LTE eRAN18.1 Feature Delta (VDF)

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Objectives

- Upon completion of this course, you will be able to:
  - Know the feature delta in eRAN18.1
  - Understand principles for new features in eRAN18.1
  - Acknowledge benefits of new features in eRAN18.1
  - Activate new features of eRAN18.1

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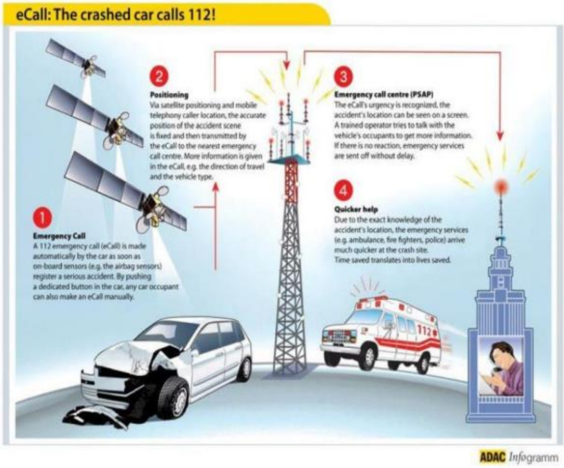
Next Generation eCall over LTE – Background



- eCall is an in-vehicle emergency call system that automatically initiates emergency calls when necessary
- Pervious eCall is carried by 2G/3G network, considering that 2G/3G has been withdrawn, operator need to migrate eCall from 2G/3G to 4G
- LTE Rel14 defines the next generation emergency call based on LTE, which is called NG-eCall
- The general NG-eCall requirement is similar as the emergency call for VoLTE

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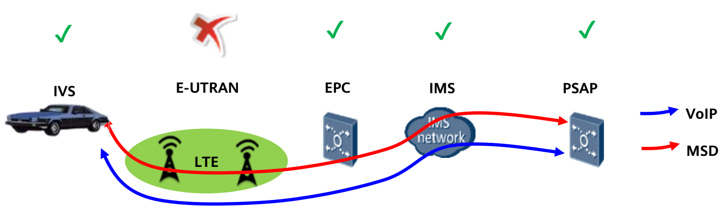
Next Generation eCall over LTE – WHY

- Due to the gradual withdrawal of 2G and 3G networks and the success of 4G networks, an IMS-based in-vehicle emergency call system has come into play.
- eCall is an in-vehicle system that automatically initiates emergency calls when necessary. It aims to provide rapid assistance for motorists involved in incidents.
- This system requires E2E support. It is currently supported by the core networks provided by Huawei and PSAP servers provided by third-party vendors. As such, Huawei released Next Generation eCall over LTE (NG-eCall for short).

Next Generation eCall over LTE – HOW

- In the event of an incident, the eCall system of the vehicle is activated and automatically contacts emergency services. It sends necessary information (including the incident location and time, number of passengers, and license plate number) to the data platform of the PSAP through a voice channel, speeding up emergency response. The eCall system can be activated as follows:
  - Manual activation: Press the emergency button to manually activate the system.
  - Automatic activation: The in-vehicle sensor automatically activates the system once it detects an opened airbag or emergency situation such as a collision or rollover.



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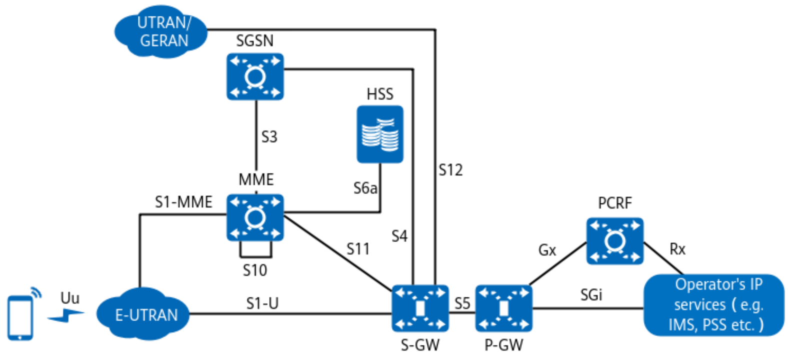
- MSD: Related Initial Data
- IVS: in-vehicle system
- PSAP: public safety answering point

Next Generation eCall over LTE – HOW (Cont.)

- The network architecture of NG-eCall is the same as that of IMS-based emergency call.



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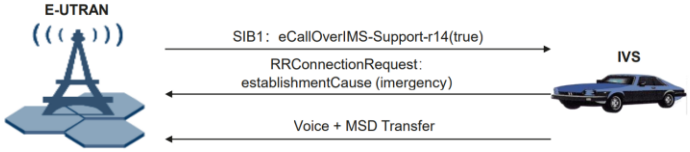
Key Procedure

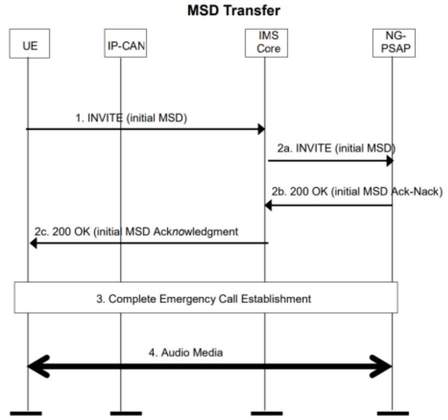
- A serving network shall provide an Access Stratum broadcast indication to UEs as to whether eCall Over IMS is supported



Domain Selection Rules for eCall over IMS session attempts for E-UTRAN radio access networks

	PS Available	VoIMS	EMS	ECL	First eCall Attempt	Second eCall Attempt
A	Y	Y	Y	Y	PS	CS if available
B	Y	Y	Y	N	CS if available	PS (UE establishes IMS emergency session)
C	Y	Y or N	N	N	CS if available	No attempt is made in the PS domain
D	Y	N	Y	Y	PS or CS if available	CS if first attempt in PS PS if first attempt in CS
E	Y	N	Y	N	CS if available	PS (UE establishes IMS emergency session)
F	N	-	-	-	CS if available	

VoIMS = Voice over IMS over PS sessions support as indicated by IMS Voice over PS session supported indication.
EMS = IMS Emergency Services supported as indicated by Emergency Service Support indicator.
ECL = eCall Over IMS support as indicated by the eCall support indicator.



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Next Generation eCall over LTE – Network Analysis

- Benefits
  - NG-eCall brings rapid assistance to motorists involved in incidents by speeding up emergency response through communication between the eCall system and the PSAP.
- Impacts
  - None

Next Generation eCall over LTE – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations DBS3900 LampSite and DBS5900 LampSite • Boards No requirements • RF Modules No requirements
Software Requirements	• Prerequisite Functions SRVCC to UTRAN, SRVCC to GERAN, VoIP semi-persistent scheduling • Mutually Exclusive Functions None
Network Requirements	The IMS network has been deployed.
NE Requirements	None

- Software:
  - SRVCC to UTRAN: If SRVCC handovers are required for emergency call services, the **UtranSrvccSwitch** option of the **CellHoParaCfg**.HoModeSwitch parameter needs to be selected.
  - SRVCC to GERAN: If SRVCC handovers are required for emergency call services, the **GeranSrvccSwitch** option of the **CellHoParaCfg**.HoModeSwitch parameter needs to be selected.
  - VoIP semi-persistent scheduling: If **CellAlgoSwitch**.EmcSpsSchSwitch is set to **ON**, uplink and downlink semi-persistent scheduling needs to be enabled.
- License
  - There are no license requirements for basic functions.

Next Generation eCall over LTE – Feature Deployment (Cont.)

- Activation
  - Configuring NG-eCall for UEs in the normal service state(MOD EMC is a high-risk command.)
    - MOD EMC: CnOperatorId=0, EmcEnable=ON, EmergCallOptimizationSw=NG_ECALL_SW-1;
  - Configuring NG-eCall for UEs in the limited service state
    - MOD EMC: CnOperatorId=0, EmcEnable=ON, EmcEnableInLimitedMode=ON, EmergCallOptimizationSw=NG_ECALL_SW-1;

Next Generation eCall over LTE – Feature Verification

- Activation verification
  - Assume that a UE has initiated an emergency call on a network. If L.RRC.ConnReq.Att.Emc and L.EMC.E-RAB.AttEst have non-zero values, this function has taken effect.
- Counter

Counter Name	Counter ID	Counter Description
L.RRC.ConnReq.Att.Emc	1526728217	Number of RRC connection setup attempts with a cause value of emergency
L.EMC.E-RAB.AttEst	1526728167	Number of E-RAB setup attempts for emergency calls in a cell

Q&A

1. The network architecture of Next Generation eCall over LTE (NG-eCall) is the same as that of IMS-based emergency call.
   - √
   - x

- Answer: √

Section Summary

- Next Generation eCall over LTE (NG-eCall) is an evolution of IMS-based emergency call , with the network architecture remaining unchanged.

Contents

3GPP R16 NB-IoT Specifications Solution Overview – WHY

- According to 3GPP R14, UEs report downlink CQIs in Msg3, after which no CQI will be reported. In the event of channel quality changes, the repetition counts of the NPDCCH and the NPDSCH
- The capacity of an NB-IoT cell is mainly limited by downlink channels. In multi-carrier scenarios, the CQI reported in Msg3 indicates only the Msg2 carrier. If the power configurations and suffered interference vary between carriers in multi-carrier scenarios, the repetition counts of downlink channels may not match the actual conditions after carrier switching, causing performance loss.

3GPP R16 NB-IoT Specifications Solution Overview – HOW

- DCQR transmission in RRC_CONNECTED mode
  - The eNodeB can proactively send a MAC control element (MCE) to instruct a UE to report a CQI. Based on the CQI reported by the UE, the eNodeB determines whether to adjust the repetition counts of the NPDCCH and the NPDSCH in downlink scheduling.
- AS-RAI enhancement
  - The eNodeB can proactively send a MCE to instruct a UE to report an AS-RAI. Based on the AS-RAI reported by the UE, the eNodeB determines whether to release the RRC connections as soon as possible or retain the RRC connections.

- Downlink Channel Quality Report (DCQR) transmission in RRC_CONNECTED mode: If the **CONN_DCQR_SWITCH** option of the **CellAlgoExtSwitch**.NbCellAlgoExtSwitch parameter is selected, the eNodeB can proactively send a MAC control element (MCE) to a UE complying with 3GPP R16 and capable of DCQR transmission in RRC_CONNECTED mode, instructing the UE to report a CQI. Based on the CQI reported by the UE, the eNodeB determines whether to adjust the repetition counts of the NPDCCH and the NPDSCH.
- Access Stratum Release Assistance Indication (AS-RAI) enhancement: If the **AS_RAI_ENH_SWITCH** option of the **CellAlgoExtSwitch**.NbCellAlgoExtSwitch parameter is selected, the eNodeB can proactively send a MCE to a UE complying with 3GPP R16 and capable of AS-RAI reporting, instructing the UE to report an AS-RAI. Based on the AS-RAI reported by the UE, the eNodeB determines whether to release the RRC connections as soon as possible or retain the RRC connections.

3GPP R16 NB-IoT Specifications Solution – Network Analysis

- Benefits
  - DCQR transmission in RRC_CONNECTED mode adjusts the repetition counts of downlink channels in real time to improve scheduling performance and cell capacity.
  - AS-RAI enhancement can trigger UE release in advance so that the UEs enter idle mode, reducing power consumption.
- Impacts
  - The UE information retrieval procedure increases service delay for UEs whose information is originally not required to be acquired.

3GPP R16 NB-IoT Specifications Solution – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations, and DBS3900 and DBS5900 LampSite base stations • Boards All NB-IoT-capable boards support this function. • RF Modules All NB-IoT-capable RF modules support this function.
Software Requirements	• Prerequisite Functions UE information retrieval procedure • Mutually Exclusive Functions None
Network Requirements	None
NE Requirements	UEs must comply with 3GPP R16 and support DCQR transmission in RRC_CONNECTED mode and AS-RAI reporting.

- For details about UE capabilities, see section 6.7.3 "NB-IoT information elements" in 3GPP TS 36.331 V16.4.0.
- DCQR transmission in RRC_CONNECTED mode and AS-RAI enhancement depend on the UE information retrieval procedure.
- License
  - There are no license requirements.

3GPP R16 NB-IoT Specifications Solution – Feature Deployment (Cont.)

- Activation
  - DCQR transmission in RRC_CONNECTED mode(**MOD CELLALGOEXTSWITCH** is a high-risk command.)
    - MOD CELLALGOEXTSWITCH: LocalCellId=0, NbCellAlgoExtSwitch=CONN_DCQR_SWITCH-1;
  - AS-RAI enhancement(**MOD CELLALGOEXTSWITCH** is a high-risk command.)
    - MOD CELLALGOEXTSWITCH: LocalCellId=0, NbCellAlgoExtSwitch=AS_RAI_SWITCH-1;

3GPP R16 NB-IoT Specifications Solution – Feature Verification

- Counter
  - DCQR transmission in RRC_CONNECTED mode increases the average uplink and downlink throughput of NB-IoT cells.

