5G RAN Interfaces and eCPRI

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Introduction

This paper provides an overview of external and internal interfaces of a 5G base station (gNB). The New Radio gNB is connected to the Access and Mobility Management Function (AMF) and the User Plane Function (UPF) in the 5G Core Network (5GC). A new Xn interface inter-connects gNBs that are connected to the 5GC. The 5G RAN internal structure has been discussed heavily in the standardization process of 5G. Different split options that are under discussion are also introduced in this paper.

Interfaces to 5G Core

Figure 1 illustrates the gNB architecture and its interfaces. There are control plane and user plane interfaces towards the 5G Core network. The reference points are called N3 and N2, while the protocol defined by RAN3 will be called NG-C and NG-U, respectively. The interfaces are very similar to the known S1-C and S1-U interfaces of LTE. The newly defined application protocols will use the same lower layer protocols as LTE/EPC, which are GTP/UDP/IP for the user plane and SCTP/UDP/IP for the control plane [1].

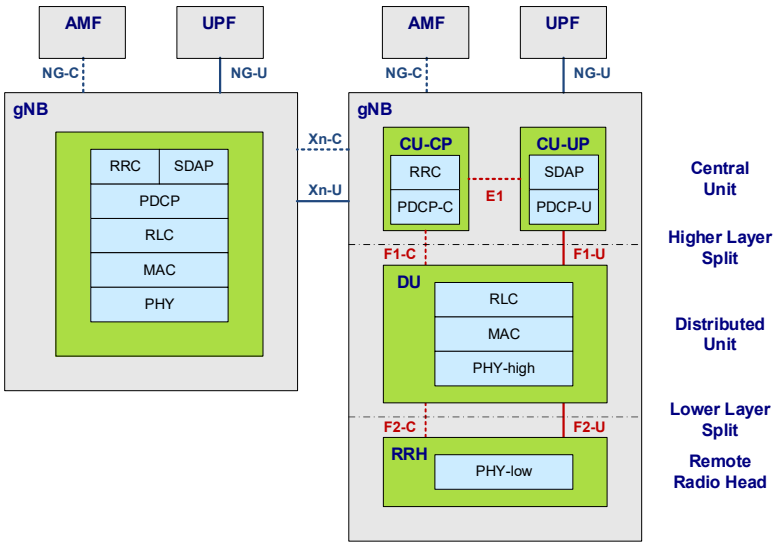

Figure 1: New Radio gNB interfaces (internal and external)

Inter-gNB Interfaces

The Xn interface [1] is used between two gNBs connected to the 5GC. To avoid confusion (or to add confusion), if a NR gNB connects to an LTE base station, that is still connected to an EPC, the legacy X2 interface will be used for signalling related to UEs connected to the EPC while the new Xn interface will be used for UEs connected to the 5GC. You can imagine that there are various mobility scenarios of UEs connected to EPC or 5GC and base stations connected to the EPC and/or the 5GC.

The Xn interface supports the following functions:

Control plane functions

- interface management and error handling (e.g. setup, reset, removal, configuration update)
- connected mode mobility management (handover procedures, sequence number status transfer, UE context retrieval)
- support of RAN paging
- dual connectivity functions (secondary node addition, reconfiguration, modification, release, etc.)

User plane functions

- data forwarding
- flow control

One of the key functions is the support of Dual Connectivity, where Xn is the interface between the Master Node and the Secondary Node. Since the key scenario for initial 5G deployment is LTE – NR Dual Connectivity (see figure 2), it was natural to take LTE Dual Connectivity as the baseline for 5G.

A full coverage LTE macro base station serves as master node and will serve one or more 5G gNBs as secondary nodes. Possible deployment scenarios are an extension of the macro cells as well as heterogeneous networks as illustrated.

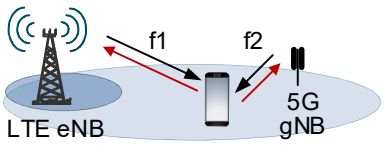

Figure 2: LTE - NR Dual Connectivity

This "non-standalone" 5G deployment will speed up the deployment of 5G since the higher layer protocols and even the EPC can be used without major modifications.

The success of 5G largely depends on the Dual Connectivity technology. As one of the problems of Dual Connectivity, the UE complexity increases since multiple uplink transmitters are required. Nevertheless, the overall transmit power is still limited to 23dBm. Considering that there will be two MAC schedulers operating independently, a dynamic power split might not be possible unless a joint LTE / NR C-RAN is used. Furthermore, 5G will be using higher frequency bands than LTE. Hence, the uplink coverage will be much smaller compared to LTE. The 5G downlink may compensate for this somewhat by its large transmit power. Sharing the LTE uplink spectrum with 5G uplink is one concept to overcome these shortcomings. The 5G carrier, most likely a TDD carrier, will primarily be used in downlink while LTE and 5G will shared the uplink spectrum at a lower frequency. Spectrum will be shared in time and/or frequency domain.

