## NSA performance optimization experience

### UE Camp Strategy

Considering not all LTE carriers support EN-DC and UE may support limited EN-DC band combination, there is a need for the NW to identify NSA UE and try to let it camp on the suitable LTE carrier.

NW should identify NSA UE and get its EN-DC combination information from UE capability. UE includes EN-DC capability indication in LTE attach request message, so NW could enquire UE’s NR and EN-DC capability in the following UE capability transfer procedure. With the detailed UE NR/EN-DC capability, NW could configure UE accordingly, including UE camping and SCG addition etc.

NW should be able to handover the NSA UE to the EN-DC capable LTE carrier before or during SCG addition. And NW could send specific carrier priority to the NSA UE when RRC release, to keep UE camping on the EN-DC capable LTE carrier in the idle state.

In addition, NW should also consider load balance between LTE carriers, due to specific UE camp strategy for the NSA UE.

### SCG Addition and Release

#### Addition Strategy

There are two possible methods to add SCG for the UE.

* Blind addition, which means that eNB directly add SCG for the UE without UE measurement. It is suitable for the scenario that the NR gNB is deployed 1:1 as eNB, and the coverage of gNB is also similar with eNB. Although this method is simple, there is possibility that the SCG addition is failed or the gNB added is not the best cell for the UE.
* NR measurement based, i.e. eNB add SCG for the UE based on measurement report from UE. This method is used more widely as it can be used for any scenarios. It needs measurement configuration from NW (see more details in part 6.3.2.2).

Blind SCG add is not recommended for early deployment as NR coverage is not ubiquitous. In addition, blind addition may lead to higher UE power consumption, esp for FR2. Measurement based is recommended.

Besides based on RF, traffic could be another factor to be considered in combination with RF in deciding/ implementing on demand SCG add. The traffic consideration may include the underline LTE adv features and capabilities deployed, and the offered traffic and delay requirements, as well as the thresholds and needs for LTE offloading to NR. Another thing to consider is network KPIs on NR usage ratio. This can be an operator individual needs per their specific 5G build out situation and market competition landscape.

#### NR measurement in LTE

NR measurement is an IRAT measurement for LTE. The configuration of measurement from eNB should include

* Measurement object: here measObjectNR-r15 is defined for NR, and it include carrierFreq, rs-ConfigSSB, threshRS-Index, maxRS-IndexCellQual etc. The field need to notice is the IE measTimingConfig in rs-ConfigSSB, which specifies the measurement timing configuration (MTC) applicable for SSB based NR measurements i.e. the time occasions for performing these measurments. Network should make sure the measurement gap (if configured based on UE capability) covers SSB transmission timing. More importantly, frame timing sync between gNB and eNB is required for fast and accurate IRAT measurement, which is also required for following DSS deployment etc.
* Report configuration: The event B1, “neighbor cell is better than an absolute threshold” is typically used to trigger the NR Cell addition in EN-DC. And network could configure the UE to report beam-level measurements, in addition to the cell-consolidated measurements. To maximize NR footprint without impacting experience, the B1 related parameters should be optimized according to deployed scenarios.
* If necessary, determined by UE capability, measurement gaps need to be configured so that UE can tune way from operating frequency.

According to the configuration above, UE will perform NR measurement and send out the measurement report if the condition meets.

#### SCG addition

In the SCG addition procedure, there are two configurations from NW, one is radio bearer configuration, and another is NR configuration mainly referring to low layer configuration for NR SCG.

For the radio bearer configuration:

* It is recommended that NW configure proper PDCP version based on service and UE capability. For example, NW selects NR PDCP version for Internet Data DRB (QCI=9), while for VoLTE DRB (QCI=1 and 5), LTE PDCP should be kept (NR PDCP can be used for VoLTE DRB only when it is indicated in UE Capability).
* For UL bearer, it is recommended that NW configure split or non-split bearer according to UE’s capability. Furthermore, for the UE not supporting UL split bearer, when NR coverage is good, configure UL bearer terminated at gNB; if the NR UL coverage becomes poor while the NR DL coverage is still acceptable, NW could reconfigure the UL bearer terminated at eNB before final SCG release.

