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XRAN Southbound Working Group;

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# Introduction



Figure 1: Basic xRAN Architecture

An xRAN compliant controller shall interface with control applications as shown in figure through the northbound interface (NBI) A1 and with the eNodeB/gNodeB through southbound interface (SBI) B1.  The controller shall serve the following purposes:

* centralizing near-real time radio resource management for multiple eNodeBs/gNodeB’s, which includes functionalities like (but not limited to) admission control, bearer admission and modification, mobility management, load balancing, inter-cell interference coordination, multi-DU/cell radio resource management.
* exposing a “logical” RAT agnostic near-real time network state through radio network information base (R-NIB)
* ability for control applications to induce physical network change by reading and writing to radio R-NIB.

This document presents the details of the protocol used for B1 interface used to facilitate communication between the RAN controller and the RAN elements like eNodeB/gNodeB.

## Schema

ASN.1 is used as the schema for message exchange on the B1 interface. The corresponding ASN.1 schema files can be found in the xran repository as “xRAN-API-PDUs.asn1” and “xRAN-API-IEs.asn1”. Note that there might be a brief time period when the this document will be out of sync with the ASN.1 files. When in doubt, the ASN.1 files are the authoritative source page.

## Notation

In the subsequent sections, the names of the southbound ASN.1 PDU are italicized. RAN controller is referred to as the xranc. Although the call flows the show the entity interacting with xranc as eNodeB, it could be a gNodeB, or a CU with gNodeB.

# Message Description

Each B1 PDU consists of a header and a body. The header carries the specification version identifier and body PDU id. The following sections detail the different messages exchanged on this interface and the corresponding call flows.

## Transport Layer

The transport layer for the southbound interface is SCTP. It will be assumed that the topology information, along with the ECGI for each cells with corresponding IP/Port for the SCTP connection is available at the controller a priori. The value 0 will be used for the SCTP payload protocol identifier.

## Configuration Messages

### Cell Configuration

Upon receiving *CellConfigRequest* from xranc to the eNodeB, the eNodeB will respond back with *CellConfigReport* message. On receiving this response, the xranc will assume that the cell is up and running (broad casting MIBs and SIBs), and is under the purview of the xranc. The xranc may send *CellConfigRequest* messages periodically to check or get updates on the cell configuration.

*CellConfigReport* may also go from eNodeB unsolicited after establishment of the SCTP association.

**eNodeB**

**xRANc**

CellConfigRequest

CellConfigReport

Figure 2: Cell Configuration

**CellConfigRequest**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| ecgi | ECGI | E-UTRAN Global Cell ID (PLMN ID + ENodeB ID + Cell ID) |

**ECGI**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| PLMN-Identity | OCTET STRING (SIZE(3)) | PLMN identity - digits 0 to 9, encoded 0000 to 1001, - 1111 used as filler digit, two digits per octet, - bits 4 to 1 of octet n encoding digit 2n-1 - bits 8 to 5 of octet n encoding digit 2n -The Selected PLMN identity consists of 3 digits from MCC followed by either -a filler digit plus 2 digits from MNC (in case of 2 digit MNC) or -3 digits from MNC (in case of a 3 digit MNC). |
| EUTRANCellIdentifier | BIT STRING (SIZE (28)) |  |

**CellConfigReport**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| ecgi | ECGI | E-UTRAN Global Cell ID (PLMN ID + ENodeB ID + Cell ID) |
| pci | PhysCellId | Physical Cell Identity |
| candidate\_scells | SEQUENCE OF CandScell | PCI and Downlink EARFCN of the cells that can be configured as secondary cell with this cell’s primary component carrier |
| earfcn\_dl | ARFCN-Value | Downlink EARFCN |
| earfcn\_ul | ARFCN-Value | Uplink EARFCN |
| rbs\_per\_tti\_dl | INTEGER | Downlink Bandwidth (in RBs per TTI) |
| rbs\_per\_tti\_ul | INTEGER | Uplink Bandwidth (in RBs per TTI) |
| num\_tx\_antenna | INTEGER | Number of TX Antenna ports |
| duplex\_mode | ENUMERATED(fdd,tdd) | TDD(1) or FDD(0) |
| tdd\_config | INTEGER(0..6) OPTIONAL | TDD Uplink-Downlink config |
| tdd\_Spl\_sf\_config | INTEGER(0..8) OPTIONAL | TDD Special Subframe config |
| max\_num\_connected\_ues | INTEGER | Maximum number of UEs in RRC\_Connected State that the cell can support |
| max\_num\_bearers | INTEGER | Maximum number of bearers that the cell can support |
| max\_num\_ues\_sched\_per\_tti\_dl | INTEGER | Max number of UEs that can be scheduled for TX per TTI in the Downlink |
| max\_num\_ues\_sched\_per\_tti\_ul | INTEGER | Max number of UEs that can be scheduled for TX per TTI in the Uplink |
| dlfs\_sched\_enable | BOOLEAN | Sched does Frequency Selective Scheduling in the DL |