Counter Name	Counter ID	Counter Description
L.NB.Thrp.bits.UL.SRB	1526744708	Number of bits received on uplink SRBs in an NB-IoT cell
L.NB.Thrp.Time.UL.SRB	1526744711	Duration when uplink SRBs receive data from UEs in an NB-IoT cell
L.NB.Thrp.bits.DL.SRB	1526744702	Number of bits successfully transmitted on downlink SRBs in an NB-IoT cell
L.NB.Thrp.Time.DL.SRB	1526744705	Duration when downlink SRBs have data to transmit in an NB-IoT cell

  - After AS-RAI enhancement is enabled, run the **LST CELLALGOEXTSWITCH** command to check whether the AS-RAI enhancement switch is on.

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- Average uplink throughput of an NB-IoT cell =L.NB.Thrp.bits.UL.SRB/L.NB.Thrp.Time.UL.SRB
- Average downlink throughput of an NB-IoT cell = L.NB.Thrp.bits.DL.SRB/L.NB.Thrp.Time.DL.SRB

Q&A

1. Which of the following functions are added to 3GPP R16 NB-IoT Specifications?
   A. DCQR transmission in RRC_CONNECTED mode
   B. System information broadcast
   C. AS-RAI enhancement
   D. Idle mode management

- Answer: AC

Section Summary

- The following functions have been added to 3GPP R16 NB-IoT Specifications:
  - DCQR transmission in RRC_CONNECTED mode
  - AS-RAI enhancement

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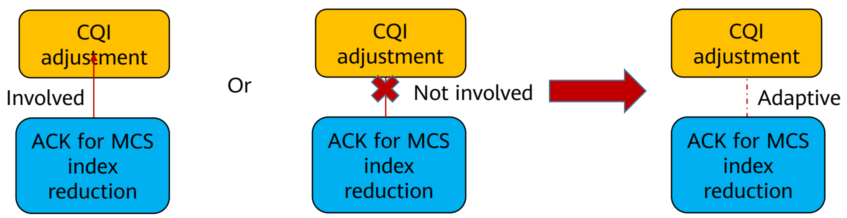
FDD Downlink MCS Selection Optimization Solution Overview – WHY

- During initial transmissions, always using the ACK after MCS index reduction for CQI adjustment may cause mismatch between the MCS index selected for scheduling and the actual channel quality.
- If there are remaining RB resources in a cell during retransmissions, cell RB resources may be wasted.
- Downlink MCS selection optimization is intended for both initial transmissions and retransmissions.

- ACK for MCS index reduction: During scheduling, if the MCS index of a UE is reduced and the HARQ feedback after the MCS index reduction is ACK, the eNodeB adaptively determines to use the ACK in CQI adjustment.

FDD Downlink MCS Selection Optimization Solution Overview – HOW (Cont.)

- MCS Selection optimization for initial transmissions
  - The IBLER measured in the previous period is compared with the target IBLER and the ACK for MCS index reduction in the current period is adaptively used for CQI adjustment based on the comparison result.



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- **CellCqiAdjAlgo**.IblerTargetOffset: target IBLER offset
- When MCS selection for initial transmissions takes effect:
  - When the measured IBLER in the previous period is greater than the target IBLER plus the offset specified by **CellCqiAdjAlgo**.IblerTargetOffset, the UE BLER is relatively high and the ACK for MCS index reduction in the current period is not used for CQI adjustment.
  - When the measured IBLER in the previous period is less than the target IBLER minus the offset specified by **CellCqiAdjAlgo**.IblerTargetOffset, the UE BLER is relatively low and the ACK for MCS index reduction in the current period is used for CQI adjustment.
  - When the measured IBLER in the previous period ranges from the result of the target IBLER minus the offset specified by **CellCqiAdjAlgo**.IblerTargetOffset to the result of the target IBLER plus this offset, the ACK for MCS index reduction in the current period is used for CQI adjustment based on a certain weighting proportion.

FDD Downlink MCS Selection Optimization Solution Overview – HOW (Cont.)

- MCS selection optimization for retransmissions
  - Allocates more RBs for initial transmission when there are remaining RBs in a cell, a UE has both retransmission and initial transmission requests to be scheduled.
  - Increases the TBS indexes used for the first and second downlink HARQ retransmissions to spare RBs for initial transmission scheduling if no remaining RB resources are expected to be available in a cell.

FDD Downlink MCS Selection Optimization – Network Analysis

- Benefits
  - MCS selection optimization for initial transmissions accelerates the IBLER convergence.
  - MCS selection optimization for retransmissions increases the downlink RB usage.
  - When the RB usage is greater than 30%, MCS selection optimization for initial transmissions and retransmissions increases the average downlink UE throughput by 1–5% and shortens the downlink first-packet transmission delay.
  - When the RB usage is less than or equal to 30%, this function increases the average downlink UE throughput less significantly but does not bring negative impacts.
- Impacts
  - After downlink MCS selection optimization takes effect, the downlink RBLER may increase.

- Average downlink UE throughput: User Downlink Average Throughput = (L.Thrp.bits.DL – L.Thrp.bits.DL.LastTTI)/L.Thrp.Time.DL.RmvLastTTI
- Downlink first packet delay for UEs = L.Traffic.DL.EmptyBuf.PDCPLat.Time/L.Traffic.DL.EmptyBuf.PDCPLat.Num
- RBLER: residual block error rate
- Downlink RBLER = (L.Traffic.DL.SCH.QPSK.ErrTB.Rbler + L.Traffic.DL.SCH.16QAM.ErrTB.Rbler + L.Traffic.DL.SCH.64QAM.ErrTB.Rbler + L.Traffic.DL.SCH.256QAM.ErrTB.bits.Rbler)/(L.Traffic.DL.SCH.QPSK.TB + L.Traffic.DL.SCH.16QAM.TB + L.Traffic.DL.SCH.64QAM.TB + L.Traffic.DL.SCH.256QAM.TB)
- When MCS selection optimization for retransmissions takes effect, TBS index rise for downlink HARQ retransmissions does not take effect. TBS index rise for downlink HARQ retransmissions is controlled by the **PreciseMcsAdaptSwitch** option of the **CellAlgoSwitch**.CqiAdjAlgoSwitch parameter.

FDD Downlink MCS Selection Optimization – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations DBS3900 LampSite and DBS5900 LampSite • Boards No requirements • RF Modules No requirements
Software Requirements	• Prerequisite Functions None • Mutually Exclusive Functions None
Network Requirements	None
NE Requirements	None

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- The cell bandwidth is 5 MHz or higher.
- License
  - There are no license requirements.

FDD Downlink MCS Selection Optimization – Feature Deployment (Cont.)

- Activation
  - Enabling MCS selection optimization for initial transmissions
    - MOD CELLCQIADJALGO: LocalCellId=0, IblerTargetOffset=5;
  - Enabling MCS selection optimization for retransmissions and configuring the increase in the TBS index used for the first downlink HARQ retransmission(**MOD CELLALGOEXTSWITCH** and **MOD CELLDLSCHALGO** are high-risk command.)
    - MOD CELLALGOEXTSWITCH: LocalCellId=0, DlSchEnhSwitch=RETRANS_OPT_ENH_SW-1;
    - MOD CELLDLSCHALGO: LocalCellId=0, DlFirstHarqTxTbsIncNum=4;

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FDD Downlink MCS Selection Optimization – Feature Verification

- Counter

Counter Name	Counter ID	Counter Description
L.Thrp.bits.DL	1526728261	Total downlink PDCP-layer traffic volume in a cell
L.Thrp.bits.DL.LastTTI	1526729005	Downlink PDCP-layer traffic volume sent in the last TTIs before the buffer is empty
L.Thrp.Time.DL.RmvLastTTI	1526729015	Data transmission duration excluding the last TTIs before the downlink buffer is empty
L.Traffic.DL.EmptyBuf.PDCPLat.Time	1526732765	Total transmission delay of the first PDCP SDUs of DRB services in the empty buffer in a cell
L.Traffic.DL.EmptyBuf.PDCPLat.Num	1526732755	Total number of downlink PDCP SDUs that enter the empty buffer

- Average downlink UE throughput: User Downlink Average Throughput = (L.Thrp.bits.DL – L.Thrp.bits.DL.LastTTI)/L.Thrp.Time.DL.RmvLastTTI
- Downlink first packet delay for UEs = L.Traffic.DL.EmptyBuf.PDCPLat.Time/L.Traffic.DL.EmptyBuf.PDCPLat.Num

Q&A

1. Which of the following are included in downlink MCS selection optimization?

   A. MCS selection optimization for initial transmissions

   B. MCS selection optimization for retransmissions

- Answer: AB

Target IBLER Optimization Solution Overview – WHY

- In a massive MIMO cell, multiple UEs can use the same time-frequency resources for downlink data transmission. UE pairing for MU beamforming may cause interference to a UE from other paired UEs in a cell, with the interference level varying with the number of paired layers.
- Target IBLER optimization improves the downlink cell spectral efficiency. This function is supported only in TDD.

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- IBLER: initial block error rate
- MU beamforming: multi-user beamforming
- Downlink spectral efficiency = L.Thrp.bits.DL/(L.Cell.DL.PDSCH.Tti.Num x L.ChMeas.PRB.DL.DrbUsed.Avg)

Target IBLER Optimization Solution Overview – HOW (Cont.)

- Target IBLER acquisition based on the maximum reinforcement learning duration and the reinforcement learning mode
  - Maximum duration of reinforcement learning

    Specified by the **EnodebRLAlgoConfig**.RLMaxDuration parameter.
  - Reinforcement learning mode

    Specified by the **EnodebAlgoExtSwitch**.ReinforcementLearningMode parameter.
- Adaptive change based on the number of paired layers in a cell and channel fluctuation of UEs

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- Target IBLER optimization can be enabled for a maximum of 36 cells served by a single main control board.
- During maximum reinforcement learning duration configuration, the reinforcement learning type (**EnodebRLAlgoConfig**.RLCaseType) must be set to **MU_IBLER_TARGET_OPT**. When this parameter is reconfigured: For an intelligent use case that has started reinforcement learning, the previously configured value is still used as the maximum learning duration and the new parameter value does not take effect until next learning is started. For an intelligent use case that has not started reinforcement learning, the new parameter value takes effect immediately.
- If the reinforcement learning type is set to **LEARNING**, all intelligent use cases for reinforcement learning are allowed to enter the learning state, and the intelligent models for reinforcement learning are updated and used. If the reinforcement learning type is set to **HOLDING**, all intelligent use cases for reinforcement learning enter the holding state and the intelligent models are not updated. However, the current learning results are still used.
- Model building requires a large amount of memory on the main control board. The option configuration requirements for the **eNodeBResModeAlgo**.ServiceMode parameter vary depending on the main control board:
  - UMPTe/UMPTga: The AI_ENHANCEMENT_SWITCH option of the **eNodeBResModeAlgo**.ServiceMode parameter must be selected.
  - UMPTg: The UMPTG_ENHANCEMENT_SWITCH option of the **eNodeBResModeAlgo**.ServiceMode parameter must be selected.

Target IBLER Optimization Solution Overview – Network Analysis

- Benefits
  - Increases the downlink spectral efficiency of massive MIMO cells.
  - Increases the average downlink throughput of massive MIMO cells.
- Impacts
  - The downlink IBLER may increase.
  - The downlink RBLER may increase.
  - During reinforcement learning training, the base station may obtain a non-optimal target IBLER. This may cause the downlink spectral efficiency, average downlink UE throughput, and average downlink cell throughput to slightly decrease, as compared with using a fixed setting.

