NF, including automated software management

### 5.2.1 Goal

The new-installed NG-RAN node or 5G Core Network node to be configured in automated manner with no or minimal manual intervention.

### 5.2.2 Pre-conditions

The NG-RAN or 5G Core Network node has been installed. The node has implementation of the self-configuration function. It is configured with initial OAM setup information e.g. local OAM IP address

The producer of the self-configuration service in the network is activated.

### 5.2.3 Steps

1. The network node is powered up.

2. The network node may start the process of discovering self-configuration services provided in the network.

3. When proper self-configuration service producer is discovered, the network node establishes connection with the self-configuration service producer.

4. Mutual authentication and authorization is performed by the network node and the self-configuration service producer.

5. The network node requests configuration data and software from the self-configuration service producer and receives the configuration data that may include radio configuration data, connectivity data, etc. and software

6. The network node performs self-configuration and automated software management procedure based on the received configuration data and software.

7. The network node establishes external interfaces to other network nodes and becomes operational.

## 5.3 Automatic Neighbour Relation (ANR) management (including automatic X2 and Xn setup)

### 5.3.1 Introduction

ANR is defined by RAN3 in clause 5.3.3 of TR 38.300 [13] and resides in the gNB. Typically, it runs continually from the deployment of the gNB. When ANR discovers a new Neighbour Cell Relation (NCR) candidate, either for an intra-NR cell or for an LTE cell, it adds the NCR to its internal list of NCRs and sets up an Xn connection to the neighbour gNB, or an Xn connection to the neighbour ng-eNB, or an X2 connection to the neighbour en-eNB. NCRs that have not been used for handovers after a certain time are removed by ANR.

In some cases, an NCR needs to be prohibited, or enforced.

### 5.3.2 Pre-conditions

5G NR cells are in operation.

The ANR function is active in gNBs.

The NG-RAN and the provider(s) of the NG-RAN provisioning management service is deployed and active.

### 5.3.3 Description

The default configuration for a newly deployed gNB is for the ANR function in a gNB to be active for all its cells. As ANR might not be wanted for a cell in a gNB, the ANR function can be switched off for that cell.

The ANR function, residing in the gNB, automatically adds NCRs to the internal list of NCRs. It also has the ability to remove an NCR, for example when the NCR has not been used for handover for a certain amount of time. The MnS producer has the possibility to send notifications when an NCR has been added. The MnS consumer, receiving this notification might find out that this NCR is not wanted. In this case, the MnS consumer can blacklist that NCR. Blacklisting consists of marking the NCR as not to be used for handover and marking it sticky, i.e. the ANR function will not time out and not remove the NCR.

Conversely, the MnS consumer might find that the ANR function fails to add a wanted NCR. In this case the MnS consumer can whitelist that NCR. Whitelisting consists of creating the NCR from the MnS consumer, marking it to be used for handover and marking it sticky, i.e. the ANR function will not time out and not remove the NCR.

The MnS producer also lets the MnS consumer read the list of NCRs, the whitelist and the blacklist.

## 5.4 Automatic Neighbour Relation (ANR) optimization

### 5.4.1 Goal

The goal is to optimize the Neighbor Cell Relations (NCRs) configured at the NG-RAN node.

### 5.4.2 Pre-conditions

The NG-RAN and the provider(s) of the NG-RAN provisioning management service and NG-RAN PM service are deployed and active.

The ANR optimization function is deployed and active. It is a consumer of NG-RAN provisioning management service and also it is subscribed to the PM measurements related to mobility management and the RLF/RCEF reports. The measurements may include such performance indicators as statistics of failed / dropped RRC connections, handover failures etc.

### 5.4.3 Steps

The ANR optimization function optimizes the NCRs in the following ways:

1. The ANR optimization function gets the geographical data and terrain data of the NR cells from a data source (such as radio planning tool), and consumes the NF provisioning management service to get the configuration parameters of the NR cells. The ANR optimization function analyses the received data and determines to add or blacklist one or more NCRs.

2. The ANR optimization function monitors the performance (e.g. failed / dropped RRC connections, handover failures, RLF/RCEF reports, etc.) of the NCRs of the NR cells. Based on the performance of the NCRs, the ANR optimization function may decide to blacklist one or more NCRs.

This Use Case ends when the NG-RAN cells are taken out of service or when the ANR optimization function is stopped.

## 5.5 PCI Configuration

### 5.5.1 Introduction

Each gNB is assigned a PCI (Physical-layer Cell ID) that is broadcast in PSS (Primary Synchronization signal) and SSS (Secondary Synchronization signal). When an UE receives PSS and SSS to acquire time and frequency synchronization, it also obtains the PCI that is used to uniquely identify an NR cell. There are 1008 unique PCIs (see clause 7.4.2 in TS 38.211 [25]). Therefore, PCIs need to be reused, as massive number of NR cells and small cells operating in millimetre wave bands are deployed. Typically, operators use network planning tool to assign PCIs to cells when the network is deployed to insure all neighbouring cells have different PCIs. However, due to the addition of new cells or changes of neighbour relations from ANR functions, problems can arise, such as:

- PCI collision: Two neighboring cells have the same PCIs;

- PCI confusion: A cell has 2 neighboring cells with the same PCI value, where Cell #A has PCI that is different from the PCIs of its two neighbors – Cell #B and Cell #C, but Cell #B and Cell #C have the same PCI. PCI confusion can impact the handover performance as UEs are confused with which cell they should handover to.

The goal is to configure the PCIs of NR cells which are newly deployed and to re-configure the PCIs of NR cells which endure the problem of PCI confliction or PCI confusion. There are two ways to configure the PCI – centralized PCI configuration and distributed PCI configuration, as described in clause 5.2.1 in TR 37.816 [12].

### 5.5.2 Pre-conditions

The NG-RAN is deployed and active, besides, the provider(s) of NG-RAN provisioning management service or NG-RAN fault management service is deployed and active.

The PCI optimization function (located in 3GPP management system) is deployed and activated. It is a consumer of NG-RAN provisioning management service or NG-RAN fault management services related to PCI confliction or confusion.

### 5.5.3 Steps

#### 5.5.3.1 Management of distributed PCI configuration

1. The PCI management and control function sets a list of PCI values to be used by a NR cell, and activates the distributed PCI configuration function.

2. The distributed PCI configuration function randomly selects a PCI value from the list of PCI values provided by PCI management and control function (see clause 5.2.1 in TR 37.816 [12]).

3. The distributed PCI configuration function reports the PCI value selected for this NR cell to the PCI management and control function.

#### 5.5.3.2 Centralized PCI configuration

1. The centralized PCI configuration function monitors and collects the PCI related data (e.g. the measurements related to measurement report, such as physCellId, MeasQuantityResults, which are generated from the MeasResultNR (see clause 6.3.2 in TS 38.331 [6])) reported by NG-RAN.

2. The centralized PCI configuration function analyses the PCI related information to detect new deployed NG-RAN or PCI confliction or confusion of the NR cells.

3. The centralized PCI configuration function consumes NG-RAN provisioning service to configure a specific PCI value or a list values for each newly deployed NR cell or re-configure a PCI value or a list values for the NG-RAN cell which is in the problem of PCI confliction or confusion.

4. NG-RAN performs PCI selection according to the configured specific PCI or list of PCIs.

5. If the newly deployed NR-RAN cell is not correctly configured or PCI confliction or confusion is not resolved, the centralized PCI configuration function reverts to Step 3.

This Use Case ends when the new deployed NG-RAN cells are configured successfully, or the NG-RAN cells are taken out of service or when the centralized PCI configuration function is stopped.

### 5.5.4 Post-conditions

The PCIs for the NR cells have been configured or corrected.

## 5.6 Automatic Network Configuration Data Handling

### 5.6.0 Introduction

The use case for automatic radio network configuration data handling described in clause 6.4.1.1 in TS 32.501 [3] can be applicable to 5G.