For the NR configuration:

* Parameters for different protocol layers and different channels/signals are configured here. There are more parameters/features in NR system and the settings are more flexible in NR than that in LTE. NW should configure these parameter settings strictly according to UE capability reported. Setting network parameters according to interoperability test results feature and capability agreements, and based on UE capability would ensure that operator’s network have a uniform performance in network KPIs and in user perception. Network operator plays an important role in determine what the network parameters and configurations should be and how they want to network to perform, so operator should take charge in mandate and streamline the network’s key parameters.

#### SCG release

A2 based SCG release is recommended. Otherwise, SCG failure will be triggered, which results in bad user experience. Additionally, on demand SCG release can be considered, which means SCG should be released after an inactivity period or data volume decrease below certain threshold.

### SCG failure handling

SCG failure could happen during EN-DC, triggered by SCG RLF, SN change failure, etc. Then UE will report the SCG failure information to MN and may also include the measurement results of SN. MN handles the SCG failure information message and may decide to keep, change, or release the SN.

Currently, one common method is to release the SN after SCG failure, then reconfigure B1 event for NR measurement for the next round of SCG addition. In this way, UE may encounter a long period without NR service.

A potential optimization deserved to be considered is that MN can utilize the NR measurement results included in the SCG failure information. For some scenarios, if there are better NR cell/beam candidates in the measurement result, MN can use such information to change SCG directly.

### Mobility

There are three scenarios for NSA mobility, LTE handover with SCG unchanged, SCG change without LTE handover and LTE handover with SCG change. Especially, the first two scenarios are very common in real NSA network.

#### LTE Handover with SCG unchanged

LTE handover with SCG unchanged can be implemented by three ways.

* The first is to inherit previous SCG configuration by omit spCellConfigCommon under ReconfigurationWithSync and set endc-ReleaseAndAdd-r15 to FALSE,
* The second is to reconfigure the SCG by setting endc-ReleaseAndAdd-r15 to TRUE and reconfigure spCellConfigCommon under ReconfigurationWithSync.
* The third is to release the SCG firstly by setting nr-Config-r15 to release during LTE handover command, then add SCG in the target LTE cell by a new round of B1 measurement config and report

From configuration processing complexity and NR interruption delay perspective, 1st method is better.

For the LTE handover with SCG unchanged, commonly there should be no need to reconfigure or update the SCG configuration, so the 1st method is recommended.

Although SCG is unchanged, sometimes there may be some configurations update required by the new LTE anchor eNB. In such scenario, 2nd method is recommended.

The 3rd method is not recommended, implementation improvement is needed.

#### SCG change without LTE change

SCG change can be triggered by both MN and SN. Commonly, inter-rat measurement for NR is removed from MN after NW received B1 measurement report (before SCG addition), so the SCG change is mainly triggered by SN from filed trial experience. NR measurement for SCG handover is configured with A3 event. Once A3 measurement report is reported, SCG change procedure is triggered.

The common way observed is to reconfigure SCG with new NR cell in only one RRCReconfiguration message.

### Other optimization on NR e.g. Beam switching

The aspects in first 4 parts are specifically related with NSA. Besides, there are also many optimizations needed on NR network itself, e.g. Beam switching for multi-SSB deployment.

SSB based beam switching is highly recommended at early NSA stage, which is also mandatory per 3gpp requirement. Otherwise, network performance will be impacted, causing issues to user experiences, such as low UL/DL throughput, SCG RLF, etc.

When deploying and optimizing the network, operators should mandate that network equipment to follow 3GPP requirements to ensure below configurations:

* Configure different CSI-RS/TRS QCLed with different SSBs
* Configure different TRS in orthogonal time/freq-domain resource
* MAC-CE SSB beam switch based on UE L1-RSRP beam report