- Downlink spectral efficiency = L.Thrp.bits.DL/(L.Cell.DL.PDSCH.Tti.Num x L.ChMeas.PRB.DL.DrbUsed.Avg)
- Average downlink cell throughput = L.Thrp.bits.DL/L.Thrp.Time.Cell.DL.HighPrecision
- Downlink IBLER = (L.Traffic.DL.SCH.QPSK.ErrTB.Ibler + L.Traffic.DL.SCH.16QAM.ErrTB.Ibler + L.Traffic.DL.SCH.64QAM.ErrTB.Ibler + L.Traffic.DL.SCH.256QAM.ErrTB.bits.Ibler)/(L.Traffic.DL.SCH.QPSK.TB + L.Traffic.DL.SCH.16QAM.TB + L.Traffic.DL.SCH.64QAM.TB + L.Traffic.DL.SCH.256QAM.TB)
- Downlink RBLER = (L.Traffic.DL.SCH.QPSK.ErrTB.Rbler + L.Traffic.DL.SCH.16QAM.ErrTB.Rbler + L.Traffic.DL.SCH.64QAM.ErrTB.Rbler + L.Traffic.DL.SCH.256QAM.ErrTB.bits.Rbler)/(L.Traffic.DL.SCH.QPSK.TB + L.Traffic.DL.SCH.16QAM.TB + L.Traffic.DL.SCH.64QAM.TB + L.Traffic.DL.SCH.256QAM.TB)
- Average downlink UE throughput = (L.Thrp.bits.DL – L.Thrp.bits.DL.LastTTI)/L.Thrp.Time.DL.RmvLastTTI

Target IBLER Optimization – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations • Boards Main control board: UMPTe/UMPTga/UMPTg BBP: UBBPem/UBBPf1/UBBPf3/UBBPfw1/UBBPg2a/UBBPg3/UBBPg3b/UBBPg4 • RF Modules Only 64T64R AAUs and 32T32R AAUs support massive MIMO cells.
Software Requirements	• Prerequisite Functions Massive MIMO introduction, downlink 4-layer/8-layer/16-layer/24-layer MU beamforming, MU beamforming pairing for HARQ retransmission UEs, CQI adjustment • Mutually Exclusive Functions Machine learning-based post-pairing intelligent MCS prediction optimization
Network Requirements	None
NE Requirements	None

- Prerequisite Functions
  - Massive MIMO introduction: If target IBLER optimization for MU beamforming is enabled, **Cell**.TxRxMode must be set to **32T32R** or **64T64R** for massive MIMO introduction.
  - Downlink 4-layer/8-layer/16-layer/24-layer MU beamforming: Target IBLER optimization for MU beamforming requires at least one of these functions (controlled by the **MuBfAlgoSwitch** option of the **CellAlgoSwitch**.MuBfAlgoSwitch parameter) be enabled.
  - MU beamforming pairing for HARQ retransmission UEs: controlled by the **HarqRetranPairSwitch** option of the **CellAlgoSwitch**.MuBfAlgoSwitch parameter.
  - CQI adjustment: controlled by the **CqiAdjAlgoSwitch** option of the **CellAlgoSwitch**.CqiAdjAlgoSwitch parameter.
- Mutually Exclusive Functions
  - Machine learning-based post-pairing intelligent MCS prediction optimization: Target IBLER optimization for MU beamforming can be enabled only when **CellMMAlgo**.MubfTbsForecastPairLyrThld is set to **0** for all cells served by the local eNodeB.
- License
  - There are no license requirements.

Target IBLER Optimization – Feature Deployment (Cont.)

- Activation
  - Turning on the switch for target IBLER optimization(**MOD CELLALGOEXTSWITCH** is a high-risk command.)
    - MOD CELLALGOEXTSWITCH: LocalCellId=0, CellRLOptSwitch=MU_IBLER_TARGET_OPT_SW-1;
  - Setting the maximum duration of reinforcement learning
    - MOD ENODEBRLALGOCONFIG: RLCaseType=MU_IBLER_TARGET_OPT, RLMaxDuration=48;
  - Setting the reinforcement learning mode (this command will take effect on all reinforcement learning functions of the base station)
    - MOD ENODEBALGOEXTSWITCH: ReinforcementLearningMode=LEARNING;

Target IBLER Optimization – Feature Deployment (Cont.)

- Activation
  - Turning on the switch for AI enhancement mode when the UMPTe/UMPTga is used as the main control board(**MOD ENODEBRESMODEALGO** is a high-risk command.)
    - MOD ENODEBRESMODEALGO: ServiceMode=AI_ENHANCEMENT_SWITCH-1;
  - Turning on the UMPTg enhancement switch when the UMPTg is used as the main control board(**MOD ENODEBRESMODEALGO** is a high-risk command.)
    - MOD ENODEBRESMODEALGO: ServiceMode=UMPTG_ENHANCEMENT_SWITCH-1;
  - Resetting the eNodeB application (**RST APP** is a high-risk command.)
    - RST APP: AID=1;

Target IBLER Optimization – Feature Verification

- Activation verification
  - Run the **LST CELLALGOEXTSWITCH** command. If **MU_IBLER_TARGET_OPT_SW:On** is displayed for **Cell Reinforcement Learning Opt Sw** in the command output, this function has been enabled.
- Counter

Counter Name	Counter ID	Counter Description
L.Thrp.bits.DL	1526728261	Total downlink PDCP-layer traffic volume in a cell
L.Cell.DL.PDSCH.Tti.Num	1526730558	Total number of PDSCH TTIs
L.ChMeas.PRB.DL.DrbUsed.Avg	1526728763	Average number of PRBs used by PDSCH DRBs
L.Thrp.Time.Cell.DL.HighPrecision	1526728997	Total duration of downlink data transmission in a cell (with a precision of 1 ms)

- Downlink spectral efficiency = L.Thrp.bits.DL/(L.Cell.DL.PDSCH.Tti.Num x L.ChMeas.PRB.DL.DrbUsed.Avg)
- Average downlink cell throughput = L.Thrp.bits.DL/L.Thrp.Time.Cell.DL.HighPrecision

Q&A

1. Which of the following benefits are provided by the target IBLER optimization function?
   A. The downlink spectral efficiency improves.
   B. The downlink IBLER decreases.
   C. The downlink RBLER decreases.
   D. The average downlink cell throughput increases.

- Answer: AD

Section Summary

- FDD downlink MCS selection optimization
  - MCS selection optimization for initial transmissions allows the ACK after MCS index reduction to adaptively participate in CQI adjustment, resolving the issue that the MCS index used for scheduling does not match channel quality.
  - MCS selection optimization for retransmissions prevents RB resource waste in a cell.
- Target IBLER optimization
  - Target IBLER acquisition based on the maximum reinforcement learning duration and the reinforcement learning mode
  - Adaptive change based on the number of paired layers in a cell and channel fluctuation of UEs
  - Increase in the downlink spectral efficiency and average downlink cell throughput of massive MIMO cells

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Enhanced VoLTE Reliability – Background

- As network service requirements increase, network load and interference increase, especially in the downlink. The increase in downlink interference has a negative impact on voice experience, including missing PDCCH detection and PDSCH bit errors caused by downlink channel deterioration
- These will cause the uplink and downlink packet loss rates deteriorate in KPIs
- This feature uses redundancy technologies in multiple dimensions such as power, time domain, and frequency domain, to achieve high reliability of voice services

Enhanced VoLTE Reliability – HOW

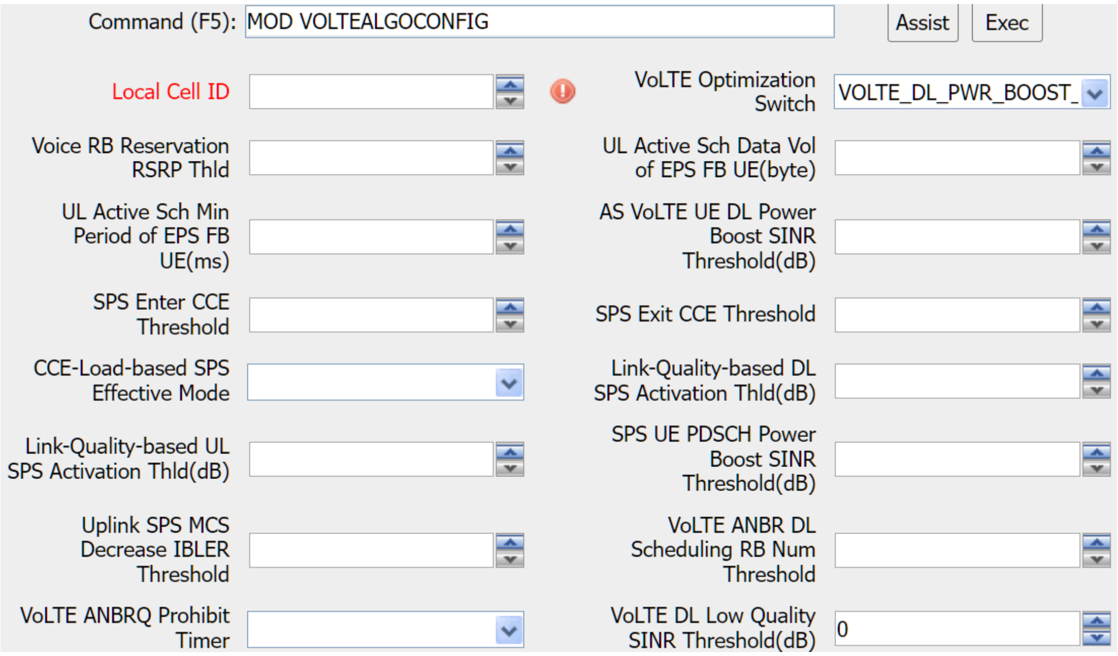
- Downlink power increase for VoLTE UEs
  - Identification of UEs with poor downlink voice quality
  - Downlink power increase for the identified UEs
  - Improves downlink transmission reliability for voice services.
- Downlink voice packet duplication for VoLTE UEs
  - Frequency-domain duplication (preferred)
  - Time-domain duplication

Solution – Power Domain Enhancement

DL User Tx Power

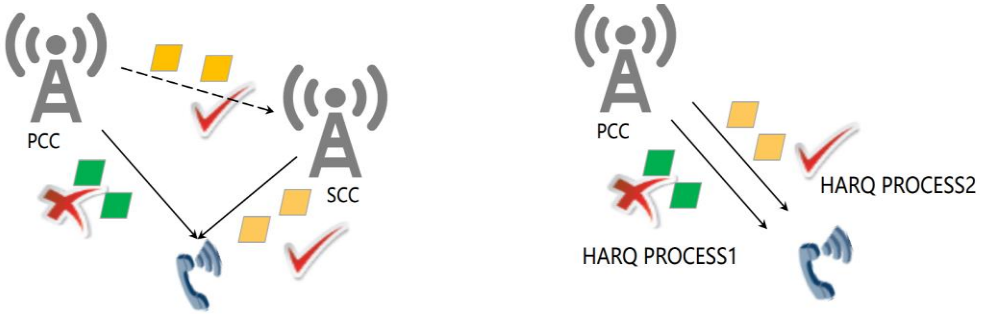
- With this function, the base station identifies UEs with poor downlink voice quality and then increases the downlink power for these UEs to improve the downlink transmission reliability of voice services
  - Identification of UEs with poor downlink voice quality: It identifies a voice service UE as a UE with poor downlink voice quality only when rank 1 is used for the UE and the downlink SINR is less than or equal to the value of **VolteAlgoConfig**.*VolteDlLowQualSinrThld*
  - Downlink power increase:Before scheduling voice data, the eNodeB estimates the number of RBs to be used for scheduling based on the volume of voice data to be scheduled, and calculates the increase in the PDSCH power for this scheduling based on the remaining power of the current cell

- This function is controlled by the **VOLTE_DL_PWR_BOOST_SW** option of the **VolteAlgoConfig**.*VolteOptSwitch* parameter
- Relevant configuration



Solution2 – Frequency & Time Domain Duplication

- With this function, the base station sends duplicated downlink voice packets in the frequency or time domain to reduce the probability of downlink voice packet transmission failures



Frequency domain duplication : Intra-eNB CA is required

Time domain duplication

- This function is controlled by the **VOLTE_DL_PKT_DUPLICATE_SW** option of the **VolteAlgoConfig**.*VolteOptSwitch* parameter. When it is enabled, downlink voice packets for VoLTE UEs are duplicated in the frequency domain (preferred) or time domain. Poor coverage UE detection method is the same as previous function.
  - Frequency domain duplication: It relies on CA deployment, the eNodeB duplicates downlink voice packets in the optimal SCell so that the same downlink voice packets can be simultaneously transmitted in the PCell and Scell(Only for inra-eNB CA scenario)
  - Time domain duplication: If frequency domain duplication is not capable, time domain duplication will be taken effect. This enables the same downlink voice packets to be transmitted in different HARQ processes

Enhanced VoLTE Reliability – HOW (Cont.)

- Maximum tolerable relaxed backhaul on the network side
  - Complies with the relaxed requirements for transmission delay over the air interface to increase the number of retransmissions.
  - Reduces uplink and downlink packet loss rates.
  - Improves link reliability for VoLTE UEs.

Enhanced VoLTE Reliability – Network Analysis

- Benefits
  - It is recommended that Enhanced VoLTE Reliability be enabled to reduce the Uplink Packet Loss Rate (VoIP) and Downlink Packet Loss Rate (VoIP) when all of the following conditions are met.

Scenario	Condition
The number of voice service UEs meets the condition.	L.Traffic.User.VoIP.Avg/L.Traffic.User.Avg > 5%
The uplink voice packet loss rate over the air interface is relatively high.	Uplink Packet Loss Rate (VoIP) > 1%
The downlink voice packet loss rate over the air interface is relatively high.	Downlink Packet Loss Rate (VoIP) > 0.5%
The CCE usage of the cell is relatively low.	(L.ChMeas.CCE.CommUsed + L.ChMeas.CCE.ULUsed + L.ChMeas.CCE.DLUsed)/L.ChMeas.CCE.Avail < 50%
The number of CA UEs meets the condition.	L.Traffic.User.PCell.DL.Avg/L.Traffic.User.Avg > 20%

Enhanced VoLTE Reliability – Network Analysis (Cont.)

- Impacts
  - Downlink power increase for VoLTE UEs
    - There is a negative impact on the downlink cell throughput and UE throughput. The larger the number of UEs with poor voice quality, the larger the impact.
    - The increased power of the serving cell will increase the interference to the downlink channels of neighboring cells.
  - Downlink voice packet duplication for VoLTE UEs
    - The UE power consumption, uplink BLER, and resource consumption of voice service UEs increase, while the number of UEs in DRX mode slightly decreases in a cell.
    - The probability of performing CA on voice service UEs increases, the number of RRC connection reconfiguration messages increases, the voice service drop rate slightly increases, and the call setup success rate slightly decreases.
    - The cell and UE rates slightly decrease.