### 5.6.1 Goal

Transfer the automatic network configuration data to the MF providing ANCF data and ensure that it is valid when it is used during self-configuration. ANCF data are the data which are required for successful activation of NF and cannot be generated during self-configuration process.

### 5.6.2 Pre-conditions

Automatic network configuration data is known to the ANCF MnS Consumer.

### 5.6.3 Steps

1. (Optional) MF consuming the ANCF data indicates need for automatic network configuration data to the MF providing ANCF data.

2. MF providing ANCF data transfers the automatic network configuration data to MF consuming ANCF data or indicate the MF consuming ANCF data where the automatic network configuration data is available and MF consuming ANCF data retrieve the data from there.

3. (Optional) MF providing ANCF data requests the MF consuming ANCF data to validate the received automatic network configuration data.

4. MF consuming ANCF data validates the received automatic network configuration data.

### 5.6.4 Post-condition

The self-configuration process can use the automatic network configuration data.

## 5.7 Load Balancing Optimization

### 5.7.1 Introduction

It includes the management of distributed LBO and centralized LBO.

### 5.7.2 Pre-conditions

NG RAN and 5GC are in operation.

### 5.7.3 Description

#### 5.7.3.1 The management of distributed LBO

The LBO management and control function sets the target of D-LBO function

The LBO management and control function activates the D-LBO function to balance the cell load among gNB(s) automatically.

#### 5.7.3.2 Centralized LBO

The LBO management and control function receive the target of LBO from consumers.

The C-LBO function collects the load performance measurements (e.g. radio resource usage, HW / VR / TNL load indicators, Composite Available Capacity PRB, TNL measurements, …) or notifications (e.g. threshold crossing of certain measurements) from gNB-CU-CP, gNB-CU-UP(s), gNB-DU(s).

The C-LBO function analyses the load measurements to determine the actions, if needed, including the configuration of the handover and/or reselection parameters, and the initiation of changing virtualized resources, to optimize the traffic load distributions among neighboring cells,

The C-LBO function collects the performance measurements (e.g. the number of RRC connection establishment / release, abnormal release, handover failures, call drops, etc…) to evaluate the LBO performance, and may update the handover and/or reselection parameters of the cell or its neighbors.

### 5.7.4 Post-conditions

The cell load of gNB(s) have been optimized.

## 5.8 Void

## 5.9 RACH Optimization (Random Access Optimization)

### 5.9.1 Introduction

A poorly configured RACH (Random Access Channel) may increase the time it takes for an UE to access the network, and may increase the accesses failures that can impact call setup performance. RACH optimization is to automatically configure the RACH parameters in a cell in order to achieve the optimal network performance by reducing the network access time, and minimize the failures.

### 5.9.2 Pre-conditions

5G NR cells are in operation.

RACH management and control function is in operation.

RACH optimization function is active.

### 5.9.3 Description

RACH optimization function is running to optimize the RACH performance by adjusting RACH parameters, such as RACH-ConfigCommon properties specified in TS 38.331 [6], clause 6.3.2 automatically.

The RACH management and control function sets the targets for RACH optimization function, and collects the following performance measurements to monitor the RACH performance:

- Distribution of the number of preamble UEs sent to achieve synchronization, where the number of preamble sent corresponds to PREAMBLE\_TRANSMISSION\_COUNTER (see clause 5.1.1 in TS 38.321 [5]) in UE.

- Distribution of the time needed for UEs to achieve synchronization;

NOTE: These performance measurements are reported in the most timely manner to monitor the RACH performance.

The RACH management and control function analyses the measurements, and may perform one of the following actions, if the RACH performance does not meet the target:

1. Update the targets for RACH optimization function;

2. Update the ranges of RACH parameters for NR cells;

3. Disable RACH optimization function, and configure the RACH parameters for the NR cells with values deemed to improve RACH performance.   
The RACH management and control function should not configure the RACH parameters when the RACH optimization function is active.

### 5.9.4 Post-conditions

The RACH performance in NR cells is optimized.

## 5.10 Centralized Capacity and Coverage Optimization

### 5.10.1 Goal

The goal is NG-RAN coverage and capacity optimization for NR cells.

### 5.10.2 Pre-conditions

NG-RAN in certain geographic area is active, managed by the provider(s) of the NG-RAN provisioning management service and the PM service.

The CCO SON function is active and consumes the NG-RAN and 5GC provisioning management services and the PM services, provided by the corresponding providers.

The measurements received by the CCO function may include indicators of network performance, which may include indications of bad coverage such as of RSRP and RSRQ statistics, RLFs, failed / dropped RRC connections, handover failures etc. Additional information sources can be taken into account, such as MDT (UE level trace) and information carried in the CDRs.

### 5.10.3 Steps

1. The CCO function is monitoring the performance indicators of the NG-RAN cells, certain areas or beams within the cells, and may monitor 5GC for example CDRs of such events as voice call drops, by collecting performance measurements, such as RSRP, RSRQ, SINR, and RLF measurements for cells and beams within the cell (see clause 6.3.2 in TS 38.331 [6]).

2. If the CCO function detects coverage hole or capacity (performance) degradation in some cells, certain areas or beams within the cell, by analysing measurements, such as RSRP, RSRQ, SINR, and RLF measurements of DL SSB beams.

Some examples of degradation criteria are too low signal strength, low success rate for RRC connection attempts, for random access attempts etc.

3. The CCO function determines the actions needed to improve the coverage and/or capacity of cell and areas within the cell.

4. The CCO function modifies the configuration parameters in the cell and/or in one or several neighbor cells or configuration of the 5GC, such as PCF policies to reduce the load, and continues monitoring the PM measurements.

5. If the network performance does not recover, the CCO function adjusts the modifications made in the Step 2.

6. Return to the Step 1.

This Use Case ends when the monitored cells are taken out of service or when the CCO function is stopped.

## 5.11 Self-healing

The use cases of Self Recovery of NE Software, Self-healing of board faults and Self-healing of Cell Outage described in TS 32.541 [14] can be applied for 5G NE. The description of use case needs to be revisited to align with the service based management architecture.

## 5.12 SON coordination

The function SON coordination has not been addressed in the present document.

## 5.13 Multi-vendor Plug and Play of NFs

### 5.13.0 Introduction

Use case of multi-vendor plug and connect eNB to network defined in clause 6.4.3 in TS 32. 501[3] can be applicable for non-virtualized NF in 5G network.

Use case of managing EM IP address provided to instantiated VNF using MVPNP defined in clause 6.4.3 in TS 28.525 [4] can be applicable for VNF in 5G network.

### 5.13.1 Multi-Vendor Plug and Connect NF to Management System

#### 5.13.1.1 Goal

After NF deployed (physical installation for non-virtualized NF or instantiation for VNF), connect the NF (e.g. NG RAN Node, 5GC Node) to its management system providing support for self-configuration processes automatically as possible.

#### 5.13.1.2 Pre-condition

The NF is deployed (physical installation for non-virtualized NF or instantiation for VNF).

#### 5.13.1.3 Steps

1. If a VLAN ID is available the NF uses it. Otherwise the NF uses the native VLAN where PnP traffic is sent and received untagged.

2 The NF acquires its IP address through stateful or stateless IP auto-configuration.

3. The NF acquires the IP address of the CA/RA server.

4. The NF performs Certificate Enrolment.

5. The NF acquires the IP address of the OAM SeGW.

6. The NF establishes a secure connection (tunnel) to the Security Gateway.

7. The NF acquires the IP address of the correct management system providing support for self-configuration process.

8. The NF establishes a connection to the provided management system providing support for self-configuration and acquires its configuration and software if any.

#### 5.13.1.4 Post-condition

One or more secure connections exist between the NF and the management system providing support for self-configuration process.

### 5.13.2 Self-configuration of a new NF

#### 5.13.2.1 Goal

After NF deployed (physical installation for non-virtualized NF or instantiation for VNF), put in an automated manner the NF into a state to be ready to carry traffic.

#### 5.13.2.2 Pre-condition

- The NF is deployed (physical installation for non-virtualized NF or instantiation for VNF) and connect to IP network.