**CandScell**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| pci | PhysCellId | Physical Cell Identity |
| earfcn-dl | ARFCN-Value | downlink EARFCN |

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| PhysCellId | INTEGER (0..503) |  |
| ARFCN-Value | INTEGER (0..65535) |  |

### UE Capability

Upon receiving *UECapabilityEnquiry* from xRANc, the eNodeB obtains the UE capabilities (if not already) and responds with *UECapabilityInfo*.

eNodeB may send *UECapabilityInfo* unsolicited (e.g. upon receiving UE capability information from the UE) to the xRANc.



Figure 3: UE Capability Information Exchange

**UECapabilityEnquiry**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global cell Id of connecting cell |

**UECapabilityInfo**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global cell Id of connecting cell |
| ca-cap | CACap | Capabilities related to CA, OPTIONAL |
| dc-cap | DCCap | Capabilities related to DC, OPTIONAL |

**CACap**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| band | INTEGER | C-RNTI assigned to UE |
| caclassdl | ENUMERATED(a,b,c,d,e,f,…) | DL capabilities related to CA |
| caclassul | ENUMERATED(a,b,c,d,e,f,…) | DL capabilities related to CA |
| crossCarrierSched | BOOLEAN | True if supported by the UE, else False |

**DCCap**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **drb-TypeSplit** | ENUMERATED {supported} | This field defines whether the DRB type of Split bearer is supported by the UE which is capable of DC. |

## Procedural Messages

### Admission Control



Figure 4: UE Admission Control

**UEAdmissionRequest**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global cell Id of connecting cell |
| adm\_est\_cause | ENUMERATED (emergency, highp-access, mt-access, mo-signalling,mo-data) | Connection establishment cause |

**UEAdmissionResponse**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Cell Id of connecting cell |
| adm\_est\_response | ENUMERATED(success, failure) | Success of Failure; Cause value if failure (TBD) |

**UEAdmissionStatus**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Cell Id of connecting cell |
| adm\_est\_status | ENUMERATED(success, failure) | Success or Failure; Cause value if Failure |

**UEContextUpdate**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Cell Id of connecting cell |
| mme\_ue\_s1ap\_id | MME-UE-S1AP-ID | ID for UE association over the S1 interface within the MME |
| enb\_ue\_s1ap\_id | ENB-UE-S1AP-ID | ID for UE association over the S1 interface within the eNodeB |
| imsi | UTF8String | UE’s IMSI if available. OPTIONAL |

**UEReconfigInd**

(sent from eNodeB to xRAN controller, on RRC Connection Re-Establishment complete)

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti\_old | CRNTI | Old C-RNTI assigned to UE |
| ecgi | ECGI | Cell Id of connecting cell |
| crnti\_new | CRNTI | New C-RNTI assigned to UE |
| reconfig\_cause | ENUMERATED (rlf, ho-fail, others) | Cause value for Reconfig |

**UEReleaseInd**

(eNodeB -> xRANc is indication when UE goes from RRC\_ACTIVE to RRC\_IDLE, and xRANc -> eNodeB is control when xRANc wants to deactivate the UE)

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | Old C-RNTI assigned to UE |
| ecgi | ECGI | Cell Id of connecting cell |
| release\_cause | ENUMERATED (inactivity, rlf, others) | releaseCause |

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| CRNTI | BIT STRING (SIZE (16)) |  |
| MME-UE-S1AP-ID | INTEGER (0..4294967295) |  |
| ENB-UE-S1AP-ID | INTEGER (0..16777215) |  |

### Handover Management



Figure 5: Call flow for xRANc triggered handover

The xRAN controller sends the *HORequest* to both the Source and Target eNodeB. This way, the target eNodeB also is informed to expect an X2/S1 handover message from the source eNodeB. If the X2 interface does not exist between the source and the target eNode, the eNodeBs can do a S1 based HO.