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Enhanced VoLTE Reliability – Network Analysis (Cont.)

- Impacts
  - Maximum tolerable relaxed backhaul on the network side
    - The voice packet delay and jitter increase, the air interface resource consumption increases, and the cell and UE rates slightly decrease.

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Enhanced VoLTE Reliability – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations DBS3900 LampSite and DBS5900 LampSite • Boards LBBPd and UBBP boards are compatible with this function. • RF Modules No requirements
Software Requirements	• Prerequisite Functions None • Mutually Exclusive Functions None
Network Requirements	None
NE Requirements	None

Enhanced VoLTE Reliability – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LOFD-171206	LTE FDD	Enhanced VoLTE Reliability	LT1SEVOLTER0	eNodeB FDD	Per Cell
TDLOFD-171206	LTE TDD	Enhanced VoLTE Reliability	LT4SEHVTRTDD	eNodeB TDD	Per Cell

Enhanced VoLTE Reliability – Feature Deployment (Cont.)

- Activation
  - Enabling downlink power increase for VoLTE UEs
    - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteOptSwitch=VOLTE_DL_PWR_BOOST_SW-1;
  - Enabling downlink voice packet duplication for VoLTE UEs
    - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteOptSwitch=VOLTE_DL_PKT_DUPLICATE_SW-1;
  - Enabling maximum tolerable relaxed backhaul on the network side
    - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteRanDelayBudget=MS200;

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- //Configuring the VolteDlLowQualSinrThld parameter
  - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteDlLowQualSinrThld=0;
- //Configuring parameters related to downlink voice packet duplication for VoLTE UEs
  - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteUeUlCaMgmtStrategy=VOLTE_PREFERRED;
  - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteDlLowQualSinrThld=0;
- //Setting the RlcMode parameter in the RlcPdcpParaGroup MO corresponding to QCI 1 to RlcMode_UM
  - MOD RLCPDCPPARAGROUP: RlcPdcpParaGroupId=0, RlcMode=RlcMode_UM;
- //Configuring parameters related to maximum tolerable relaxed backhaul on the network side
  - MOD QCIPARA: Qci=1, RlcModeReconfigSwitch=ON, PdcpDiscardTimerReconfigSw=ON;
- Deactivation command examples:
- //Disabling downlink power increase for VoLTE UEs
  - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteOptSwitch=VOLTE_DL_PWR_BOOST_SW-0;
- //Disabling downlink voice packet duplication for VoLTE UEs
  - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteOptSwitch=VOLTE_DL_PKT_DUPLICATE_SW-0;
- //Disabling maximum tolerable relaxed backhaul on the network side
  - MOD VOLTEALGOCONFIG: LocalCellId=0, VolteRanDelayBudget=DISABLE;

Enhanced VoLTE Reliability – Feature Verification

- Counter

Counter Name	Counter ID	Counter Description
L.Traffic.DL.PktUuLoss.Loss.QCI.1	1526727934	Number of downlink PDCP SDUs discarded for services carried on DRBs with a QCI of 1 in a cell over the Uu interface
L.Traffic.DL.PktUuLoss.Tot.QCI.1	1526727935	Number of downlink PDCP SDUs transmitted for services carried on DRBs with a QCI of 1 in a cell over the Uu interface
L.Traffic.UL.PktLoss.Loss.QCI.1	1526727961	Number of uplink PDCP SDUs discarded for services carried on DRBs with a QCI of 1 in a cell
L.Traffic.UL.PktLoss.Tot.QCI.1	1526727962	Number of expected-to-be-received uplink PDCP SDUs for services carried on DRBs with a QCI of 1 in a cell
L.Traffic.User.PCell.DL.Avg	1526728426	Average number of downlink CA UEs that treat the local cell as their PCell
L.Traffic.User.SCell.DL.Avg	1526728427	Average number of downlink CA UEs that treat the local cell as their SCell
L.Voice.Packet.Duplicate	1526765223	Number of duplicated downlink voice packets in a cell

Q&A

1. What can Enhanced VoLTE Reliability do? (   )
   A. Reduce uplink and downlink voice packet loss rate over the Uu interface.
   B. Reduce the downlink power of users.
   C. Reduce downlink transmission reliability.

- Answer: A

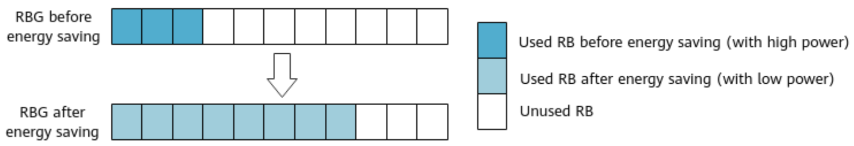
Section Summary

- Enhanced VoLTE Reliability uses redundancy technologies in multiple dimensions such as power, time domain, and frequency domain, to achieve high reliability of voice services. It provides the following functions:
  - Downlink power increase for VoLTE UEs
  - Downlink voice packet duplication for VoLTE UEs
  - Maximum tolerable relaxed backhaul on the network side

Contents

Energy Saving Based on Flexible Frequency-Domain Scheduling Solution Overview – WHY

- Energy saving based on flexible frequency-domain scheduling expands available frequency-domain resources for target UEs when there are idle frequency-domain resources on the network and dynamically lowers the transmit power of the base station. This reduces the energy consumption of the base station.



Energy Saving Based on Flexible Frequency-Domain Scheduling Solution Overview – HOW

- Triggering:
  - After energy saving based on flexible frequency-domain scheduling is enabled in a cell, the cell checks whether all data of UEs to be scheduled can be transmitted in each TTI. If all data can be transmitted and there are remaining RBs, the cell enters the state of energy saving based on flexible frequency-domain scheduling.
- Leaving:
  - A cell exits the state of energy saving based on flexible frequency-domain scheduling if the **FLEX_FREQ_SCH_ENERGY_SAVING_SW** option of the **CellPwrSavingAlgo**.PwrSavingAlgoSwitch parameter is deselected.

Energy Saving Based on Flexible Frequency-Domain Scheduling Solution Overview – HOW

- Based on the number of remaining RBs and the volume of data to be scheduled, the eNodeB performs the following operations:
  - For FDD cells:
    - Reduces the power of each RB and expands RBGs for UEs using demodulation reference signals (DMRSs) and rank-1 UEs using quadrature phase shift keying (QPSK) but not DMRSs.
    - Changes the modulation mode to QPSK for rank-1 UEs not using QPSK or DMRSs, and reduces the power of each RB and expands RBGs for these UEs.
    - Changes the rank to rank 1 and the modulation mode to QPSK for non-rank-1 UEs not using DMRSs, and reduces the power of each RB and expands RBGs for these UEs.
  - For TDD cells:
    - Reduces the power of each RB and expands RBGs for beamforming UEs, closed-loop TM9 UEs, and rank-1 UEs using QPSK but not DMRSs.

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- Energy saving based on flexible frequency-domain scheduling is not performed for special UEs, such as VoLTE UEs, eMTC UEs, UEs for which signaling messages are being scheduled, and TM6 UEs.

Energy Saving Based on Flexible Frequency-Domain Scheduling – Network Analysis

- Benefits
  - Energy saving based on flexible frequency-domain scheduling reduces the power spectral density in TTIs with remaining RBs to lower the total transmit power, which in turn reduces the total energy consumption. It is recommended that this function be deployed when the cell has a light load, the tail packet duration accounts for a large proportion, and a small number of UEs are to be scheduled every TTI.

Energy Saving Based on Flexible Frequency-Domain Scheduling – Network Analysis (Cont.)

- Impacts
  - The Cell Downlink Average Throughput and User Downlink Average Throughput may decrease.
  - The PRB usage of the cell increases.
  - The average downlink modulation and coding scheme (MCS) index decreases.
  - The spectral efficiency decreases.
  - The values of certain indicators may fluctuate, including those related to downlink IBLER and RBLER.
  - The proportion of high-rank UEs decreases.
  - The proportion of QPSK UEs increases.

Energy Saving Based on Flexible Frequency-Domain Scheduling – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations • Boards All main control boards support this feature. LBBP series boards do not support this feature. • RF Modules • All AAUs support energy saving based on flexible frequency-domain scheduling. • Run the **DSP BRDMFRINFO** command. The RRU supports energy saving based on flexible frequency-domain scheduling if the value of the **Description** parameter in the command output includes "V6", "KUNLUN", "KL", "WUYI", "V9", "WY", "TIANSHAN", or "TS".
Software Requirements	• Prerequisite Functions None • Mutually Exclusive Functions CSPC, inter-eNodeB SFN based on eNodeB coordination, soft split dynamic downlink power sharing, enhanced flexible power configuration for beamforming UEs, nTnR-assisted massive MIMO, NB-IoT cell, eMTC-only cell, load simulation
Network Requirements	None
NE Requirements	None

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Energy Saving Based on Flexible Frequency-Domain Scheduling – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LOFD-180201	LTE FDD	Energy Saving Based on Flexible Frequency-Domain Scheduling	LT1S0ESBFFDS	eNodeB FDD	Per Cell
TDLOFD-180201	LTE TDD	Energy Saving Based on Flexible Frequency-Domain Scheduling	LT4SESFFDTDD	eNodeB TDD	Per Cell

Energy Saving Based on Flexible Frequency-Domain Scheduling – Feature Deployment (Cont.)

- Activation
  - Activating energy saving based on flexible frequency-domain scheduling
    - MOD CELLPWRSAVINGALGO: LocalCellId=0,PwrSavingAlgoSwitch=FLEX_FREQ_SCH_ENERGY_SAVING_SW-1;

Energy Saving Based on Flexible Frequency-Domain Scheduling – Feature Verification

- Activation verification
  - Run the **DSP FLEXFREQSCHENERGYSAVSTAT** command to check the value of **Flex Freq-Domain Sch Energy Saving Status**. If it is **ENABLED**, energy saving based on flexible frequency-domain scheduling has been enabled for the cell.
  - On the MAE-Access, check the value of the **L.ChMeas.DFEE.FlexFreqSchEnergySavingTti.Num** counter. If the value is not **0**, energy saving based on flexible frequency-domain scheduling has taken effect for the cell.

Q&A

1. Which of the following scenarios are recommended for energy saving based on flexible frequency-domain scheduling?

   A. The load is light.

   B. The tail packet duration accounts for a large proportion.

   C. A small number of UEs are to be scheduled every TTI.

   D. The load is heavy.

- Answer: ABC

Section Summary

- Energy saving based on flexible frequency-domain scheduling expands available frequency-domain resources for target UEs in TTIs with remaining RB resources and dynamically lowers the transmit power of the base station to reduce the overall energy consumption.

Contents

CRS Dynamic Muting Solution Overview – WHY

- CRS dynamic muting: According to the UE's CRS measurement actions, CRSs do not need to be transmitted in all the CRS symbols of each subframe. When there are no RRC_CONNECTED UEs in a cell or all RRC_CONNECTED UEs in the cell are in DRX sleep time, CRSs can be muted in some subframes in the time domain, to improve the symbol power saving effect and reduce the power consumption of RF modules
- CRS dynamic muting enhancements in this version:
  - Added support for CRS dynamic muting in LTE TDD.
  - Added support for DRX parameter optimization for CRS dynamic muting.

CRS Dynamic Muting Solution Overview – HOW

- DRX Parameter Optimization
  1. After DRX parameter optimization is enabled, the effective duration of CRS dynamic muting changes to all day long during model training. Information is collected every 5 minutes for model training.
  2. After the model is successfully built and put in use, the effective duration of CRS dynamic muting is restored to the specified period.
  3. The cell checks its state every 5 minutes based on the trained model and selects appropriate DRX parameter settings to increase the proportion of TTIs in which CRS dynamic muting takes effect.

- The following information is collected:
  - Downlink user-perceived rate
  - First packet delay
  - Average scheduling probability
  - Proportion of TTIs in which CRS dynamic muting takes effect
  - PRB usage
  - Average number of online UEs
  - Proportion of UEs whose DRX parameters can be adjusted in the cell

CRS Dynamic Muting – Network Analysis

- Benefits
  - It is recommended that DRX parameter optimization for CRS dynamic muting be enabled to increase the proportion of TTIs in which CRS dynamic muting takes effect and improve energy saving gains if the proportion is low due to inappropriate DRX parameter settings.

- If DRX parameter optimization is enabled but the downlink user-perceived rate or first packet delay of a cell always does not meet the customer's expectation, the model will use the baseline parameter settings in the end. In this case, DRX parameter optimization cannot improve the energy saving gains.

CRS Dynamic Muting – Network Analysis (Cont.)