- One or more secure connections exist between the NF and the management system providing support for self-configuration.

- The (transport and radio) configuration data and software packages for the NF is made available in management system providing support for self-configuration.

#### 5.13.2.3 Steps

1. The NF provides information about its type, hardware and other relevant data about itself to the management system providing support for self-configuration.

2. Management system providing support for self-configuration take the decision of which software and (transport and radio) configuration data have to be downloaded to the NF.

3. Management system providing support for self-configuration download the software and (transport and radio) configuration data to the NF.

4. Management system providing support for self-configuration also update the dependent nodes with new configuration data as well if required.

5. NF performs a self-test.

6. Management system providing support for self-configuration inform its Consumer about the progress of the self-configuration process and important events occurring during the self-configuration process.

#### 5.13.2.4 Post-condition

The NF (5GC Node or NG-RAN Node) is ready to carry traffic.

## 5.14 SON for AAS-based Deployments

In E-UTRAN networks, SON for AAS-based Deployments uses techniques like cell splitting and cell merging. As the NG-RAN uses beamforming for sub-sector structures, these techniques are not relevant for NR-RAN. Instead, Coverage and Capacity Optimization will cover this topic.

## 5.15 Trace and MDT

Use cases from TS 32.421 [30], clause 5.8 apply.

## 5.16 Mobility Robustness Optimization

### 5.16.1 Introduction

5G NR cells may experience issues, such as too early or too late handover, handover to wrong cell, ping-pong handover, that not only impact user experience, but also waste network resources, if handover parameters are not set properly. Mobility Robustness Optimization (MRO) is intended to automatically configure the handover parameters in cells in order to improve the handover performance.

### 5.16.2 Pre-conditions

5G NR cells are in operation.

MRO management and control function is in operation.

MRO function is active.

### 5.16.3 Description

MRO function is running to optimize the handover performance by adjusting handover parameters automatically.

The MRO management and control function sets the ranges of the NR and EUTRAN handover parameters and the targets for the MRO function, and collects handover related measurements and radio link failure (see clause 5.3.10 in TS 38.331 [6]) reports to monitor the handover performance:

The MRO management and control function analyses the measurements and radio link failure reports, and may perform one of the following actions, if the handover performance does not meet the target:

1. Update the targets for MRO function;

2. Update the ranges of handover parameters for the NR neighbour relations and EUTRAN neighbour relations;

3. Disable MRO function, and configure the handover parameters (see clause 5.5.4 in TS 38.331 [6]) for NR neighbour relations with values deemed to improve handover performance.

Note: The MRO management and control function should not configure the handover parameters when the MRO function is active.

### 5.16.4 Post-conditions

The handover performance in and across NR and EUTRAN neighbour relations is optimized.

## 5.17 Energy Saving Management

Energy saving management is addressed in TS 28.310 [24].

## 5.18 Automatic NSI creation

### 5.18.1 Introduction

Network slicing in 5G provides mobile operators opportunities and flexibility to create services tailored for various customers on demand. Automatic NSI creation enables operators to create the NSI that contains 5G CN NF, gNB CU, and gNB DU automatically, based on the requirements given by the customers.

### 5.18.2 Pre-conditions

NG RAN and 5GC are in operation.

### 5.18.3 Description

The service producer of automatic NSI creation receives the network slice related requirements to support communication services from an authorized consumer.

The service producer of automatic NSI creation analyses requirements to determine the NSSIs, network functions and resources needed to support the requirements.

The service producer of automatic NSI creation creates an NSI, which may include the instantiation of new network functions, configuration of existing NF, and interworking with transport management system to allocate the transport resources if needed.

### 5.18.4 Post-conditions

The NSI is created.

## 5.19 Optimization of the quality of communication services

### 5.19.1 Goal

The goal is to enable service quality optimization. For example, the goal can be to minimize average latency on the communication services provided to the URLLC category of services.

### 5.19.2 Pre-conditions

A set of communication services is provided by the network to certain group (category) of the UEs. The services may be provided with relation to certain NSI(s).

The following functions are deployed and active:

- NG-RAN, 5GC

- The providers of the NG-RAN and 5GC provisioning and Performance assurance MnS for the NG-RAN and 5GC nodes, which are essential for the quality of the set of services.

- The providers of the NSI / NSSI provisioning and Performance assurance MnS for the relevant NSI(s) / NSSI(s) (if there are any), which are essential for the quality of the set of services received by the group (category) of the UEs;

- Network management system consuming above services; this function is aware of the performance requirements imposed on the set of services.

For example, for the URLLC latency optimization, the latency components can be measured by the involved network nodes and processed to compute the average end-to-end latency.

### 5.19.3 Steps

1. The service optimization function is collecting the performance data and monitoring the performance indicators related to the targeted services.

For example, for the URLLC latency optimization, the management system may collect the latency components contributed by the involved network nodes and communication links measured by the involved network nodes; these components are processed to compute the average end-to-end latency.

2. If the service optimization function detects performance degradation, it modifies the configuration parameters in the corresponding NG-RAN and 5GC nodes and NSI(s)/NSSI(s), using the NG-RAN, 5GC, and NSI(s)/NSSI(s) (if relevant) provisioning services, and continues monitoring the performance.

3. If the network performance does not recover, the service optimization function adjusts the modifications made in the Step 2.

4. Return to the Step 1.

This Use Case ends when the monitored services or network nodes or NSI(s)/NSSI(s) are taken out of service or when the service optimization is stopped.

## 5.20 Cross-slice network resource optimization

### 5.20.1 Goal

The goal is to enable the authorized consumer to optimize the resource allocation across multiple NSIs of the total available physical and virtual resources. The resources associated with an NSI are those resources associated with NSSIs in 5GC and resources associated with NSSIs in NG-RAN.

### 5.20.2 Pre-conditions

- Multiple NSIs have been deployed.

- The NSI management service producer is in operation.

### 5.20.3 Steps

1. (Optional) For shared NSIs, the NSI management service provider may need to check policies, slice priorities and resource requirements of several services sharing the NSI.

2. Unless there are policies already determining configurations, the SON service provider determines thresholds to trigger network resource optimizations (e.g. increase or decrease NSI capacities like storage, computing, network bandwidth and radio resources), such as thresholds in network traffic loading, a network resource usage percentage, and available bandwidth, based on policies and requirements of services using the NSI and taking the slice priority into account.

3. The SON service provider collects the performance data (related to data volume, the number of registered UEs, the number of PDU sessions, … etc.), as well as data indicating changes in the network resources (e.g. from the NFV-MANO system or from the TN network) available for the NSIs, and utilizes the historical performance data collected in the past days, weeks, months, and beyond to understand the traffic patterns for the NSIs, and predictions regarding the demand for each NSI for a given time and location. This information is analysed, for example, by the MDAF, and the information may include data from NSI constituents data analytics entities, such as NWDAF, e.g. regarding the load of some network functions.

4. Based on analytics reports, current situation and changes in network resource usage, and the network resource optimization targets, the SON service provider determines whether the NSIs can still be supported by the available resources. If this is not the case, the SON service provider determines how resource allocation (e.g. addition, reduction) for the NSIs needs to be adjusted. If NSI needs to be adjusted, e.g. configure policies, scale in or out resources, the SON service provider checks the feasibility of the change requirements.

5. If network resource optimization cannot fulfill the resource requirements and policies of all NSIs, the SON function will inform the CSP that resource requirements or slice priorities need to be changed to help solve NOP resource problems.

6. The CSP responds to the request with a set of adjusted resource requirements and slice priorities.

7. The SON service provider provides the (adjusted) resource requirements and slice priority data provided by the CSP to the NSI management service provider which then initiates the provisioning of changes.

8. The SON service provider continues monitoring NSIs to validate the actions being taken, and may perform additional adjustments if necessary.

### 5.20.4 Post-conditions

The total virtual and physical resource allocation is optimized to sustain all the NSI with their current resource utilization.