If the source eNodeB gets a negative response from the target eNodeB as part of the “X2AP:Handover request ack”, then the source eNodeB sends the *HOFailure* message to the eNodeB. If not, then the source eNodeB sends a “RRC Connection Reconfig” message to the UE.

*HOComplete* is sent to the xRAN controller, on receiving the “RRC Connection Reconfig” message by the target eNodeB.

**HORequest**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi\_s | ECGI | Cell ID of source cell |
| ecgi\_t | ECGI | Cell ID of target cell |

**HOFailure**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi\_s | ECGI | Cell ID of source cell |
| ho\_failure\_cause | ENUMERATED (other) | Cause for failure (TBD) |

*.*

**HOComplete**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti\_new | CRNTI | New c-RNTI assigned to the UE by the Target eNodeB |
| ecgi\_s | ECGI | Global Cell ID of source cell |
| ecgi\_t | ECGI | Global Cell ID of the target cell |

### Bearer Management

**eNodeB**

**xRANc**

Bearer

Admission Control

**BearerAdmissionStatus**

**BearerAdmissionResponse**

**BearerAdmissionRequest**

Figure 6: Bearer Admission and Modification

**BearerAdmissionRequest**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global Cell ID |
| ue\_ambr | UEAMBR | [UE AMBR DL, UE AMBL UL] |
| num\_erabs\_list | INTEGER(1..maxNumERABS) | Number of eRABS to be added or modified |
| erabs\_params | SEQUENCE (SIZE (1..maxNumERABS)) OF ERABParams-Item | List of ERABs to be added or modified with bearer\_params |

**BearerAdmissionResponse**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global Cell ID |
| num\_erab\_list | INTEGER(1..maxNumERABS) | Number of eRABS to be added or modified |
| erab\_response | SEQUENCE (SIZE (1..maxNumERABS)) OF ERABResponse-Item | Success or Failure (List of Causes) |

**BearerAdmissionStatus**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global Cell ID |
| num\_erab\_list | INTEGER(1..maxNumERABS) | Number of eRABS to be added or modified |
| erab\_response | SEQUENCE (SIZE (1..maxNumERABS)) OF ERABResponse-Item | Success or Failure (List of Causes) |

**BearerReleaseInd**

**(From eNodeB to xRANc)**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | C-RNTI assigned to UE |
| ecgi | ECGI | Global Cell ID |
| num\_erab\_list | INTEGER(1..maxNumERABS) | Number of eRABS to be added or modified |
| erabs\_ids | SEQUENCE (SIZE (1..maxNumERABS) ) OF ERAB-ID | List of erabs released |

**UEAMBR**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ambr-dl | BitRate |  |
| ambr-ul | BitRate |  |

**ERABParams-Item**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| id | ERAB-ID |  |
| direction | ERABDirection |  |
| type | ERABtype |  |
| qci | QCI |  |
| arp | INTEGER |  |
| gbr-dl | BitRate |  |
| gbr-ul | BitRate |  |
| mbr-dl | BitRate |  |
| mbr-ul | BitRate |  |

**ERABResponse-Item**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| id | ERAB-ID |  |
| decision | ERABDecision |  |

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| BitRate | INTEGER (0..10000000000) |  |
| ERAB-ID | INTEGER (0..15, ...) |  |
| ERABDirection | ENUMERATED (dl, ul, both) |  |
| ERABType | ENUMERATED (default, dedicated) |  |
| QCI | INTEGER (0..255) |  |
| maxNumERABS | INTEGER ::= 11 | constant |

## Measurements

### EUTRAN Periodic Measurements



Figure 7: EUTRAN Periodic Measurements

*RXSigMeasConfig* specifies the configuration on how often and what measurements should be reported to xRANc from eNodeB. The corresponding RRC measurement identity formation to be sent to UE, and the parameters (not specified in the configuration) are left to eNodeB implementation.