- Impacts
  - If DRX parameter optimization for CRS dynamic muting is enabled, DRX parameter settings are adjusted to maximize the proportion of TTIs in which CRS dynamic muting takes effect. This may cause the values of the indicators affected by CRS dynamic muting to further deteriorate. The values of the following KPIs fluctuate during model building and application, but can still meet the requirements of the **EnodebPwrSavingAlgo**.DlPerceivedRateTarget and **EnodebPwrSavingAlgo**.DlPdcpFirstPktLatTarget parameters during model application:
    - User Downlink Average Throughput
    - First packet delay (**L.Traffic.DL.EmptyBuf.PDCPLat.Time**/**L.Traffic.DL.EmptyBuf.PDCPLat.Num**)

- When CRS dynamic muting takes effect, UE DRX On Duration alignment is performed and CRS interference decreases. As such, the values of the indicators listed below may increase if the average number of UEs is less than 10 and the downlink PRB usage is less than 5% in a cell during off-peak hours in a continuous coverage area (for example, the typical inter-site distance is less than or equal to 500 m) with obvious co-channel interference. In other scenarios, the values of these indicators may decrease.
  - User Downlink Average Throughput
  - Average downlink CQI
  - Average MCS index
  - Spectral efficiency
- CRS dynamic muting also has other impacts on the network:
  - UEs' RSRP measurement results may fluctuate.
  - The radio paging success rate of cell edge users (CEUs) may decrease in some scenarios. To reduce the impact, the number of protection subframes prior to and following POs can be increased.
  - The PUCCH resource allocation for CQI reporting changes, triggering PUCCH RB range extension at an earlier time. This increases uplink PRB usage. In addition, the HARQ feedback on downlink transmissions may converge on the PUCCH, leading to increased uplink interference.

  - The values of uplink access indicators (such as the random access success rate), User Uplink Average Throughput, uplink MCS indexes, uplink IBLERs, and uplink RBLERs may fluctuate.
- Assume that there are UEs that support CRS interference cancellation (CRS-IC) in neighboring cells of the local cell and the interference caused by CRSs of the local cell is strong. Enabling CRS dynamic muting to take effect in the local cell may lead to deterioration of the CRS-IC performance of CRS-IC-capable UEs in neighboring cells and decrease the throughput to a certain extent during light-load periods such as at night. This is because the proportion of TTIs in which CRS dynamic muting takes effect may be high during light-load periods, and therefore the symbols for CRS transmission in the local cell may frequently change on a per TTI basis.

CRS Dynamic Muting – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations, and DBS3900 and DBS5900 LampSite base stations • Boards All main control boards support CRS dynamic muting. DRX parameter optimization for CRS dynamic muting requires that the main control board be UMPTb or later. All BBPs except the UBBPem, UBBPex2, and LBBP support CRS dynamic muting. • RF Modules See *Energy Conservation and Emission Reduction Feature Parameter Description*.
Software Requirements	• Prerequisite Functions Basic symbol power saving, DRX • Mutually Exclusive Functions eMIMO, Smart 8T8R, 3D beamforming, virtual 4T4R, Breathing Pilot, SFN, eMTC, NB-IoT basics, eMBMS, extended CP, Short TTI, UMTS and LTE Dynamic Power Sharing
Network Requirements	None
NE Requirements	None

CRS Dynamic Muting – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LOFD-171202	LTE FDD	CRS Dynamic Muting	LT1S0CRSDM00	eNodeB FDD	per cell
TDLOFD-180202	LTE TDD	CRS Dynamic Muting	LT4SCRSDMTDD	eNodeB TDD	per cell

CRS Dynamic Muting – Feature Deployment (Cont.)

- Activation
  - Enabling DRX parameter optimization for CRS dynamic muting
    - MOD SYMBOLPWRSAVING: LocalCellId=0, SymbolShutdownEnhancedSw=CRS_DYNAMIC_MUTING_DRX_OPT_SW-1;

CRS Dynamic Muting – Feature Verification

- Activation verification
  1. Run the **DSP AIMODELINFO** command with the **AICaseType** parameter set to **CRS_DYNAMIC_MUTING_DRX_OPT** to query the value of the **Model Status** parameter under **Intelligent Case Model Information**. If the value of the **Model Status** parameter is **CONVERGENCE_STATUS**, the model is successfully built.
  2. Run the **DSP SYMBOLPWRSAVINGDRXOPT** command to verify that the value of the CRS **Dynamic Muting DRX Opt Status** parameter is **ENABLED**.

Q&A

1. After DRX parameter optimization is enabled, model training is performed every () minutes.
   A. 1
   B. 2
   C. 5
   D. 10

- Answer: C

Section Summary

- CRS dynamic muting can now work in LTE TDD.
- DRX parameter optimization is supported for CRS dynamic muting. It can increase the proportion of TTIs in which CRS dynamic muting takes effect and improve energy saving gains.

Contents

2. Optional Features

RF Channel Dynamic Muting Solution Overview – WHY

- RF channel dynamic muting enhancements in this version:
  - Added support for RF channel dynamic muting threshold optimization.
  - Added support for RF channel dynamic muting in TM9 (FDD).
  - Added support for low-power RF channel dynamic muting (TDD).

RF Channel Dynamic Muting Threshold Optimization Solution Overview – WHY

- This function uses reinforcement learning to adaptively adjust the settings of the relevant RF channel dynamic muting thresholds for different service loads. This maximizes the proportion of TTIs in which RF channel dynamic muting takes effect while meeting the downlink user-perceived rate and first packet delay requirements.

- Threshold parameters related to RF channel dynamic muting are as follows:
  - Threshold of the number of downlink high-load TTIs for entering the RF channel muting state (specified by the **CellRfChnDynMuting**.RfMuteDlHighLoadTtiNumThld parameter)
  - Downlink PRB usage threshold for entering the RF channel muting state (specified by the **CellRfChnDynMuting**.RfMuteDlPrbThld parameter)
  - Threshold of the number of downlink high-load TTIs for triggering RF channel restoration (specified by the **CellRfChnDynMuting**.RfRcyDlHighLoadTtiNumThld parameter)
  - Downlink PRB usage threshold for triggering RF channel restoration (specified by the **CellRfChnDynMuting**.RfRcyDlPrbThld parameter)

RF Channel Dynamic Muting Threshold Optimization Solution Overview – HOW

- RF channel dynamic muting threshold optimization
  1. After RF channel dynamic muting threshold optimization is enabled, co-PA cells use reinforcement learning to adaptively adjust the settings of the RF channel dynamic muting thresholds. During model training, the effective duration of RF channel dynamic muting changes to all day long for co-PA cells. Information is collected every 5 minutes for model training.
  2. After the model is successfully built and put in use, the effective duration of RF channel dynamic muting is restored to the specified period.
  3. The cell checks its state every 5 minutes based on the trained model and selects appropriate RF channel dynamic muting threshold settings to increase the proportion of TTIs in which RF channel dynamic muting takes effect.

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- The following information is collected:
  - Downlink user-perceived rate
  - First packet delay
  - Proportion of TTIs in which RF channel dynamic muting takes effect
  - PRB usage

RF Channel Dynamic Muting Threshold Optimization – Network Analysis

- Benefits
  - It is recommended that RF channel dynamic muting threshold optimization be enabled to increase the proportion of TTIs in which RF channel dynamic muting takes effect and improve energy saving gains if the proportion is low due to inappropriate threshold settings.

- If RF channel dynamic muting threshold optimization is enabled but the downlink user-perceived rate or first packet delay of a cell always does not meet the customer's expectation, the model will use the baseline parameter settings in the end. In this case, RF channel dynamic muting threshold optimization cannot improve the energy saving gains.

RF Channel Dynamic Muting Threshold Optimization – Network Analysis (Cont.)

- Impacts
  - If RF channel dynamic muting threshold optimization is enabled, related threshold settings are adjusted to maximize the proportion of TTIs in which RF channel dynamic muting takes effect. This may cause the values of the preceding indicators to further deteriorate. The values of the following KPIs fluctuate during model building and application, but can still meet the requirements of the **EnodebPwrSavingAlgo**.DlPerceivedRateTarget and **EnodebPwrSavingAlgo**.DlPdcpFirstPktLatTarget parameters during model application:
    - User Downlink Average Throughput
    - First packet delay (**L.Traffic.DL.EmptyBuf.PDCPLat.Time**/**L.Traffic.DL.EmptyBuf.PDCPLat.Num**)

- After some transmit channels are muted during RF channel dynamic muting, the following impacts may occur:
  - The downlink diversity gains of UEs decrease, which leads to a decrease in the Cell Downlink Average Throughput and User Downlink Average Throughput.
  - The radio paging success rate, handover success rate, and indicators related to uplink access (such as the random access success rate) decrease slightly. The service drop rate and uplink interference increase slightly.
  - The average downlink modulation and coding scheme (MCS) index and average downlink channel quality indicator (CQI) may fluctuate.
  - The values of indicators related to downlink DTX, IBLER, and RBLER may fluctuate.
  - The uplink and downlink scheduling delays increase.
  - The proportion of high-rank UEs decreases.
  - The average PDCCH aggregation level, number of used CCEs, number of CCE allocation failures, and number of OFDM symbols used by the PDCCH may increase.
  - The number of UEs scheduled in the uplink and downlink per TTI may decrease.
  - The power of some channels may fluctuate during RRU output power monitoring.

RF Channel Dynamic Muting Threshold Optimization – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations, and DBS3900 and DBS5900 LampSite base stations • Boards RF channel dynamic muting threshold optimization requires that the main control board be UMPTb or later. • RF Modules See *Energy Conservation and Emission Reduction Feature Parameter Description*.
Software Requirements	• Prerequisite Functions Basic symbol power saving, BBU-RRU joint clipping, multi-RAT coordinated symbol power saving • Mutually Exclusive Functions See *Energy Conservation and Emission Reduction Feature Parameter Description*.
Network Requirements	None
NE Requirements	None

RF Channel Dynamic Muting Threshold Optimization – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LOFD-171201	LTE FDD	RF Channel Dynamic Muting	LT1S0RFCDM00	eNodeB FDD	per cell
TDLOFD-171201	LTE TDD	RF Channel Dynamic Muting	LT4SRFCDMTDD	eNodeB TDD	per cell

RF Channel Dynamic Muting Threshold Optimization – Feature Deployment (Cont.)

- Activation
  - Enabling RF channel dynamic muting threshold optimization
    - MOD CELLRFCHNDYNMUTING: LocalCellId=0,RfChnDynMutingAlgoSwitch=RF_CHN_DYN_MUTING_THLD_OPT_SW-1;

RF Channel Dynamic Muting Threshold Optimization – Feature Verification

- Activation verification

1. Run the **DSP AIMODELINFO** command with the **AICaseType** parameter set to **RF_CHN_DYN_MUTING_THLD_OPT** to query the value of the **Model Status** parameter under **Intelligent Case Model Information**. If the value of the **Model Status** parameter is **CONVERGENCE_STATUS**, the model is successfully built.
2. Run the **DSP CELLRFCHNDYNMUTINGTHLDOPT** command to verify that the value of the **RF Chn Dynamic Muting Thld Opt Status** parameter is **ENABLED**.

Q&A

1. RF channel dynamic muting threshold optimization can maximize the ( ) of RF channel dynamic muting.
   A. Period
   B. Quantity
   C. Duration
   D. Proportion of TTIs

- Answer: D

Section Summary

- RF channel dynamic muting threshold optimization aims to maximize the proportion of TTIs in which RF channel dynamic muting takes effect while meeting the requirements of the downlink user-perceived rate and first packet delay.

RF channel dynamic muting in TM9 Solution Overview – WHY

- With RF channel dynamic muting in TM9, RF channels are dynamically muted for TM9 services in TTIs in which TM9 UEs are scheduled when cells served by FDD massive MIMO modules have sufficient unused RBs.

RF channel dynamic muting in TM9 Solution Overview – HOW

- After RF channel dynamic muting in TM9 is enabled in a cell, RF channels are dynamically muted for TM9 services in TTIs in which TM9 UEs are scheduled if the eNodeB determines that the cell has sufficient unused RBs.
- When multiple cells share a PA, any cell can independently enter the RF channel dynamic muting in TM9 state without coordinating with other cells.

- RF channel dynamic muting in TM9 does not take effect for special UEs, such as UEs involved in MU pairing, VoLTE UEs, eMTC UEs, and UEs for which signaling messages are being scheduled.

RF Channel Dynamic Muting in TM9 – Network Analysis

- Benefits
  - RF channel dynamic muting in TM9 enables transmit channels to be dynamically muted to reduce the power consumption of RF modules when the instantaneous cell load is light, and to be quickly restored to ensure service provisioning when the instantaneous cell load increases. This function is recommended for massive MIMO cells to reduce the equipment power consumption.

RF Channel Dynamic Muting in TM9 – Network Analysis (Cont.)

- Impacts
  - RF channel dynamic muting in TM9 has the following impacts on the network:
    - The Cell Downlink Average Throughput and User Downlink Average Throughput may decrease.
    - The PRB usage of the cell increases.
    - The average downlink modulation and coding scheme (MCS) index decreases.
    - The spectral efficiency decreases.
    - The values of certain indicators may fluctuate, including those related to downlink IBLER and RBLER.
    - The proportion of high-rank UEs decreases.
    - The proportion of QPSK UEs increases.