## 5.21 Multi-aspect / multi-domain resource optimization

### 5.21.1 Goal

The goal is to enable joint resource optimization across multiple domains (e.g. AN, CN) among multiple network aspects including the Radio resources, virtualized network functions and network slices.

### 5.21.2 Pre-conditions

A set of communication services is provided by the network to certain group (category) of the UEs. The services can be provided with or without relation to certain NSI(s).

The following functions and services are deployed and active:

- NG-RAN, 5GC, NSI(s).

- The performance assurance (PM), fault supervision (FM) and provisioning (CM) services are available across different network aspects.

- The provider of Multi-Aspect Resource Optimization (MARO).

The provisioning, assurance and supervision services provide information on the multiple aspects, the information characterized by:

- Status details on network resources for different resource types, e.g. both physical radio resource and virtual resources.

- Information from one or multiple network slices and slice subnets.

- For each subnet/slice/infrastructure aspect, information on allocated resources and their utilization, event history (e.g. recent overload situations), history of actions taken (e.g. LB decisions, scaling of virtual resources).

### 5.21.3 Description

The provider of MARO is running to jointly optimize resource utilization among multiple network aspects.

The provider of MARO consumes network resource-related provisioning, assurance and supervision services on the different network aspects including Radio resources and virtual resources; the deployment environments including virtual machines or cloud instances; as well as the slices and subnets utilizing these functions.

The provider of MARO offers management capabilities on the resource parameters configuration.

### 5.21.4 Steps

The provider of multi-aspect resource optimization (MARO) takes network status inputs from multiple domains and derives the policies for network configuration and optimization. This may be specific to a single network slice or it may be applicable to multiple network slices.

The provider of MARO consumes performance assurance (PM), fault supervision (FM) and provisioning (CM) services across different domains. The information retrieved may consists of network resource-related data (both physical and virtual resources), which may be characterized as, but not restricted to:

- The information from one or multiple network slices, slice subnets and/or infrastructure domains (physical and virtual)

- For each domain/subnet/slice, information on allocated resources and their utilization, event history (e.g. recent overload situations), history of actions taken (e.g. MLB decisions, scaling of resources)

The provider of MARO then:

- Analyses the collected data for resource optimization across different infrastructure domains for either a single network slice or multiple network slices

- Correlates the data across network slices or slice subnets. Note that although from network planning some initial mapping on resource allocation across domains is known, correlation of performance in the different domains is still necessary. For example, even given CU/DU split with known resource allocation in each domain the relative performance in each domain (CU-virtual resource utilization, vs. DU physical load) needs to be correlated.

- Calculates/generates network resource provisioning policy improvements. Non-exhaustive list of examples of policy improvements may be:

- Adjusting the policy on scaling of virtual resources based on the observation that RAN MLB (on physical resources) was performing well but the virtual resources were not adequately provisioned.

- Change the characteristics of transport links based on observed transport network performance bottleneck.

- Change in the network slice or subnet resource provisioning for inter-slice resource optimization

- Exposes obtained policy improvements as a service toward other network functions.

The policy improvement service exposed can be either:

- Directly applied by MDROF by utilizing the configuration management service of the related network function

- Consumed by the domain-specific control function which:

- takes into account all the existing policy improvement requests related to that particular domain/resource.

- analyses potential conflicts among policy improvements.

- resolves identified conflicts among policy improvements and derives the actual policy improvement to be applied within that specific domain.

- applies the resulting policy improvement through the configuration management of involved network function.

## 5.22 Automatic CSI creation

### 5.22.1 Goal

The goal is to enable operators to properly design and initiate a new communication service. Automatic CSI creation is able to digest the SLA into service profile so that corresponding network functionalities can use the service profile.

### 5.22.2 Pre-conditions

A set of E2E services is provided by the network to certain group (category) of the UEs.

The following functions and services are deployed and active:

- NG-RAN, 5GC, CSI(s), NSI(s)

### 5.22.3 Description

The service producer of automatic CSI creation receives the SLA requirements from an authorized consumer.

The service producer of automatic CSI creation analyses SLA requirements to determine the resource parameters configuration needed to support the requirements.

The service producer of automatic CSI creation needs to analysis between the input SLA with the capability of existing network resource during feasibility check, and provide the possible negotiate the output service profile.

### 5.22.4 Post-conditions

The CSI is created.

# 6 Potential requirements

## 6.1 Self-Establishment of NG-RAN and 5GC nodes, including automated Software Management

**REQ-SC-1** The self-establishment functionality at the network node should be capable of self-configuration service producer discovery, mutual authentication, authorization, and registration for the service with the producer of the self-configuration service

**REQ-SC-2** The self-establishment functionality at the network node, should be capable of receiving the configuration data, and consequent self-configuration

**REQ-SC-3** The producer of the self-configuration service should be capable of supporting the procedure of self-configuration service producer discovery, mutual authentication and authorization

**REQ-SC-4** The provider of the self-configuration service should be capable of delivery of the configuration data to the consumer that requested the data

**REQ-SC-5** The self-establishment functionality at the network node, should be capable of receiving the software, and consequently using

## 6.2 Automatic Neighbour Relation (ANR) management (including automatic X2 setup)

**REQ-ANR-CON-1** The MnS (i.e., MnS for ANR management) producer shall support a capability allowing the MnS consumer to switch ANR on and off for each cell. The default value for ANR is to be switched on.

**REQ-ANR-CON-2** The MnS producer shall support a capability allowing the MnS consumer to whitelist an NCR.

**REQ-ANR-CON-3** The MnS producer shall support a capability allowing the MnS consumer to blacklist an NCR.

**REQ-ANR-CON-4** The MnS producer shall support a capability allowing the MnS consumer to prohibit the setting up of Xn or X2 connections to a neighbour for a certain NCR.

**REQ-ANR-CON-5** The MnS producer shall support a capability allowing the MnS consumer to read the NCRs, the blacklist and the whitelist.

**REQ-ANR-CON-6** The MnS producer shall support a capability allowing the MnS consumer to receive notification when the ANR function adds or removes an NCR in an NR cell

## 6.3 Automatic Neighbour Relation (ANR) optimization

**REQ-ANRO-1** The ANR optimization function should be able to monitor the performance of the cells using by NG-RAN PM services.

**REQ-ANRO-2** The ANR optimization function should be able to set / modify the neighbour configuration parameters in the cells using the NG-RAN Provisioning services.

**REQ-ANRO-3** The ANR optimization function should be able to monitor the statistics of UE measurement results for intra-RAT neighbour relations and inter-RAT neighbour relations for NR cells.

**REQ-ANRO-4** The ANR optimization function should be able to create, modify, or delete the intra-RAT and inter-RAT neighbour relations for NR cells.

## 6.4 PCI Configuration

**PCI-OPT-CON-1** The MnS of performance assurance should have a capability to collect the information related to PCI collision or PCI confusion.

**PCI-OPT-CON-2** The MnS of performance assurance should have a capability to provision the PCIs of one or more NR cells.

**PCI-CONFIG-3** The MnS of provisioning should have a capability to set the list of PCI values for a NR cell.

**PCI-CONFIG-4** The MnS of provisioning should have a capability to activate or deactivate the distributed PCI configuration function for a NR cell.

## 6.5 Void

## 6.6 Load Balancing Optimization

**REQ-LBO-1** LBO management and control function should have the capability to set and update the LBO targets and initiates the changes of virtualized resources for distributed LBO.

**REQ-LBO-2** LBO management and control function should have the capability to activate or deactivate D-LBO function.

**REQ-LBO-3** C-LBO function should have the capability to collect the load performance measurements and notifications needed for LBO function.

**REQ-LBO-4** C-LBO function should have the capability to determine the actions, including the configuration of the handover and/or reselection parameters, and the initiation of changing virtualized resources, to optimize the traffic load distributions among neighbouring cells.

**REQ-LBO-5** C-LBO function should have the capability to collect the performance measurements to evaluate the C-LBO performance.

## 6.7 Void

## 6.8 RACH Optimization (Random Access Optimization)

**REQ-RACH-1** RACH management and control function should have a capability to set the targets for RACH optimization function.