**RXSigMeasConfig**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| crnti | CRNTI | CRNTI of UE |
| report\_qty | ENUMERATED (RSRP = 0, RSRQ = 1, BOTH = 2) | RSRP/RSRQ/BOTH |
| meas\_cells | SEQUENCE OF PCI-ARFCN | PCI and downlink EARFCN of the cells to perform measurement on |
| report\_interval\_ms | ENUMERATED (ms-120, ms-240, ms-480,ms-640, ms-1024, ms-2048, ms-5120, ms-10240, min-1, min-6, min-12, min-30, min-60) | Time between sending two measurement reports |

**RXSigMeasReport**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| crnti | CRNTI | CRNTI of UE |
| ecgi | ECGI | Cellid of associated cell |
| cell\_meas\_reports | SEQUENCE OF RXSigReport | RSRP/RSRQ of cells on which measurement is performed |

**RXSigReport**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| pci-arfcn | PCI-ARFCN |  |
| rsrp | RSRP-Range |  |
| rsrq | RSRQ-Range |  |

**PCI-ARFCN**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Values | Description |
| pci | PhysCellId | Physical Cell Identity |
| earfcn-dl | ARFCN-Value | Downlink EARFCN |

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| RSRP-Range | INTEGER(0..97) |  |
| RSRQ-Range | INTEGER(0..34) |  |

### L2 Measurements

**eNodeB**

**xRANc**

L2MeasConfig

L2 Measurement

Reports

(periodic)

Figure 8: L2 Measurements

**L2MeasConfig**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| eCGI | ECGI | Cell ID of associated cell |
| report\_interval\_ms | INTEGER | Time between sending two measurement reports (T)  (min time – 100ms) |

Note: For all L2 measurements, to support partial features, an invalid measurement value can be indicated by reporting 0xFFFF for that field.

**RadioMeasReportPerUE**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| crnti | CRNTI | CRNTI of UE |
| radio\_report\_serv\_cells | SEQUENCE OF RadioRepPerServCell | Radio report over the set of serving cells |

**RadioRepPerServCell**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| pci-arfcn | PCI-ARFCN |  |
| cqi\_hist | SEQUENCE (SIZE(maxNumCQIs)) OF INTEGER | CQI distribution reported by each UE over the measurement period (configured by xRANc) |
| ri\_hist | SEQUENCE (SIZE(maxNumRIs)) OF INTEGER | Number of rank 1 and rank 2 samples as reported by the UE over the measurement period (configured by xRANc) |
| pusch\_sinr\_hist | SEQUENCE (SIZE(sinrHistSize)) OF INTEGER | PUSCH SINR distribution measured by the eNodeB for the UE in ranges (-inf,-18], (-18,-15], (-15,-12], (-12,-9], (-9,-6], (-6,-3], (-3,-0], (-0,3], (3,6], (6,9], (9,12], (12,15], (15,18], (18,inf)} |
| pucch\_sinr\_hist | SEQUENCE (SIZE(sinrHistSize)) OF INTEGER | PUCCH SINR distribution measured by the eNodeB for the UE in ranges { (-inf,-18], (-18,-15], (-15,-12], (-12,-9], (-9,-6], (-6,-3], (-3,0], (0,3], (3,6], (6,9], (9,12], (12,15], (15,18], (18,inf)} |

**RadioMeasReportPerCell**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| pusch\_intf\_pwr\_hist | SEQUENCE (SIZE(intrfHistSize)) OF INTEGER | PUSCH interference + noise power (dBm) distribution measured by the eNodeB on the uplink in ranges {(-inf,-120], (-120,-118], (-118,-116], (-116,-114], (-114,-112], (-112,-110], (-110,-108], (-108,-106], (-106,-104], (-104,-102], (-102,-100], (-100,-98], (-98,-96], (-96,-94], (-94,-92], (-92,-90], (-90,inf)} |
| pucch\_intf\_power\_hist | SEQUENCE (SIZE(intrfHistSize)) OF INTEGER | PUCCH interference + noise power (dBm) distribution measured by the eNodeB on the uplink in ranges {(-inf,-120], (-120,-118], (-118,-116], (-116,-114], (-114,-112], (-112,-110], (-110,-108], (-108,-106], (-106,-104], (-104,-102], (-102,-100], (-100,-98], (-98,-96], (-96,-94], (-94,-92], (-92,-90], (-90,inf)} |