RF Channel Dynamic Muting in TM9 – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations, and DBS3900 and DBS5900 LampSite base stations • Boards Main control board: The UMPT series and later main control boards support RF channel dynamic muting in TM9. BBP: Only the UBBPg series boards support RF channel dynamic muting in TM9. • RF Modules AAU5726, AAU5726e, AAU5733, AAU5711a
Software Requirements	• Prerequisite Functions Basic symbol power saving • Mutually Exclusive Functions CSPC, eCSPC, intra-eNodeB CSPC, downink turbo pilot
Network Requirements	None
NE Requirements	None

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RF Channel Dynamic Muting in TM9 – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LOFD-171201	LTE FDD	RF Channel Dynamic Muting	LT1S0RFCDM00	eNodeB FDD	per cell

RF Channel Dynamic Muting in TM9 – Feature Deployment (Cont.)

- Activation
  - Activating RF channel dynamic muting in TM9
    - MOD CELLRFCHNDYNMUTING: LocalCellId=0,RfChnDynMutingAlgoSwitch=TM9_TTI_CHN_DYN_MUTING_SW-1;

RF Channel Dynamic Muting in TM9 – Feature Verification

- Activation verification
  1. Run the **DSP CELLRFCHNDYNMUTING** command to check the value of the **TM9 TTI RF Channel Dynamic Muting Status** parameter. If it is **ENABLED**, RF channel dynamic muting in TM9 has been enabled for the cell.
  2. On the MAE-Access, check the value of the L.ChMeas.DFEE.FddTm9TtiDynMutingTti.Num counter. If the value is not **0**, RF channel dynamic muting in TM9 has taken effect for the cell.

Q&A

1. When multiple cells share a PA, can any cell independently enter the RF channel dynamic muting in TM9 state?

   A. Yes

   B. No

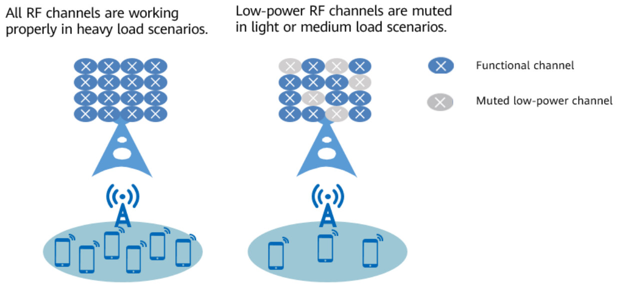
- Answer: A

Section Summary

- With RF channel dynamic muting in TM9, RF channels are dynamically muted for TM9 services in TTIs in which TM9 UEs are scheduled when cells served by FDD massive MIMO modules have sufficient unused RBs, thereby reducing the equipment power consumption.
- This function applies only to LTE FDD.

Low-Power RF Channel Dynamic Muting Solution Overview – WHY

- Low-power RF channel dynamic muting enables the base station to dynamically mute beamforming services of non-paired UEs on low-power transmit channels within a specified period to reduce power consumption. If only beamforming services of non-paired UEs are running on these transmit channels, the base station further mutes the transmit channels to save more energy.



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- This function applies only to LTE TDD.

Low-Power RF Channel Dynamic Muting Solution Overview – HOW

- If the low-power RF channel dynamic muting function is enabled, this function is triggered in the specified period when the downlink PRB usage of the cell is less than the specified threshold and the cell is not in the RF channel dynamic muting state.

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- Downlink PRB usage threshold (**CellRfChnDynMuting**.LowPwrRfDynMutingDlPrbThld)
- For 32T32R or 64T64R TDD cells, if the downlink transmit power of a transmit channel is lower than the **CellRfChnDynMuting**.LowPwrRfDynMutingDlPwrThld parameter value, beamforming services of non-paired UEs are muted on this channel.
- If only beamforming services of non-paired UEs are running on this channel, the base station further mutes the transmit channel.
- Low-power RF channel dynamic muting is not performed in TTIs with special UEs, such as VoLTE UEs and UEs running low-latency services.

Low-Power RF Channel Dynamic Muting Solution Overview – Network Analysis

- Benefits
  - Low-power RF channel dynamic muting enables transmit channels to be dynamically muted to reduce the power consumption of RF modules when the instantaneous cell load is light, and to be quickly restored to ensure service provisioning when the instantaneous cell load increases. This function is recommended for 32T/64T TDD cells to reduce the equipment power consumption.

- To prevent energy saving–triggered shutdown from affecting the lifespan of RF modules, the RF modules may exit the energy saving state when their own temperature differential exceeds a specified threshold within 24 hours. Energy saving gains decrease in this case.

Low-Power RF Channel Dynamic Muting Solution Overview – Network Analysis (Cont.)

- Impacts
  - After some transmit channels are muted during low-power RF channel dynamic muting, the following impacts may occur:
    - The downlink diversity gains of UEs decrease, which leads to a decrease in the Cell Downlink Average Throughput and User Downlink Average Throughput.
    - The radio paging success rate, handover success rate, and indicators related to uplink access (such as the random access success rate) decrease slightly. The service drop rate and uplink interference increase slightly.
    - The average downlink modulation and coding scheme (MCS) index and average downlink channel quality indicator (CQI) decrease.
    - The values of indicators related to downlink DTX, IBLER, and RBLER may fluctuate.
    - The uplink and downlink scheduling delays increase.

Low-Power RF Channel Dynamic Muting Solution Overview – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations • Boards Main control board: All main control boards support low-power RF channel dynamic muting. BBP: Only 32T and 64T LTE TDD BBPs complying with the eCPRI protocol support low-power RF channel dynamic muting. • RF Modules Only 32T and 64T RF modules complying with the eCPRI protocol support low-power RF channel dynamic muting.
Software Requirements	• Prerequisite Functions Basic symbol power saving • Mutually Exclusive Functions nTnR-assisted Massive MIMO
Network Requirements	None
NE Requirements	None

Low-Power RF Channel Dynamic Muting Solution Overview – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
TDLOFD-171201	LTE TDD	RF Channel Dynamic Muting	LT4SRFCDMTDD	eNodeB TDD	per cell

Low-Power RF Channel Dynamic Muting Solution Overview – Feature Deployment (Cont.)

- Activation
  - Activating low-power RF channel dynamic muting
    - MOD CELLRFCHNDYNMUTING: LocalCellId=0,RfChnDynMutingAlgoSwitch=LOW_POWER_RF_DYN_MUTING_SW-1;

Low-Power RF Channel Dynamic Muting Solution Overview – Feature Verification

- Activation verification
  1. Run the **DSP CELLRFCHNDYNMUTING** command to check the value of the **Low Power RF Channel Dynamic Muting Status** parameter. If it is **ENABLED**, low-power RF channel dynamic muting has been enabled for the cell.
  2. On the MAE-Access, check the value of the L.ChMeas.DFEE.LowPowerRFDynMutingTti.Num counter. If the value is not **0**, low-power RF channel dynamic muting has taken effect for the cell.

Q&A

1. Which of the following type of services is muted by the low-power RF channel dynamic shutdown function?

   A. Beamforming services of non-paired UEs

   B. Beamforming services of paired UEs

- Answer: A

Section Summary

- Low-power RF channel dynamic muting enables the base station to dynamically mute beamforming services of non-paired UEs on low-power transmit channels within a specified period to reduce power consumption.
- This function applies only to LTE TDD.

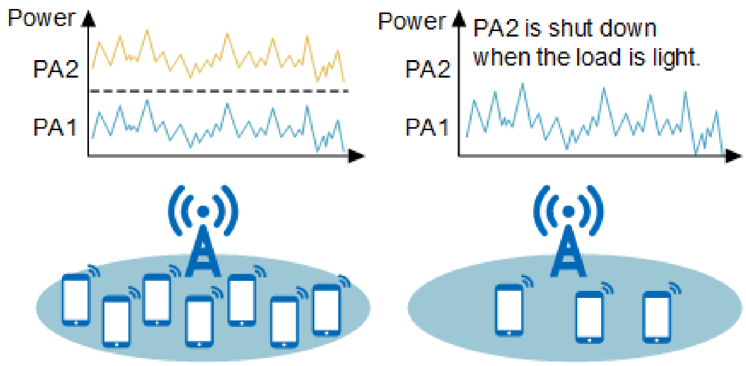
Contents

2. Optional Features

- 2.1 (N) LOFD-171206 Enhanced VoLTE Reliability/TDLOFD-171206 Enhanced VoLTE Reliability
- 2.2 (N) LOFD-180201 Energy Saving Based on Flexible Frequency-Domain Scheduling/TDLOFD-180201 Energy Saving Based on Flexible Frequency-Domain Scheduling
- 2.3 (E) LOFD-171202 CRS Dynamic Muting/ (N) TDLOFD-180202 CRS Dynamic Muting
- 2.4 (E) LOFD-171201 RF Channel Dynamic Muting/TDLOFD-171201 RF Channel Dynamic Muting
- **(E) LOFD-001039 RF Channel Intelligent Shutdown**

RF Channel Intelligent Shutdown

- RF channel intelligent shutdown enables the eNodeB to shut down some of the transmit channels in a cell when the cell has no service or has a light service load within specified periods.



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LTE Multi-Carrier Coordinated Channel Shutdown

- In 4-port scenarios, if LTE multi-carrier coordinated channel shutdown is enabled, the **RF_SHUTDOWN_4PORT_OPT_SW** option of the **CellRfShutdown.RfShutdownAlgoSwitch** parameter can be used to specify which RF channel shutdown combinations can be selected.
  - If the option is deselected, transmit channels of ports 1 and 2 or ports 2 and 3 can be shut down.
  - If the option is selected, only transmit channels of ports 1 and 2 can be shut down.

- The **RF_SHUTDOWN_4PORT_OPT_SW** option has been added to specify whether to enable optimization for RF channel intelligent shutdown in 4-port scenarios.

Support for RF Channel Intelligent Shutdown by RF Modules

- The following RF modules now support RF channel intelligent shutdown:
  - 8T8R RF modules
  - AAU5733 and AAU5726e
  - Easy Macro RF modules: AAU5243, AAU5245, AAU5942, AAU3940, AAU5940, RRU5235E, and RRU5263E.

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3. 4.5G Features

UL 256QAM Solution Overview – WHY

- Services on the network have increasingly higher rate requirements.
- 3GPP has introduced UL 256QAM.
- This feature increases the uplink transmission rate of UEs with favorable radio conditions to meet service rate requirements.
  - The average uplink cell throughput increases by up to 40%.
  - The UL peak UE throughput increases by 10% to 40%.

UL 256QAM Solution Overview – HOW (Cont.)

- MCS table configurations
  - Two MCS tables are defined in 3GPP specifications:
    - MCS table with UL 256QAM
    - MCS table without UL 256QAM
  - Adaptive selection between the two MCS tables or using a fixed one is supported.
  - An MCS table with UL 256QAM can be specified for whitelisted UEs.

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- Adaptive selection between the two MCS tables or using a fixed one is supported, depending on the setting of **PUSCHCfg**.Ul256QamMcsTblCfgStrategy.
  - If this parameter is set to **ADAPTIVE_CONFIGURATION**, adaptive MCS table selection takes effect. The eNodeB adaptively selects the MCS table with UL 256QAM or the MCS table without UL 256QAM for 256QAM-capable UEs based on the evaluated channel quality.
    - If channel quality deteriorates for 256QAM-capable UEs, the eNodeB switches to the MCS table without UL 256QAM, maintaining the UL rates of QPSK-based services on the UEs. Therefore, this setting is recommended.
    - As the eNodeB must use RRC signaling to notify UEs of the MCS table used, this setting increases RRC signaling overhead.
  - If this parameter is set to **FIXED_CONFIGURATION**, the eNodeB always uses the MCS table with UL 256QAM for 256QAM-capable UEs.
    - The MCS table with UL 256QAM references fewer low-order TBSs (TBSs with indexes 1, 3, 5, 7, and 9 are not supported) than the MCS table without UL 256QAM. Therefore, this parameter setting may result in decreases in the UL rates of QPSK-based services for 256QAM-capable UEs.

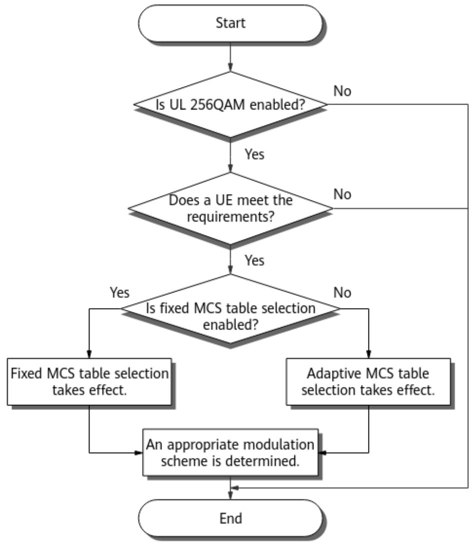
UL 256QAM Solution Overview – HOW (Cont.)

- MCS table configurations
  - Two MCS tables are defined in 3GPP specifications:
    - MCS table with UL 256QAM
    - MCS table without UL 256QAM
  - Adaptive selection between the two MCS tables or using a fixed one is supported.
  - An MCS table with UL 256QAM can be specified for whitelisted UEs.