**REQ-RACH-2** RACH management and control function should have a capability to collect performance measurements, such as distribution of the number of preamble UEs sent to achieve synchronization, distribution of the time needed for UEs to achieve synchronization.

**REQ-RACH-3** RACH management and control function should have a capability to set and update the targets of RACH optimization function, and the ranges and values of the RACH parameters for NR cells.

**REQ-RACH-4** RACH management and control function should have a capability to enable or disable the RACH optimization function.

## 6.9 Centralized Capacity and Coverage Optimization

**REQ-CCO-1** The CCO function should be able to collect the performance indicators related to coverage and capacity, using PM management services

**REQ-CCO-2** The CCO function should be able to set / modify the RAN and 5GC configuration parameters that affect coverage and capacity.

**REQ-CCO-3** The CCO function (in 3GPP management system) should have a capability to collect measurements, such as RSRP, RSRQ, SINR, and RLF measurements for cells and DL SSB beams.

**REQ-CCO-4** The MnS producer shall provide a capability allowing the MnS consumer to configure sectors. A sector is defined by its spatial information (pointing direction, width and shape).

## 6.10 Void

## 6.11 Self-healing

The function Self-healing has not been addressed in the present document.

## 6.12 SON coordination

The function SON coordination has not been addressed in the present document

## 6.13 Multi-vendor Plug and Play of NFs

See clause 6.1.

## 6.14 SON for AAS-based Deployments

In E-UTRAN networks, SON for AAS-based Deployments uses techniques like cell splitting and cell merging. As the NG-RAN uses beamforming for sub-sector structures, these techniques are not relevant for NR-RAN. Instead, Coverage and Capacity Optimization will cover this topic.

## 6.15 Trace and MDT

Requirements from TS 32.421 [30] clause 5 apply.

## 6.16 Mobility Robustness Optimization

**REQ-MRO-1** MRO management and control function should have a capability to set the targets for MRO function.

**REQ-MRO-2** MRO management and control function should have a capability to receive handover related performance measurements and radio link failure reports.

**REQ-MRO-3** MRO management and control function should have a capability to configure the ranges of handover parameters for NR neighbour relations and EUTRAN neighbour relations.

**REQ-MRO-4** MRO management and control function should have a capability to enable or disable the MRO function.

## 6.17 Energy Saving Management

Energy saving management is addressed in TS 28.310 [24].

## 6.18 NSI resource allocation optimization

**REQ-NSI\_RAO-1** 3GPP management system should have a capability to collect the performance data (including data volume, the number of registered UEs, and the number of PDU sessions … etc.) for NSIs and NSI constituents.

**REQ-NSI\_RAO-2** NSI resource allocation optimization function should have a capability to adjust the resource allocations for the NSIs and NSI constituents.

## 6.19 Automatic NSI creation

**REQ-ANSIC-CON-1** The service producer of automatic NSI creation should have a capability to receive the network slice related requirements to support the communication service.

**REQ-ANSIC-CON-2** The service producer of automatic NSI creation should have a capability to create an NSI.

## 6.20 Requirements related to the service quality optimization

**REQ-SQO-1** The Performance assurance MnS for NG-RAN, 5GC and slicing, should support the capabilities to provide performance data related to the quality of communication services provided to a group (category) of UEs.

**REQ-SQO-2** The provisioning MnS for NG-RAN, 5GC and slicing, should support the capabilities allowing to set / modify the configuration parameters affecting the quality of communication services provided to a group (category) of UEs.

## 6.21 Cross-slice network resource optimization

**REQ-CNRO-1** 3GPP management system should have a capability to collect the performance data (including data volume, the number of registered UEs, and the number of PDU sessions … etc.) for NSSIs and NSSI constituents.

**REQ-CNRO-2** 3GPP management system should have a capability to collect the network resources utilization data (storage, computing, network bandwidth and radio resources) for NSSIs and NSSI constituents.

**REQ-CNRO-3** 3GPP management system should have a capability to detect changes in the total amount of available network resources (storage, computing, network bandwidth and radio resources) for NSSIs and NSSI constituents.

**REQ-CNRO-4** Cross-slice network resource optimization functionality should have a capability to adjust the resource allocations for the NSSIs and NSSI constituents.

**REQ-CNRO-5** Cross-slice network resource optimization functionality should have a capability to inform a CSP if resource requirements or slice priorities need to be changed in order to continue operation of the slice.

**REQ-CNRO-6** Cross-slice network resource optimization functionality should have a capability to receive a response from the CSP and adjust the NSI based on its contents.

**REQ-CNRO-7** Cross-slice network resource optimization functionality should have a capability to analyse the performance data, resource utilization data and the available network resources.

# 7 Potential solutions

## 7.1 Self-establishment of NFs including automated Software Management

The Figure 7.1-1 illustrates the major phases for self-establishment of NF (5GC Node and NG-RAN Node).

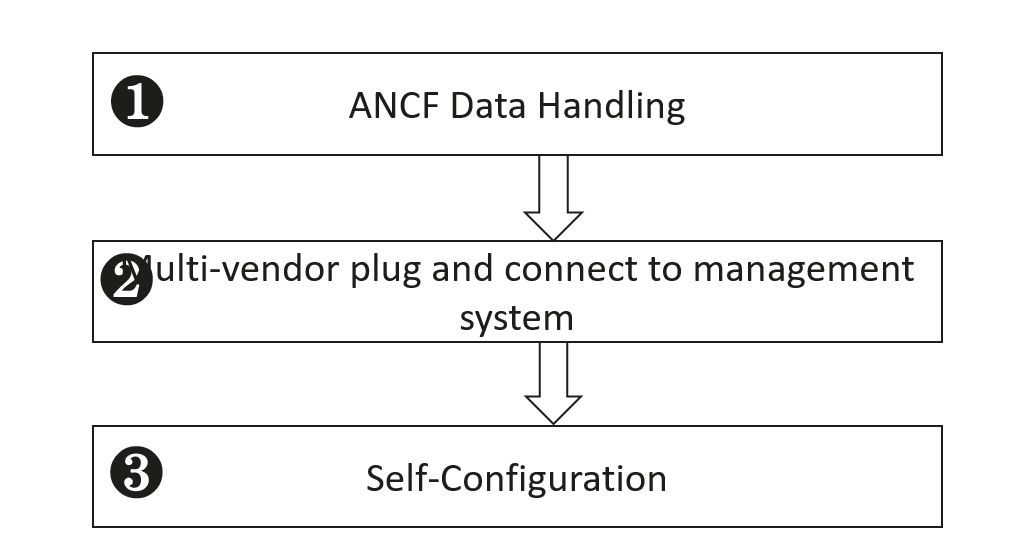


Figure 7.1-1: Major phases of NF self-establishment

Following are description for major phases of NF establishment.

**Pre-condition for self-establishment of NF:**

- NF is installed. For non-virtualized NF, the NF is physically installed. For VNF, the VNF is instantiated.

**Stage 1: ANCF data handling**

This stage is to make the Automatic Network Configuration data (ANCF data) available to the management system support self-configuration process, which may include ANCF data preparation, ANCF data transfer and ANCF data Validation.

TS 32.502 [22] defines the automation radio configuration data for eNB. For 5G, following ANCF data needs to be defined:

For NG-RAN Node: Automatic radio configuration data and automatic transport configuration data.

For 5GC Node: Automatic core network configuration data and automatic transport configuration data.

TS 32.502 [22] defines IRP based operations to transfer ARCF data. For 5G, needs to consider whether these operations can be applicable and define MnS based solution for these operations if applicable. Also needs to consider whether additional operations needed.

**Stage 2: Multi-vendor plug and connect to management system**

This stage is to connect the NF to its management system provide support self-configuration process as automatically as possible. MvPnC include following functionality: initial IP Autoconfiguration service, Certificate enrolment, establish secure connection, establish connect to management system provide support self-configuration process.