**SchedMeasReportPerUE**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| crnti | CRNTI | CRNTI of UE |
| sched-report-serv-cells | SEQUENCE OF SchedMeasRepPerServCell | scheduler report over the set of serving cells |

**SchedMeasRepPerServCell**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| pci-arfcn | PCI-ARFCN |  |
| qci\_vals | SEQUENCE (SIZE(1..maxNumSupQCI)) OF QCI | QCI values for which the following information is reported |
| prb\_usage | PRBUsage | Percentage of PRBs allocated to this CRNTI in downlink and uplink |
| mcs\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | DL MCS per UE per QCI, where each element is the average of the MCS allocated for that QCI for that UE over the time period |
| num\_sched\_ttis\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | DL Scheduled time per UE per QCI, i.e., total TTIs where that UE was scheduled on the DL for that QCI |
| mcs\_ul | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | UL MCS per UE per QCI, where each element is the average of the MCS allocated for that QCI for that UE over the time period |
| num\_sched\_ttis\_ul | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | UL Scheduled time per UE per QCI, i.e., total TTIs where that UE was scheduled on the UL for that QCI |
| rank\_dl-1 | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | Each element of the array containing the number of Rank 1 samples used by cell for that QCI |
| rank-dl-2 | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | Each element of the array containing the number of Rank 2 samples used by cell for that QCI |

**SchedMeasReportPerCell**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| qci\_vals | SEQUENCE (SIZE(1..maxNumSupQCI)) OF QCI | QCI values for which the following information is reported |
| prb-usage-pcell | PRBUsage | Percentage of PRBs used for this ECGI as the primary cell |
| prb-usage-scell | PRBUsage | Percentage of PRBs used for this ECGI as the secondary cell |

**PRBUsage**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| prb\_usage\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER(0..100) | (Total number of PRBs allocated over period T in DL/ total number of PRBs \*100) for the reported qci-vals |
| prb\_usage\_ul | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER(0..100) | (Total number of PRBs allocated over period T in DL/ total number of PRBs \*100) for for the reported qci-vals |

**PDCPMeasReportPerUe**

(For definitions see TS 36.314)

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| crnti | CRNTI | CRNTI of UE |
| qci\_vals | SEQUENCE (SIZE(1..maxNumSupQCI)) OF QCI | QCI values for which the following information is reported |
| data\_vol\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | PDCP SDU bits delivered from PDCP to RLC per QCI per UE |
| data\_vol\_ul | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | PDCP SDU bits received by PDCP at the eNodeB per QCI per UE |
| pkt\_delay\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | Average DL Pkt delay measured from PDCP arrival to MAC exit per QCI per UE (ms) |
| pkt\_discard\_rate\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | Average Pkt Discard rate at L2 per QCI per UE |
| pkt\_loss\_rate\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | Average Pkt Loss rate at DL per QCI per UE |
| pkt\_loss\_rate\_ul | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | Average Pkt Loss rate at UL per QCI per UE |
| throughput\_dl | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | DL throughput per QCI per UE in kbits/s |
| throughput\_ul | SEQUENCE (SIZE(1..maxNumSupQCI)) OF INTEGER | UL throughput per QCI per UE in kbit/s |

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| maxNumCQIs | INTEGER ::= 16 | Constant |
| maxNumRIs | INTEGER ::= 2 | Constant |
| sinrHistSize | INTEGER ::= 14 | Constant |
| intrfHistSize | INTEGER ::= 17 | Constant |
| maxNumSupQCI | INTEGER ::= 9 | Constant |