- An MCS table with UL 256QAM can be specified for whitelisted UEs.
  - The MCS table with UL 256QAM for whitelisted UEs is specified by the **Ul256QamUePara**.Ul256QamCssMcsTab parameter.
  - The configuration index for whitelisted UEs is specified by the **Ul256QamUePara**.Ul256QamUeConfigIndex parameter.
  - This function takes effect when the **UeCompat**.Ul256QamUeConfigIndex parameter value is consistent with the **Ul256QamUePara**.Ul256QamUeConfigIndex parameter value for whitelisted UEs.

UL 256QAM Solution Overview – HOW (Cont.)

- UL 256QAM-related scheduling process
  1. The eNodeB checks whether the UL 256QAM switch is on.
  2. The eNodeB checks whether the UE meets the requirements for UL 256QAM.
  3. The eNodeB checks whether adaptive MCS table selection has been enabled.
  4. The eNodeB performs scheduling based on channel quality and the selected UL MCS table.



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1. The eNodeB checks whether the UL 256QAM switch is on.
   - If the **UL_256QAM_SWITCH** option of the **PUSCHCfg**.Ul256QamAlgoSwitch parameter is selected, the eNodeB goes to step 2.
   - If the **UL_256QAM_SWITCH** option of the **PUSCHCfg**.Ul256QamAlgoSwitch parameter is deselected, the eNodeB selects QPSK, 16QAM, or 64QAM for the UE based on channel quality.
2. The eNodeB checks whether the UE meets the requirements for UL 256QAM.
   - The use of UL 256QAM requires that UEs comply with 3GPP Release 14 or later and support the UL 256QAM modulation scheme.
   - If the UE meets the requirements, the eNodeB goes to step 3.
   - If the UE does not meet the requirements, the eNodeB selects QPSK, 16QAM, or 64QAM for the UE based on channel quality.

3. The eNodeB checks whether adaptive MCS table selection has been enabled.
   - If adaptive selection has been disabled, the eNodeB always selects the MCS table with UL 256QAM for the UE.
   - If adaptive selection has been enabled, the eNodeB periodically determines whether to use the MCS table with UL 256QAM or the MCS table without UL 256QAM for the UE based on channel quality. The period is specified by the **PUSCHCfg**.Ul256QamMcsTblAdpPeriod parameter.
     - If this parameter is set to a smaller value, the eNodeB tracks channel quality changes more frequently for adaptive MCS table selection, resulting in a higher UL rate. However, RRC connection reconfiguration messages are sent more frequently. This increases the probability of service drops.
     - If this parameter is set to a larger value, the eNodeB tracks channel quality changes less frequently for adaptive MCS table selection, resulting in a lower UL rate. However, RRC connection reconfiguration messages are sent less frequently. This reduces the probability of service drops.

4. The eNodeB performs scheduling based on channel quality and the selected UL MCS table.
   - In FDD, the **PUSCHCfg**.EstdPowerReductValue256Qam parameter specifies the estimated power reduction value used in MCS index selection for UEs supporting UL 256QAM. This function reduces the impact of power reduction of UEs on the uplink user-perceived rate.
     - A smaller value of this parameter results in a higher probability that UL 256QAM takes effect for UEs and a higher BLER when UL 256QAM takes effect.
     - A larger value of this parameter results in a lower probability that UL 256QAM takes effect for UEs and a lower BLER when UL 256QAM takes effect.
   - In FDD, power reduction estimation is supported by whitelisted UEs supporting UL 256QAM.
     - The estimated power reduction for whitelisted UEs supporting UL 256QAM is specified by the **Ul256QamUePara**.Ul256QamEstdPowReductValue parameter.
     - The configuration index for whitelisted UEs is specified by the **Ul256QamUePara**.Ul256QamUeConfigIndex parameter.
     - This function takes effect when the **UeCompat**.Ul256QamUeConfigIndex parameter value is consistent with the **Ul256QamUePara**.Ul256QamUeConfigIndex parameter value for whitelisted UEs.

UL 256QAM – Network Analysis

- Benefits
  - The average uplink cell throughput increases by up to 40%.
  - The UL peak UE throughput increases by 10% to 40%.
  - When this function is enabled for whitelisted UEs, the average uplink user-perceived throughput increases.
- Impacts
  - When adaptive MCS table configuration is used and the eNodeB selects the MCS table with UL 256QAM for UEs, the number of times MCSs indicating UL 256QAM are selected is measured by counters L.ChMeas.PUSCH.256QAM.MCS.0 to L.ChMeas.PUSCH.256QAM.MCS.31. As a result, the average MCS index calculated by counters L.ChMeas.PUSCH.MCS.0 to L.ChMeas.PUSCH.MCS.31 slightly decreases.

- EVM: error vector magnitude
- The benefits of UL 256QAM vary depending on radio channel quality, the EVM of RF signals sent by UEs, and the EVM of signals received by eNodeBs. This function is recommended when radio conditions are favorable, for example, when the proportion of times MCS index 28 is selected for scheduling on the PUSCH (indicated by L.ChMeas.PUSCH.MCS.28) is more than 30% of scheduling occasions, according to 24-hour statistics.
- Average uplink cell throughput: Cell Uplink Average Throughput = L.Thrp.bits.UL/L.Thrp.Time.Cell.UL.HighPrecision
- Average UL user-perceived throughput = L.Thrp.bits.UE.UL.Experienced/L.Thrp.Time.UE.UL.Experienced

UL 256QAM – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations DBS3900 LampSite and DBS5900 LampSite • Boards Only the UBBPg supports this function. • RF Modules No requirements
Software Requirements	• Prerequisite Functions None • Mutually Exclusive Functions None
Network Requirements	None
NE Requirements	None

UL 256QAM – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LEOFD-180301	LTE FDD	UL 256QAM	LT1SUL256QAM	eNodeB FDD	Per Cell

UL 256QAM – Feature Deployment (Cont.)

- Activation
  - Enabling UL 256QAM(**MOD PUSCHCFG** is a high-risk command.)
    - MOD PUSCHCFG: LocalCellId=0, Ul256QamAlgoSwitch=UL_256QAM_SWITCH-1;
  - Enabling adaptive selection of the MCS table with UL 256QAM
    - MOD PUSCHCFG: LocalCellId=0, Ul256QamMcsTblCfgStrategy=ADAPTIVE_CONFIGURATION;
  - Setting the interval for adaptive selection of the MCS table with UL 256QAM to 10s
    - MOD PUSCHCFG: LocalCellId=0, Ul256QamMcsTblAdpPeriod=10;
  - Setting the estimated power reduction value to 3 dB for UEs on which UL 256QAM takes effect
    - MOD PUSCHCFG: LocalCellId=0, EstdPowerReductValue256Qam=30;

UL 256QAM – Feature Deployment (Cont.)

- Activation
  - Configuring the MCS table with UL 256QAM and setting the estimated power reduction value for UL 256QAM to 1 dB for whitelisted UEs
    - ADD UL256QAMUEPARA: Ul256QamUeConfigIndex=0, Ul256QamEstdPowReductValue=10, Ul256QamCssMcsTab=256QAM_TABLE;

UL 256QAM – Feature Verification

- Activation verification
  - If the value of at least one of the relevant counters is greater than 0, UL 256QAM has taken effect
- Counter

Counter Name	Counter ID	Counter Description
L.ChMeas.PUSCH.256QAM.MCS.0 to L.ChMeas.PUSCH.256QAM.MCS.31	1526749492 to 1526749523	Number of times MCS index 0 to MCS index 31 is selected on the PUSCH for UEs with uplink 256QAM enabled
L.Traffic.UL.SCH.256QAM.TB	1526749524	Number of TBs initially transmitted on the uplink SCH using 256QAM

Q&A

1. Which of the following is the MCS table that the eNodeB selects for a UE when the fixed MCS table configuration policy is used for UL 256QAM. (   )
   A. MCS table with UL 256QAM
   B. MCS table without UL 256QAM

- Answer: A

Section Summary

- UL 256QAM
  - UL 256QAM involves two UL MCS tables.
  - Adaptive selection between the two MCS tables or using a fixed one is supported.
  - An MCS table with UL 256QAM can be specified for whitelisted UEs.
  - Power reduction estimation for UL 256QAM is supported for UEs.
  - Power reduction estimation for UL 256QAM is supported for whitelisted UEs.

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NSA Anchor Coverage Extension Based on User Experience Overview – WHY

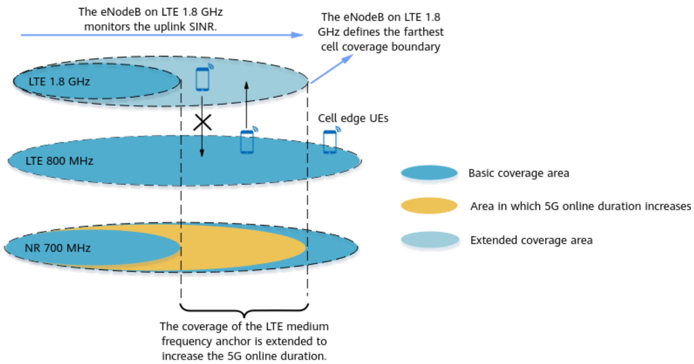
- In NSA networking with an LTE medium frequency, an LTE low frequency and an NR low frequency, when the LTE medium frequency serves as the anchor for NSA UEs, the 5G online duration of the UEs may be short and NR low frequency resources cannot be fully used due to the following reasons:
  - The coverage of the LTE medium frequency is different from that of the NR low frequency.
  - There is coverage for UEs in the NR low frequency. UEs are close to the coverage edge of the LTE medium frequency and therefore are handed over to the LTE low frequency through coverage-based inter-frequency handovers.
  - Due to the limited UE capability, the LTE low frequency cannot serve as the NSA anchor and the NR low frequency cannot be added as an SCG frequency.

NSA Anchor Coverage Extension Based on User Experience Overview – WHY (Cont.)

- Enabling principles:
  - 5G continuous online
  - Good user experience
  - Stable network KPIs
- Information used for decision-making:
  - Whether coverage-based inter-frequency handovers and inter-frequency handovers triggered by carrier selection are allowed for NSA UEs
- Benefits:
  - Extends the coverage edge of LTE medium frequencies and increases the 5G online duration of UEs.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW

- Threshold adaptation for inter-frequency handovers based on LTE coverage: delays the handover of NSA UEs from LTE medium-frequency cells to LTE low-frequency cells, increasing the 5G online duration of the UEs.



- As shown in the figure, threshold adaptation for inter-frequency handovers based on LTE coverage extends the coverage area of the LTE 1.8 GHz cell to delay the handover of UEs in this area to the LTE 800 MHz cell.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW (Cont.)

- The eNodeB selects the following target UEs for which coverage can be extended in LTE cells:
  - NSA UEs for which an SCG has been added
  - Non-emergency-call, eMTC, or eMBMS UEs
  - UEs without GBR, QCI 65, QCI 66, QCI 69, QCI 70, QCI 75, or QCI 79 bearers established

- Threshold adaptation for inter-frequency handovers based on LTE coverage is triggered only when **EutranInterNFreq**.InterFreqHoEventType is set to **EventA4** or **EventA5**.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW (Cont.)

- After receiving an event A2 measurement report related to coverage-based inter-frequency handovers from a UE for which coverage is to be extended, the eNodeB continuously monitors the uplink SINR of the UE and performs coverage-based inter-frequency handovers in the following scenarios to ensure that the UE is served by the carrier that can deliver the optimal user experience:
  - The spectral efficiency corresponding to the uplink SINR of the UE is less than **CellMultiCarrUniSch**.MobilAdaptCovUlSpctEffThld.
  - The downlink RSRP of the UE is less than or equal to **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld.
  - The spectral efficiency corresponding to the uplink SINR of the UE is greater than or equal to **CellMultiCarrUniSch**.MobilAdaptCovUlSpctEffThld, and the downlink RSRP is greater than **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld.

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- If the spectral efficiency corresponding to the uplink SINR of the UE is less than **CellMultiCarrUniSch**.MobilAdaptCovUlSpctEffThld, the eNodeB immediately performs a coverage-based inter-frequency handover. For details about coverage-based inter-frequency handovers, see *Mobility Management in Connected Mode*.

- If the downlink RSRP of the UE is less than or equal to **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld, the eNodeB immediately performs a coverage-based inter-frequency handover. This procedure is basically the same as that described in *Mobility Management in Connected Mode*. The differences are as follows:
  - In this case, the threshold for event A4 or threshold 2 for event A5 related to inter-frequency handovers is specified by **CellMultiCarrUniSch**.AdaptCovA4RsrpThld.
  - When the eNodeB receives an event A4/A5 measurement report from a UE for which coverage is to be extended and learns that the cell with the largest RSRP value reported on a neighboring frequency is served by another base station, the eNodeB further checks the **ADAPT_COV_THLD_FORBID_FLAG** option of the **EutranExternalCell**.AggregationAttribute parameter for the cell.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW (Cont.)