TS 32.508 [23] defines multi-vendor plug and connect to network procedure for eNB. For 5G, needs to consider whether the procedure is applicable for both NG-RAN Node and 5GC Node, and make it more generic to be applicable for both NG-RAN Node and 5GC Node which is virtualized or non-virtualized if applicable.

**Stage 3: Self-Configuration**

This stage is to put the NF into a state to be ready to carry traffic in an automated manner. Self-Configuration include following functionality: create self-configuration task, monitor self-configuration process, generate configuration data based on ANCF data, download and activate software, download and active configuration data, perform self-test and update network resource model, etc.

TS 32.502 [22] define several IRP based operations for self-configuration management (e.g. createScManagementProfile, resumeScProcess, notifyProcessStage) for LTE. For 5G, needs to consider whether these operations can be applicable and define the MnS based operation if applicable. Also needs to consider whether additional operations needed.

## 7.2 Automatic Neighbour Relation (ANR) management (including automatic X2 and Xn setup)

The ANR function deployed in the gNB is documented in clause 15.3.3 in TR 38.300 [13]. The ANR function is distributed, and its purpose is to add and remove NCRs.

The solution for ANR management consists of the following items:

1) When the ANR function adds a new NRCellRelation instance, the MnS producer notifies the MnS consumer that a new NCR has been created.

2) When the ANR function deletes a NRCellRelation instance, the MnS producer notifies the MnS consumer that an existing NCR has been deleted.

3) An attribute isRemoveAllowed of *NRCellRelation* allows the MnS producer to request the MnS consumer to prohibit the distributed ANR function to remove an existing NCR.

4) An attribute isHOAllowed of *NRCellRelation* allows the MnS producer to request the MnS consumer to prohibit handovers on this NCR.

5) Attributes *x2BlackList* and *xnBlackList* allow the MnS consumer to request the MnS producer to prohibit the gNB or gNB-CUCP to set up X2 respectively Xn connections for these particular NCRs.

Attributes *x2WhiteList* and *xnWhiteList* allow the MnS consumer to request the MnS producer to configure the gNB or gNB-CUCP to set up X2 respectively Xn connections for these particular NCRs.

## 7.3 PCI Configuration

### 7.3.1 General

This subclause the solutions for the use case of PCI configuration (see use case in clause 5.5).

### 7.3.2 Management of distributed PCI configuration

**pCI configuration for newly deployed gNB**

The PCI management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation (see clause 5.1.3 in TS 28.532 [26]) to configure the PCI list for a given NR cell.

The PCI management function may consume the management service for NF provisioning with *modifyMOIAttributes* operation to enable the D-PCI configuration function for a given NR cell.

The D-PCI configuration function randomly selects a PCI value from the PCI list, (see clause 5.2.1 in TR 37.816 [12]).

The D-PCI configuration function informs the management service producer for NF provisioning to send a notification notifyMOIAttributeValueChange (see clause 5.1.9 in TS 28.532 [26]), indicating the new PCI value(s) being selected.

**pCI configuration for already deployed gNB**

The D-PCI configuration function detects the PCI conflict among NR cells, and informs the management service producer for NF fault supervision (see clause 6.3 in TS 28.545 [27]) to send a notification notifyNewAlarm (see clause 6.1.1.4 in TS 28.532 [26]) to the PCI management function, indicating that the PCI conflict has been detected on NR cells.

The PCI management function may consume the management service for NF provisioning with *modifyMOIAttributes* operation to update the PCI list for a given NR cell.

D-PCI configuration function reassigns the new PCI value(s) from the PCI list for the affected NR cells (see clause 5.2.2 in TR 37.816 [12]), resulting in a notification notifyMOIAttributeValueChange (see clause 5.1.9 in TS 28.532 [26]) being sent to indicate the new PCI value(s) being reassigned to mitigate the conflict.

D-PCI configuration function detects that the PCI conflict has been resolved, resulting in a notification notifyClearedAlarm (see clause 9.2.5 in TS 28.532 [26]) being sent to the PCI management function, indicating the PCI conflict has been resolved.

NOTE 1: NRM needs enhancement to support D-PCI enable / disable, PCI list, PCI value.

NOTE 2: NF fault supervision needs enhancement to PCI conflict alarm notification.

### 7.3.3 Centralized PCI configuration

It is assumed that the C-PCI configuration function has consumed the management service to collect PCI related measurements, and the MOIs related to the PCI configuration has been created.

**pCI configuration for newly deployed gNB**

TheC-PCI configuration function determines the PCI value based on analyses of the collected data, e.g. performance measurements, historical KPIs, historical PCI configuration data.

TheC-PCI configuration function consumes the management service for NF provisioning with *modifyMOIAttributes* operation to configure a single PCI for each cell.

**pCI configuration for already deployed gNB**

The C-PCI configuration function collects the PCI related measurements (e.g. performance measurements related to connections and mobility, historical PCI configuration data) reported by NG-RAN.

The C-PCI configuration function analyses the PCI related information and detects that NR cells have experienced PCI conflict or confusion.

NOTE 1: C-PCI configuration function may record the count of PCI conflict or confusion in performance measurements.

The C-PCI configuration function consumes the management service for NF provisioning with *modifyMOIAttributes* operation (see clause 5.1.3 in TS 28.532 [26]) to configure a specific PCI value or a list values for each newly deployed NR cell.

gNB detects the PCI conflict among NR cells (see clause 5.2.2 in TR 37.816 [12]), resulting in a notification notifyNewAlarm being sent to the C- PCI configuration function, indicating the PCI conflict has been detected on NR cells.

C-PCI configuration function consumes the management service for NF provisioning with *modifyMOIAttributes* operation to reassign new PCI value(s) for each affected NR cell.

gNB detects that the PCI conflict has been resolved, resulting in a notification notifyClearedAlarm being sent to the C-PCI configuration function, indicating the PCI conflict has been resolved.

NOTE 2: PCI related measurements need to be defined to support centralized PCI configuration function.

## 7.4 Void

## 7.5 Load Balancing Optimization

### 7.5.1 General

This subclause the solutions for the use case of load balancing optimization (see use case in clause 5.7).

### 7.5.2 Management of distributed LBO

The D-LBO management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation (see clause 5.1.3 in TS 28.532 [26]) to configure the policy (e.g. threshold, target) of D-LBO function.

The D-LBO management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation to enable the D-LBO function.

D-LBO function analyses the load related information (see clause 5.4.2 in TR 37.816 [12]) to perform load balancing by means of optimization of cell reselection/handover parameters and handover actions (e.g. offloading UEs to neighboring cells) (see clause 5.4.1 in TR 37.816 [12]), resulting in a notification notifyMOIAttributeValueChanges (see clause 5.1.9 in TS 28.532 [26]) being sent to notify the D-LBO management function that the reselection/handover parameters have been changed, and/or the update of virtualized resources is needed.

The D-LBO management function collects the performance measurements (e.g. the number of RRC connection establishment / release, abnormal release, handover failures, call drops, etc…) to evaluate the D-LBO performance (see clause 4.2.5 in TS 32.522 [28]).

The D-LBO management function analyses the measurements, and may perform one of the following actions, if the D-LBO performance does not meet the target:

1. Consume the management service for NF provisioning with *modifyMOIAttributes* operation to update the policy;

2. Determine actions to optimize the traffic load distributions among neighboring cells, by invoking *modifyMOIAttributes* operation to disable the D-LBO function and change the parameters, such as the handover and/or reselection parameters (TR 38.300 [13]) of the cell or its neighbors.

NOTE: NRM may need to be enhanced to support the policy and control of D-LBO function, and handover related parameters.

### 7.5.3 Centralized LBO

It is assumed that the C-LBO function may have received LBO target from a consumer, and has consumed the management service to collect load related measurements, and relevant IOCs have been created to support C-LBO.

The C-LBO function collects the load performance measurements (e.g. radio resource usage, HW / VR / TNL load indicators, Composite Available Capacity PRB, TNL measurements, …) or notifications (e.g. threshold crossing of certain measurements) from gNB-CU-CP, gNB-CU-UP(s), gNB-DU(s) (see clause 5.4.2 in TR 37.816 [12]).