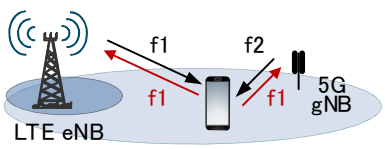

Figure 3: Uplink spectrum sharing for LTE - NR Dual Connectivity

gNB Internal Interfaces

There are multiple logical entities that a New Radio gNB can comprise: a Central Unit, Distributed Units and Remote Radio Heads. As shown in figure 1, the gNB may be split into distinct physical elements or may be collapsed into a single functional entity. Operators try to push for the standardisation of F1 and F2 interfaces in 3GPP to allow for a multi-vendor environment. Also due to resistance of key vendors, 3GPP RAN3 did not yet progress much on the standardization of these interfaces. While first specification text of the F1 interface exists [2], the specification of the F2 interface may even be harder due to the lack of Physical Layer knowledge within this group. On top of 3GPP other organizations started to work on this fronthaul interface, putting quite some pressure on vendors to agree on principles.

Eventually, also the split between control and user plane of the Central Unit is under discussion.

This reference point is called E1. Such an interface would nicely support an independent virtualization of the control and user plane. It would also enable a more flexible allocation of the functions of the central unit. A central RRM manager for Distributed Units could be separated in accordance with specific network topologies. Similarly, User Plane functions could be moved towards the core in a standardized way. One example deployment scenario illustrated in Figure 4 is a regional or national data centre. It allows for energy and cost efficient central processing and resource pooling for the user plane. Many functions like security, packet inspection, header compression and data mining could benefit from the central location. Furthermore, it would provide optimum routing of packets in case of multi-connectivity and interworking with other systems. Remaining functions in the distributed units might be integrated in the antenna; alternatively a lower layer split to Remote Radio Heads might be used.

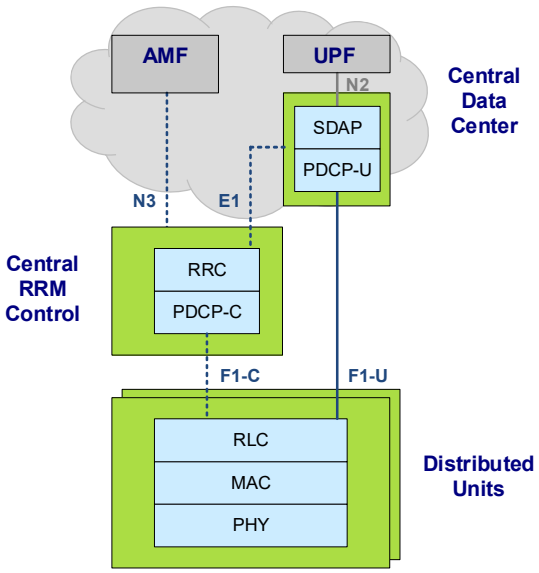

Figure 4: Centralized User Plane Processing

New eCPRI V1.0 Interface

Last week on August 31, 2017, the CPRI consortium supported by Ericsson, Huawei, NEC and Nokia released a new specification called eCPRI [3]. Version 1.0 is now ready for open download [4]. Among others, eCPRI claims [5] a 10 fold reduction of the required bandwidth, while the bandwidth can scale flexibly with the user plane traffic. In the eCPRI presentation [5] a set of split options in the physical layer is introduced. The presentation states that these split options are a "set of examples". Maybe due to the time pressure, it was not possible to find quick agreement among the vendors on this important issue. Hopefully agreement can be achieved before implementations diverge into different directions, making multi-vendor operation much more difficult.

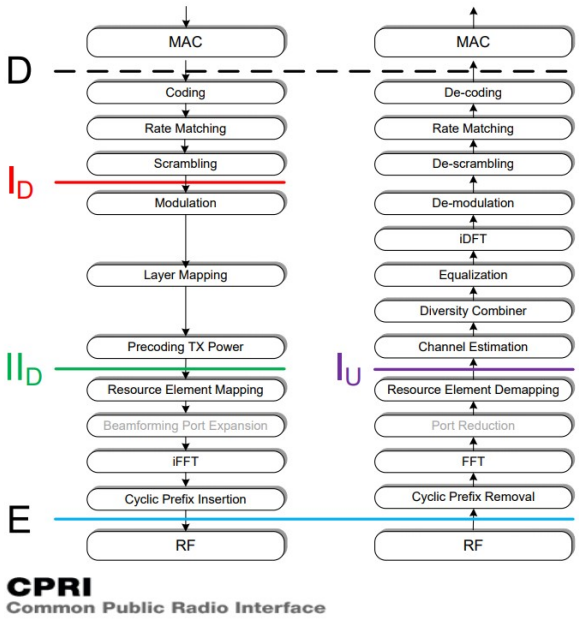

Figure 5: eCPRI Functional Decomposition (© CPRI industry cooperation)

References

[1] 3GPP TR 38.300, "New Radio; Overall description; Stage-2," V1.0.0, Sept 2017.

[2] 3GPP TS 38.401, "Next Generation-RAN; Architecture description," V0.3.0, Aug 2017.

[3] Press Release "Industry leaders release the new CPRI Specification for 5G", http://www.cpri.info/press.html

[4] eCPRI 1.0 specification
http://www.cpri.info/spec.html

[5] eCPRI 1.0 presentation
http://www.cpri.info/spec.html

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