## xICIC/Radio Resource Management Controls

**eNodeB**

**xRANc**

**XICICConfig**

ICIC/RRM Control LOGIC

Figure 9: ICIC Controls

**XICICConfig** *(note: deprecated beyond v3, RRM\_CONFIG supersedes this message)*

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| crnti | CRNTI | UE identifier(s) for which the configuration has to applied |
| pci-arfcn | PCI-ARFCN | PCI and downlink EARFCN of the CC for each UE to which the configuration is to be applied |
| p\_a | ENUMERATED (  dB-minus6,  dB-minus4dot77,  dB-minus3,  dB-minus1dot77,  dB-0,  dB-1,  dB-2,  dB-3) | PDSCH power offset for the UE (dB) |
| start\_prb\_dl | INTEGER(0..100) | Starting DL PRB allocated to UE. Valid Range 0 to 100 |
| end\_prb\_dl | INTEGER(0..100) | Ending DL PRB allocated to UE. Valid Range 0 to 100 |
| sub\_frame\_bitmask\_dl | BIT STRING (SIZE(10)) | subframe mask– bitmask. Each bit corresponds to a sub-frame. 0 indicates SF to be allocated to the UE.  LSB corresponds to SubFrame0. OPTIONAL |
| p0\_ue\_pusch | INTEGER(-8..7) | PUSCH power offset for the UE (dB). Valid Range [-8, 7] |
| start\_prb\_ul | INTEGER(0..100) | Starting UL PRB allocated to UE. Valid Range 0 to 100 |
| end\_prb\_ul | INTEGER(0..100) | Ending UL PRB allocated to UE. Valid Range 0 to 100 |
| sub\_frame\_bitmask\_ul | SEQUENCE OF BIT STRING (SIZE(10)) | subframe mask – bitmask. Each bit corresponds to a sub-frame. 0 indicates SF to be allocated.  LSB corresponds to SubFrame0. OPTIONAL |



Figure 10: RRM Controls

Upon receiving the **RRMConfig**, eNodeB applies the specified RRM parameters for the corresponding UEs. For example, for the specified UEs scheduler allocates downlink PRBs only in the range from start\_prb\_dl to end\_prb\_dl. Same is applicable for uplink. Similarly sub\_frame\_bitmask applies the ABS pattern (per frame) to be used for ICIC configuration. Upon successfully executing the **RRMConfig** intents for the specified the eNodeB replies with the **RRMConfigStatus**.

**RRMConfig**

|  |  |  |
| --- | --- | --- |
| Parameters | Type/Value | Description |
| ecgi | ECGI | Cell ID of associated cell |
| crnti | SEQUENCE OF CRNTI | UE identifier(s) for which the configuration has to applied. OPTIONAL, if not specified, the config is applied to all the UEs served by this ECGI. |
| pci-arfcn | PCI-ARFCN | PCI and downlink EARFCN of the CC for each UE to which the configuration is to be applied. OPTIONAL |
| p\_a | SEQUENCE OF ENUMERATED ( dB-minus6,  dB-minus4dot77,  dB-minus3,  dB-minus1dot77,  dB-0,  dB-1,  dB-2,  dB-3) | PDSCH power offset (dB) for the respective UEs. See TS 36.213 [23, 5.2]. OPTIONAL |
| start\_prb\_dl | SEQUENCE OF INTEGER | Starting DL PRB allocated to the corresponding UEs. Valid Range 0 to 100. OPTIONAL |
| end\_prb\_dl | SEQUENCE OF INTEGER | Ending DL PRB allocated to the corresponding UEs. Valid Range 0 to 100. OPTIONAL |
| sub\_frame\_bitmask\_dl | SEQUNCE OF BIT STRING (SIZE(10)) | DL ABS pattern – bitmask. Each bit corresponds to a sub-frame. 0 indicates SF to be allocated.  LSB corresponds to SubFrame0. OPTIONAL |
| p0\_ue\_pusch | SEQUENCE OF INTEGER(-8..7) | PUSCH power offset for the UE (dB). See TS 36.213 [23, 5.1.1.1]. Valid Range [-8, 7]. OPTIONAL. |
| start\_prb\_ul | SEQUENCE OF INTEGER | Starting UL PRB allocated to the corresponding UEs. Valid Range 0 to 100. OPTIONAL |
| end\_prb\_ul | SEQUENCE OF INTEGER | Ending UL PRB allocated to the corresponding UEs. Valid Range 0 to 100. OPTIONAL |
| sub\_frame\_bitmask\_ul | SEQUENCE OF BIT STRING (SIZE(10)) | UL ABS pattern – bitmask. Each bit corresponds to a sub-frame. 0 indicates SF to be allocated.  LSB corresponds to SubFrame0. OPTIONAL |