The C-LBO function analyses the measurements to determine the actions, as shown below, to optimize the traffic load distributions among neighbouring cells:

1. Invoke *modifyMOIAttributes* operation to change the parameters, such as the handover and/or reselection parameters (TR 38.300 [13]) of the cell or its neighbours.

The C-LBO function collects the performance measurements (e.g. the number of RRC connection establishment / release, abnormal release, handover failures, call drops, etc…).

The C-LBO function analyses the performance measurements to evaluate the LBO performance, and may invoke *modifyMOIAttributes* operation to update the handover and/or reselection parameters if the performance does not meet the target.

NOTE: LBO related performance measurements need to be defined to support C-LBO function.

## 7.6 Void

## 7.7 RACH Optimization (Random Access Optimization)

### 7.7.1 General

This subclause the solutions for the use case of RACH optimization (see use case in clause 5.9).

### 7.7.2 Management of RACH optimization

It is assumed that the RACH optimization management function has consumed the management service to collect RACH optimization related measurements.

The RACH optimization management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation (see clause 5.1.3 in TS 28.532 [26]) to configure the targets for D-RACH optimization function, as shown below (see clause 5.5.1 in TR 37.816 [12]).

- Minimize access delays for the UEs under the coverage of popular SSBs

- Minimize the delays for the UEs to request the other SIs

- Minimize the imbalance of UEs access delays on uplink (UL) and supplementary uplink (SUL) channel

- Minimize the beam failure recovery delays for the UEs in RRC\_Connected.

- Minimize the failed/unnecessary RACH attempts on RACH resource before success.

The RACH optimization management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation to enable the D-RACH optimization function for a given NR cell.

The D-RACH optimization function receives the RACH information report, and analyses them to determine the actions to optimize the RACH performance if the performance does not meet the targets by updating the following RACH parameters (see clause 5.5.2 in TR 37.861 [12]):

- RACH configuration (resource unit allocation);

- RACH preamble split (among dedicated, group A, group B);

- RACH backoff parameter value;

- RACH transmission power control parameters.

The D-RACH optimization function informs the management service producer for NF provisioning to send a notification notifyMOIAttributeValueChange to the RACH optimization management function (see clause 5.1.9 in TS 28.532 [26]), indicating the RACH parameters have been changed.

The RACH optimization management function collects the following RACH related measurements (see clause 4.6.4 in TS 32.552 [28]):

- Distribution of the number of preambles UEs sent to achieve synchronization, where the number of preambles sent corresponds to PREAMBLE\_TRANSMISSION\_COUNTER (see clause 5.1.1 in TS 38.321 [5]) in UE.

- Distribution of the time needed for UEs to achieve synchronization, including access delay and UE request delay;

- Distribution of beam failure recovery delays.

The RACH optimization management function analyses the measurements to evaluate the RACH performance, and may perform one of the following actions, when the RACH optimization performance does not meet the targets:

1) Consume the management service for NF provisioning with *modifyMOIAttributes* operation to update the targets for the RACH optimization function;

2) Consume the management service for NF provisioning with *modifyMOIAttributes* operation to disable RACH optimization function, and update the RACH parameters.

NOTE 1: NRM needs to be enhanced to support RACH optimizations related attributes, such as RACH performance targets, and RACH parameters.

NOTE 2: RACH optimization related performance measurements need to be defined.

## 7.8 Capacity and Coverage Optimization

### 7.8.0 Overview of Potential solution for CCO

There are following potential solutions to address Capacity and Coverage Optimization:

Solution A: 3GPP management system (3GPP Cross Management Domain or Management Domain) management with RAN distributed CCO:

- A-1: RAN Distributed CCO managed by only 3GPP Cross Management Domain

- A-2: RAN Distributed CCO managed by both 3GPP Cross Management Domain and Management Domain

Solution B: Centralized CCO without RAN distributed CCO:

- B-1: Domain centralized CCO managed by 3GPP Cross Management Domain

- B-2: 3GPP Cross Management Domain centralized CCO only

### 7.8.1 Potential solution for centralized CCO

The Figure 7.8.1-1 illustrates the framework for EM centralized CCO with NM controlled policies. The CCO Algorithm is located in MnS Producer for CCO.

- EM as MnS Producer for CCO is responsible for coverage and/or capacity issues detection and optimization.

- NM as MnS Consumer for CCO is responsible for CCO policy control for RAN SubNetwork.

- MnS for CCO is utilized by NM to trigger CCO optimization task with specified corresponding CCO policies, and receive the notification about the coverage and/or capacity issues occurrence and corresponding recovery.

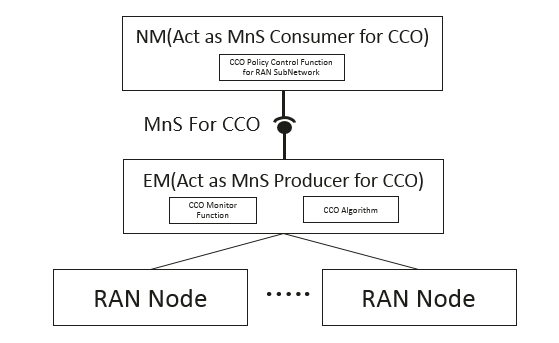


Figure 7.8.1-1: Framework for EM centralized CCO with NM controlled policies

The Figure 7.8.1-2 illustrates the procedure for EM centralized coverage and capacity optimization.

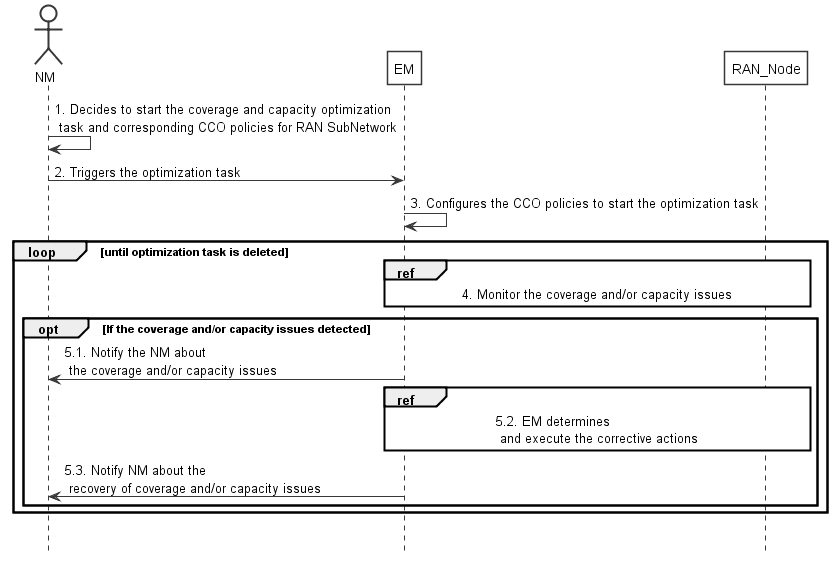


Figure 7.8.1-2: Procedure for EM centralized CCO with NM controlled policies

1) NM (act as MnS Consumer for CCO) decides to start the coverage and capacity optimization task and corresponding CCO policies for RAN Subnetwork, including coverage and/or capacity issue detection condition (e.g. SINR threshold for coverage hole and weak coverage) and optimization constraint condition (e.g. optimization regions, optimal coverage, minimum uplink interference).

2) NM triggers the optimization task to EM (act as MnS Producer for CCO) with corresponding optimization object (RAN Subnetwork) and CCO polices specified.

3) EM configures the CCO policies to start the optimization task.

4）EM monitor the coverage and/or capacity issues (i.e. Coverage hole, Weak coverage, Pilot pollution, Overshoot coverage, DL and UL channel coverage mismatch defined in TS 28.628[9]) based on CCO related performance measurements collected.