- After receiving an event A2 measurement report related to coverage-based inter-frequency handovers from a UE for which coverage is to be extended, the eNodeB continuously monitors the uplink SINR of the UE and performs coverage-based inter-frequency handovers in the following scenarios to ensure that the UE is served by the carrier that can deliver the optimal user experience:
  - The spectral efficiency corresponding to the uplink SINR of the UE is less than **CellMultiCarrUniSch**.MobilAdaptCovUlSpctEffThld.
  - The downlink RSRP of the UE is less than or equal to **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld.
  - The spectral efficiency corresponding to the uplink SINR of the UE is greater than or equal to **CellMultiCarrUniSch**.MobilAdaptCovUlSpctEffThld, and the downlink RSRP is greater than **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld.

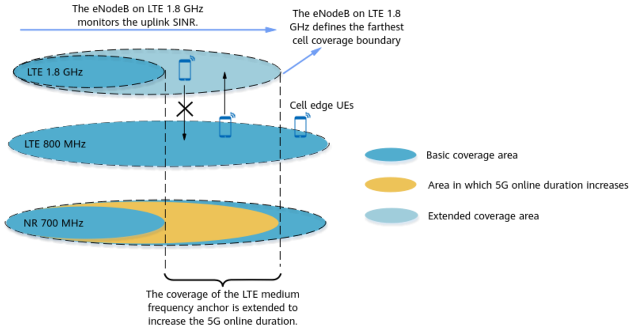
- If this option is selected, the eNodeB checks whether the RSRP of the cell with the strongest signal strength is greater than the A4 threshold or A5 threshold 2 for coverage-based inter-frequency handovers. For details, see *Mobility Management in Connected Mode*.

  If the RSRP of the cell is greater than the threshold, handovers to the cell are allowed.

  If the RSRP of the cell is less than or equal to the threshold, handovers to the cell are prohibited.
- If the option is deselected for the cell, handovers to the cell are allowed.
- If the option is not configured for the cell, handovers to the cell are allowed.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW (Cont.)

- Threshold adaptation for NSA PCC anchoring based on NR coverage: increases the probability of UEs being handed over from LTE low-frequency cells to LTE medium-frequency cells. As such, the probability of adding NR low frequencies as SCG frequencies increases, and the 5G online duration of UEs increases.



- As shown in the figure, threshold adaptation for NSA PCC anchoring based on NR coverage extends the coverage area of the LTE 1.8 GHz cell to increase the probability of handovers from the LTE 800 MHz cell to the LTE 1.8 GHz cell and the probability of adding the NR 700 MHz cell as an SCG cell for UEs.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW (Cont.)

- Threshold adaptation for NSA PCC anchoring based on NR coverage takes effect only when all of the following conditions are met:
  - The PCC anchoring procedure is not triggered by a coverage-based incoming handover.
  - The target PCell and the current PCell are served by the same base station.
  - After the target PCell and the corresponding SCG are selected by NSA PCC anchoring based on NR coverage, the eNodeB determines that the current PCell does not support the addition of this SCG.

- When NSA PCC anchoring based on NR coverage is enabled by selecting the **NSA_PCC_ANCHORING_SWITCH** option of the **NsaDcMgmtConfig**.NsaDcAlgoSwitch parameter and the **NsaDcMgmtConfig**.NsaDcPccAnchoringPolicy parameter is set to **BASED_ON_NR_COVERAGE**, threshold adaptation for NSA PCC anchoring based on NR coverage is enabled.

NSA Anchor Coverage Extension Based on User Experience Overview – HOW (Cont.)

- After threshold adaptation for NSA PCC anchoring based on NR coverage takes effect, the requirements for the target cell during PCC anchoring for NSA UEs are as follows:
  - The estimated spectral efficiency corresponding to the uplink SINR after the UEs are handed over to the target cell is greater than or equal to the value of **CellMultiCarrUniSch**.MobilAdaptCovUlSpctEffThld configured for the target cell plus 4 dB.
  - The downlink RSRP of the target cell is greater than the sum of **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld and **CellMultiCarrUniSch**.AdaptCovRsrpThldOffset configured for the target cell.

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- If **CellMultiCarrUniSch**.AdaptCovLowFreqRsrpThld of the target cell cannot be obtained, the PCC anchoring threshold specified by **PccFreqCfg**.NsaDcPccA4RsrpThld is used as the downlink RSRP threshold for the target cell.

NSA Anchor Coverage Extension Based on User Experience – Network Analysis

- Benefits
  - After this feature takes effect, the 5G camping proportion increases. The larger the value of L.NsaDc.Capable.5gUser.NoScg.BorderUE.Avg, the higher the gain.
- Impacts
  - The traffic distributions on frequency bands change. As a result, the values of band-specific performance indicators also change. In frequency bands where the traffic volume increases, the uplink throughput of UEs performing full buffer services decreases slightly. The handover success rate decreases and the service drop rate rises due to the extended cell edge.

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- After NSA anchor coverage extension based on user experience takes effect, the 5G camping proportion is used for network monitoring.
- 5G camping proportion = L.Traffic.User.NsaDc.PCell.Avg/L.NsaDc.Capable.User.RRC.Avg

NSA Anchor Coverage Extension Based on User Experience – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations. 5900 series base stations must be configured with the BBU5900 or BBU5900A. DBS3900 LampSite and DBS5900 LampSite • Boards Main control board: UMPTb and later BBP: LBBPd and later • RF Modules This function does not depend on RF modules.
Software Requirements	• Prerequisite Functions NSA PCC anchoring based on NR coverage • Mutually Exclusive Functions NSA carrier combination selection based on user experience

NSA Anchor Coverage Extension Based on User Experience – Feature Deployment (Cont.)

- Dependency

Network Requirements	• This feature applies to NSA networking involving LTE medium frequencies and NR low frequencies. • In co-site co-BBU or separate-BBU scenarios, the LTE and NR base stations in NSA networking support CI interconnection, intra-BBU backplane interconnection, and IP transmission. • In inter-site scenarios, LTE- and NR-only base stations in NSA networking support only IP transmission.

NE Requirements	• UE
	  • The UE must support NSA DC specified in 3GPP Release 15.
	  • UEs must have subscribed to LTE and NR services.
	  • The UE must match the gNodeB and eNodeB versions.
	• EPC
	  • The EPC must be CloudEPC to support Option 3 and Option 3x.
	  • The EPC must support NSA DC.
	  • If NSA DC is enabled on an eNodeB, the connected MMEs need to support NSA DC. If a connected MME does not support NSA DC, the **MmeCapInfo**.MmeNsaDcCapability parameter for this MME must be set to **NOT_SUPPORT**.

NSA Anchor Coverage Extension Based on User Experience – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	RAT	Feature Name	Model	NE	Sales Unit
LNOFD-181303	LTE FDD	NSA Anchor Coverage Extension Based on User Experience	LT1SNSACEB00	eNodeB	per eNodeB
TDLOFD-181210	LTE TDD	NSA Anchor Coverage Extension Based on User Experience	LT4SNSAUETDD	eNodeB	per eNodeB

NSA Anchor Coverage Extension Based on User Experience – Feature Deployment (Cont.)

- Activation
  - //Enabling NSA anchor coverage extension based on user experience and setting related parameters
    - MOD NSADCALGOPARAM:NsaDcAlgoExtSwitch=FDD_ANCHOR_ADAPT_COV_THLD_SW-1;
    - MOD NSADCALGOPARAM:NsaDcAlgoExtSwitch=TDD_ANCHOR_ADAPT_COV_THLD_SW-1;
    - MOD CELLMULTICARRUNISCH: LocalCellId=21, MobilAdaptCovUlSpctEffThld=2, AdaptCovLowFreqRsrpThld=-122;

NSA Anchor Coverage Extension Based on User Experience – Feature Verification

- Activation verification
  - After NSA anchor coverage extension based on user experience takes effect, the values of related counters will change.

Counter Name	Change
L.HHO.InterFreq.Coverage.PrepAttOut	Decrease
L.NsaDC.PCCAnchor.HHO.PrepAttOut	Increase
L.NsaDC.PCCAnchor.HHO.ExecAttOut	Increase
L.NsaDC.PCCAnchor.HHO.ExecSuccOut	Increase

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NSA Anchor Coverage Extension Based on User Experience – Feature Verification (Cont.)

- Counter
  - After NSA anchor coverage extension based on user experience takes effect, the values of related counters will change.

Counter ID	Counter Name
1526728933	L.HHO.InterFreq.Coverage.PrepAttOut
1526749449	L.NsaDC.PCCAnchor.HHO.PrepAttOut
1526749450	L.NsaDC.PCCAnchor.HHO.ExecAttOut
1526749451	L.NsaDC.PCCAnchor.HHO.ExecSuccOut

Q&A

1. True or False: Threshold adaptation for inter-frequency handovers based on LTE coverage delays the handover of NSA UEs from LTE low-frequency cells to LTE medium-frequency cells, increasing the 5G online duration of the UEs. (   )

   A. True

   B. False

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- Answer: B

Section Summary

- NSA Anchor Coverage Extension Based on User Experience
- Enabling principles: 5G continuous online, good user experience, and stable network KPIs.
- Information used for decision-making: Whether coverage-based inter-frequency handovers and inter-frequency handovers triggered by carrier selection are allowed for NSA UEs.
- Function: Extends the coverage edge of LTE medium frequencies and increases the 5G online duration of UEs.

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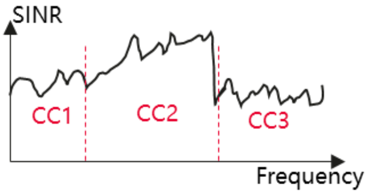
Contents

Multi-Frequency Optimal Carrier Scheduling

- On a multi-frequency network, the spectral efficiencies of different frequencies measured by a CA UE at the same time vary because of large-scale fading and small-scale fading in radio channels.



- When this function is enabled, the eNodeB calculates the scheduling capability of each carrier based on the spectral efficiency, bandwidth, and load
  - Selects the carrier with the highest scheduling capability as the main carrier for scheduling, and maintains a high scheduling priority for this carrier.
  - Adjusts the scheduling priorities of the UE on the carriers not with the highest scheduling capability based on the scheduling delay to prevent the UE from preempting resources of other UEs.

Multi-Frequency Optimal Carrier Scheduling – Network Analysis

- Benefits
  - Increases user-perceived throughput on the entire network.
- Impacts
  - The traffic distributions on frequency bands change. As a result, the values of band-specific performance indicators also change.
  - The volume of data distributed to SCells increases, which causes the following impacts:
    - The uplink and downlink control channel resource consumption increases slightly. As a result, fewer resources are available for unidentified UEs performing full buffer services, and the throughput of these UEs may decrease slightly.
    - In some scenarios, NACKs and DTXs in feedback from CA UEs cannot be distinguished from each other. As a result, the RBLER and service drop rate increase.

Multi-Frequency Optimal Carrier Scheduling – Feature Deployment

- Dependency

Hardware Requirements	• Base Station Models 3900 and 5900 series base stations, and DBS3900 and DBS5900 LampSite base stations • Boards BBP: The LBBP does not support ultra-low-latency scheduling. Main control board: The UMPTa does not support this function. • RF Modules No requirements
Software Requirements	• Prerequisite Functions Ultra-low-latency scheduling, downlink CA • Mutually Exclusive Functions None
Network Requirements	None
NE Requirements	None

Multi-Frequency Optimal Carrier Scheduling – Feature Deployment (Cont.)

- License
  - Feature licenses

Feature ID	Feature Name	Model	Sales Unit
LNOFD-151332	Multi-carrier Unified Scheduling	LT1SMCUSP100	per eNodeB

Description	Model	Sales Unit
Vertical SuperBAND (FDD)	LT1SVSBAND00	per eNodeB

Multi-Frequency Optimal Carrier Scheduling – Feature Deployment (Cont.)

- Activation
  - //Enabling multi-frequency optimal carrier scheduling
    - MOD MULTICARRUNIFIEDSCH: MultiCarrierUnifiedSchEnSw=CA_SCH_PRIORITY_OPT_SW-1;

Multi-Frequency Optimal Carrier Scheduling – Feature Verification

- Activation verification

Verification Item	Description
L.Thrp.bits.DL/L.ChMeas.PRB.DL.DrbUsed.Avg	If the value of this counter increases, multi-frequency optimal carrier scheduling has taken effect.

- Counter

Verification Item	Description
(L.Thrp.bits.DL-L.Thrp.bits.DL.LastTTI)/L.Thrp.Time.DL.RmvLastTTI	Used to observe the downlink UE throughput.

Q&A

1. Which of the following factors are considered when the multi-frequency optimal carrier scheduling function calculates the scheduling capability of each carrier? (   )
   A. Spectral efficiency
   B. Bandwidth
   C. Load
   D. Frequency

- Answer: ABC

Acronyms and Abbreviations

- PIM: passive intermodulation
- RB: resource block
- TM4: transmission mode 4
- TM9: transmission mode 9
- QPSK: quadrature phase shift keying
- IBLER: initial block error rate
- MCS: modulation and coding scheme

Acronyms and Abbreviations

- MIMO: multiple-input multiple-output
- MeNB: master eNodeB
- SgNB: secondary gNodeB
- MCG: master cell group
- SCG: secondary cell group
- PSCell: primary secondary cell

Acronyms and Abbreviations

- PCell: primary cell
- PCC: primary component carrier
- SCC: secondary component carrier

Thank You

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