**RRMConfigStatus**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **ecgi** | ECGI | Cell ID of associated cell |
| **crnti** | SEQUENCE OF CRNTI | UE identifier(s) for which **RRMConfig** was applied. OPTIONAL, not specified if not specified in **RRMConfig.** |
| **status** | SEQUENCE OF ENUMERATED(success, failure) | Status of RRM configuration application for each UE. If no crnti field is specified in RRMConfig implying cell-wide config, this field would indicate the status of the cell-wide config. |

## Carrier Aggregation Controls



Figure 11: Carrier Aggregation Control

**ScellAdd**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTI of the UE to which the sCell has to be added and activated |
| **ecgi** | ECGI | Cell-Id of the primary cell to which UE is camped on |
| **scells-prop** | SEQUENCE OF PropScell | Properties of the secondary cells to be configured for the UE |

Upon receiving the ScellAdd, eNodeB sends out RRC connection reconfiguration to the UE with the corresponding scell properties in sCellToAddModList IE. sCell MAC level activation through MAC CE activation is also performed by the Pcell. Upon expiration of deact-timer, the logic of MAC level activation of sCell lies in the eNodeB scheduler.

**ScellAddStatus**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTI of the UE to which the sCell are added |
| **ecgi** | ECGI | ECGI of the primary cell of the UE |
| **scells-ind** | SEQUENCE OF PCI-ARFCN | PCI-EARFCN of the secondary cells configured for the UE |
| **status** | SEQUENCE OF ENUMERATED(success, failure) | status of sCell addition |

Sent on RRC reconfiguration complete corresponding to the scell(s) addition.

**ScellDelete**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTI of the UE to which the sCell has to be deleted |
| **ecgi** | ECGI | ECGI of the primary cell |
| **scells-ind** | SEQUENCE OF PCI-ARFCN | PCI-EARFCN of the secondary cells to be removed for the UE |

Upon getting this message, the eNodeB sends RRC connection reconfiguration to the UE with the corresponding scell indices in sCellToReleaseList.

**PropScell**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **pci-arfcn** | PCI-ARFCN | PCI-EARFCN of the secondary cell to be configured for the UE |
| **cross-carrier-sched-enable** | BOOLEAN | Cross carrier scheduling is enabled for the UE on this scell |
| **ca-direction** | ENUMERATED (dl, ul, both) | Direction in which CA is enabled |
| **deact-timer** | INTEGER | Value in number of radio frames. SCell deactivation timer in TS 36.321. |

## Dual Connectivity Controls



Figure 12: SeNB Addition and Deletion

**SeNBAdd**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTIof the UE to which the SeNB has to be added |
| **m-ecgi** | ECGI | ECGI of the MeNB |
| **s-ecgi** | ECGI | ECGI of the SeNB |

**SeNBAddStatus**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTI of the UE at the secondary eNB |
| **ecgi** | ECGI | ECGI of the SeNB |
| **status** | ENUMERATED(success, failure) | status of SeNB addition |

**SeNBDelete**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTI of the UE (at MeNB) to which the SeNB has to be deleted |
| **m-ecgi** | ECGI | ECGI of MeNB |
| **s-ecgi** | ECGI | ECGI of SeNB |



Figure 13: Traffic splitting intent

**TrafficSplitConfig**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **crnti** | CRNTI | C-RNTI of the UE engaged in DC |
| **ecgi** | ECGI | Cell id of the MeNB |
| **traffic-split-percent** | SEQUENCE OF TrafficSplitPercentage | PDCP traffic split percentages with corresponding cell ids for the UE engaged in DC |

**TrafficSplitPercentage**

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Type/Value** | **Description** |
| **ecgi** | ECGI | cell ECGI to which this percentage applies |
| **traffic-percent-dl** | INTEGER (0..100) | Percentage of the split bearer DL traffic carried on this ECGI, OPTIONAL |
| **traffic-percent-ul** | INTEGER (0..100) | Percentage of the split bearer UL traffic carried on this ECGI, OPTIONAL |

# References

1. 3GPP 36.331, Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC);
2. 3GPP TS 36.314, Evolved Universal Terrestrial Radio Access (E-UTRA); Layer 2 – Measurements;
3. 3GPP TS 36.321, Evolved Universal Terrestrial Radio Access (E-UTRA);

Medium Access Control (MAC) protocol specification