5.1) When EM detected the coverage and/or capacity issues, EM may notify the NM about the occurrence of coverage and/or capacity issues.

5.2) EM determines the corrective actions (e.g. switch on antenna pattern) to address the coverage and/or capacity issues.

5.3) If the corrective actions are executed and the detected issues are addressed successfully, the EM may notify the NM about the recovery of coverage and/or capacity issues.

## 7.9 Self-healing

The function Self-healing has not been addressed in the present document.

## 7.10 SON coordination

The function SON coordination has not been addressed in the present document.

## 7.11 Multi-vendor Plug and Play eNB connection to the network

See clause 7.1.

## 7.12 SON for AAS-based Deployments

In E-UTRAN networks, SON for AAS-based Deployments uses techniques like cell splitting and cell merging. As the NG-RAN uses beamforming for sub-sector structures, these techniques are not relevant for NR-RAN. Instead, Coverage and Capacity Optimization will cover this topic.

## 7.13 Trace and MDT

Potential solutions from TS 32.422 [31] will be considered.

## 7.14 Mobility Robustness Optimization

### 7.14.1 General

This subclause the solutions for the use case of mobility robustness optimization (see use case in clause 5.16).

### 7.14.2 Management of mobility robustness optimization

It is assumed that the MRO management function has consumed the management service to collects handover related measurements.

The MRO management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation (see clause 5.1.3 in TS 28.532 [26]) to configure the ranges for the NR and EUTRAN handover parameters and the targets for the D-MRO function.

The MRO management function consumes the management service for NF provisioning with *modifyMOIAttributes* operation to enable the D-MRO function for a given NR cell.

The D-MRO function detects the handover issues (e.g. too late HO, too early HO and HO to a wrong cell) in intra-RAT or inter-RAT mobility by analysing the reports from UE and network side information, and then determine the actions to mitigate the HO issues by adjusting HO related parameters (see clause 5.3.1 in TR 37.861 [12]).

The D-MRO function informs the management service producer for NF provisioning to send a notification notifyMOIAttributeValueChange to the MRO management function (see clause 5.1.9 in TS 28.532 [26]), indicating the HO related parameters have been changed.

The MRO management function collects the handover related measurements and radio link failure reports to evaluate the handover performance (see clause 4.3.5 in TS 32.552 [28]).

The MRO management function analyses the measurements and radio link failure reports, and determines to perform one of the following actions, when the handover performance does not meet the targets:

1) Consume the management service for NF provisioning with *modifyMOIAttributes* operation to update the targets for the D-MRO function;

2) Consume the management service for NF provisioning with *modifyMOIAttributes* operation to update the ranges of handover parameters for the NR neighbour relations and EUTRAN neighbour relations;

3) Consume the management service for NF provisioning with *modifyMOIAttributes* operation to update the ranges of handover parameters (see clause 5.5.4 in TS 38.331 [6]) for NR neighbour relations with values deemed to improve handover performance.

NOTE 1: NRM needs to be enhanced to support MRO related attributes, such as MRO ranges, targets, and ranges of handover parameters.

NOTE 2: Handover related performance measurements need to be defined.

## 7.15 Energy Saving Management

Energy saving management is addressed in TS 28.310 [24].

## 7.16 Automatic Neighbour Relation (ANR) optimization

### 7.16.1 General

This subclause the solutions for the use case of ANR optimization (see use case in clause 5.4).

### 7.16.2 ANR optimization

1. The ANR optimization function (a.k.a. MnS producer for ANR optimization) consumes the NF provisioning service to get the attributes of the NR cells with getMOIAttributes operation.

The ANR optimization function gets the geographical data and terrain data of the NR cells from a data source (such as radio planning tool), see Note.

The ANR optimization function may get the data mentioned above regularly or once being notified that the data have been changed.

NOTE: how to get the geographical data and terrain data of NR cells is FFS.

The ANR optimization function analyses the NR cells attributes, the geographical data and terrain data, and determines to consume the NF provisioning service add or blacklist one or more NCRs:

- by operation createMOI to add a new NCR for a NR cell;

- by operation modifyMOIAttributes to blacklist a NCR (i.e., setting the is HoAllowed attribute to "no").

2. The ANR optimization function consumes the NF PM service to regularly collect the performance measurements related to abnormal RRC connection releases of the NR cells and the performance measurements about handover failures for the NCRs. The ANR optimization function may also consume the NF PM service to receive the notifyThresholdCrossing notifications for these performance measurements.

The ANR optimization function consumes the Trace/MDT service to collect the RLF/RCEF reports related the NR cells.

The ANR optimization function analyses the collected performance measurements and RLF/RCEF reports, and determines to consume the NF provisioning service to blacklist one or more NCRs if the performance about the NCRs does not meet the requirements:

- by operation modifyMOIAttributes to blacklist a NCR.

## 7.17 Cross-slice network resource optimization

The following steps support cross-slice network optimization as described in clause 5.20.

1) The NFV-MANO system sends information to the 3GPP management on changes in resources.

2) The 3GPP management analyses whether the change in resources causes problems or when resources are not optimal utilized in the supporting the network slices.

3) In case of resource problems, the CSPs are notified by the 3GPP management via an API.

4) The CSPs decide on the action they prefer: by adjusting the priority of slices or by adjusting the current minimal resource requirements needed for the slices.

5) The CSPs communicate their preferences to the 3GPP management.

6) The 3GPP management checks whether the new modification by the CSP solves the resource problems. If not, then steps 3, 4 and 5 be executed again for affected slices, with a predetermined maximum for the number of iterations.

7) If the new configuration can solve the resource problems, the slice priorities and/or resource requirements will be updated by the 3GPP Management and will be propagated via the interface Os-Ma-nfvo towards the NFV-MANO.

8) In the case of resources that are not utilized optimal, the 3GPP management system will reallocate resources to optimize performance among NSSIs.

# 8 Conclusion and recommendation

## 8.1 Self-establishment of non-virtualized NFs, including automated Software Management

The features and solution as described in clause 7.1 are recommended to be specified in the normative work.

## 8.2 Automatic Neighbour Relation (ANR) management (including automatic X2 setup)

The features and solution as described in clause 7.2 are recommended to be specified in the normative work.

## 8.3 PCI Configuration

The features and solution as described in clause 7.3 are recommended to be specified in the normative work.

## 8.4 Void

## 8.5 Automatic Neighbour Relation (ANR) optimization

The features and solution as described in clause 7.16 are recommended to be specified in the normative work.

## 8.6 Load Balancing Optimization

The features and solution as described in clause 7.5 are recommended to be specified in the normative work.

## 8.7 RACH Optimization (Random Access Optimization)

The features and solution as described in clause 7.7 are recommended to be specified in the normative work.

## 8.8 Centralized Capacity and Coverage Optimization

The features and solution as described in clause 7.8 are recommended to be specified in the normative work.

## 8.9 Self-healing

The function Self-healing has not been addressed in the present document.

## 8.10 SON coordination

The function SON coordination has not been addressed in the present document.

## 8.11 Multi-vendor Plug and Play of NFs

See clause 8.1.

## 8.12 SON for AAS-based Deployments

In E-UTRAN networks, SON for AAS-based Deployments uses techniques like cell splitting and cell merging. As the NG-RAN uses beamforming for sub-sector structures, these techniques are not relevant for NR-RAN. Instead, Coverage and Capacity Optimization will cover this topic.

## 8.14 Trace and MDT

Trace is already supported since Rel-15.

Support for MDT is present in RAN specifications for Rel-16, however, no support exists for management of MDT. Therefore, it is recommended to specify MDT management support in the normative work.

## 8.15 Mobility Robustness Optimization

The features and solution as described in clause 7.14 are recommended to be specified in the normative work.

## 8.16 Energy Saving Management

It’s recommended to do normative work for Energy Saving Management in TS 28.310 [24].

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2019-12 | SA#86 | SP-191210 |  |  |  | Presented for approval | 2.0.0 |
| 2019-12 | SA#86 |  |  |  |  | EditHelp review + change control version | 16.0.0 |