On the Support of NG-RAN Functional Splits in the 5G ESSENCE Architecture

J. Pérez-Romero, O. Sallent, R. Ferrús
Universitat Politècnica de Catalunya (UPC)
Barcelona, Spain
{jorperez,sallent,ferrus}@tsc.upc.edu

***Abstract*—The 5G ESSENCE project addresses the combination of Small Cell as a Service and edge cloud computing through a flexible two-tier architecture that can be adapted to the needs of different small cell deployment scenarios. This paper shows, by means of different illustrative examples, how this architecture can accommodate the different functional splits for decomposing the gNB of the 5G NG-RAN architecture into a centralized and a distributed unit that are considered by 3GPP.**

Keywords—SCaaS; NG-RAN; Functional Split

I. INTRODUCTION

The provision of Small Cells as a Service (SCaaS) is a solution to facilitate a third-party provisioning of radio access capacity to mobile network operators in localised areas with capacity or coverage issues. The 5G ESSENCE project [1] addresses this concept by providing a highly flexible and scalable platform, able of supporting new business models and revenue streams, and to accommodate the requirements of different use cases associated to vertical industries, which become a key differential aspect of future 5G networks.

In this context, this paper intends to present the main elements of the 5G ESSENCE architecture and to illustrate its flexibility to support the different functional splits that have been (or are currently being) standardized for the Next Generation Radio Access Network (NG-RAN) in the 5G specifications. For that purpose, section II briefly discusses the 5G ESSENCE architecture, while section III presents different configurations to show how it can accommodate different options considered in the current 3GPP NG-RAN specifications. Finally, section IV concludes the paper.

II. 5G ESSENCE ARCHITECTURE

The 5G ESSENCE architecture allows multiple network operators (tenants) to provide services to their users through a set of Cloud Enable Small Cells (CESCs) deployed, owned and managed by a third party. In this way, operators can extend the capacity of their own 5G RAN in areas where the deployment of their own infrastructure could be expensive and/or inefficient. A CESC consists of a small cell (SC) Physical Network Function (PNF) unit, where a subset of the SC functionality is implemented via tightly coupled software and hardware, and a micro server that supports the execution of Virtualized Network Functions (VNFs), which provide the rest of the SC functionality together with other added-value services.

In addition to providing the radio access, 5G ESSENCE includes a two-tier virtualised execution environment, materialised in the form of the Edge Data Center (DC), which allows also the provision of Mobile Edge Computing (MEC) capabilities to the mobile operators for enhancing the user experience and the agility in the service delivery. The first tier is the Light DC that is composed by the aggregation of the micro servers of the different CESCs. The second tier is the Main DC that hosts more computation intensive tasks and processes that need to be centralised in order to have a global view of the underlying infrastructure.

III. 5G ESSENCE IN RELATION TO 3GPP NG-RAN

In December 2017, 3GPP has just completed Stage 3 of the so-called Non-Standalone (NSA) 5G New Radio (NR) specification as part of Rel-15, under which 5G NR carriers can be used in combination with LTE carriers and the 4G Evolved Packet Core (EPC). The NG-RAN allows the connection between the UE and the 5G Core Network [2] and is composed by the gNB nodes that provide the 5G NR user/control plane terminations.

The gNB can be decomposed in a gNB Central Unit (gNB-CU) and one or more gNB Distributed Units (gNB-DU). Both units are interconnected through the F1 interface. The operation of the gNB-DU is partly controlled by the gNB-CU. One cell is supported by only one gNB-DU, but one gNB-DU can support multiple cells. According to the current release 15 of 3GPP specifications, the functional split between the gNB-CU and the gNB-DU considers that the gNB-CU hosts the Radio Resource Control (RRC), Service Data Adaptation Protocol (SDAP) and Packet Data Convergence Protocol (PDCP) layers while the gNB-DU hosts the Radio Link Control (RLC), Medium Access Control (MAC) and Physical (PHY) layers. This corresponds to the so-called split option 2 [3]. However, it is envisaged that future releases of the specifications will incorporate other lower layer splits (e.g. MAC-PHY and intra-PHY split) that are currently under study in [4].

The 5G ESSENCE architecture enables a distributed deployment of the NG-RAN functionality across the dedicated hardware embedded in the CESC (i.e. small cell PNF) and the distributed virtualised execution environment provided by the Edge DC with lightweight NFVI Points of Presence (PoP) embedded in the CESC units (e.g. Light DC) and an external centralised NFVI PoP (i.e. Main DC). Such infrastructure configuration can accommodate different deployment options such as the gNB decomposition between a gNB-CU and one or more gNB-DUs considered in the 3GPP NG-RAN. In general terms, it can be envisaged that the main DC can host the functionalities of the gNB-CU in addition to some other functionalities of the gNB-DU with higher computational requirements.

To illustrate the flexibility of the 5G ESSENCE architecture to support different splits between gNB-CU and

This work has been supported by the EU funded H2020 5G-PPP project 5G ESSENCE under the grant agreement 761592.

978-1-5386-1478-5/18/$31.00 ©2018 IEEE

gNB-DU some examples are given in Fig. 1 to Fig. 4. For simplicity, in all these figures only the CESC and the main DC components of the 5G ESSENCE architecture are shown, together with the Transport Network (TN) used to interconnect the different CESCs and the main DC. The different logical interfaces between entities are depicted in red.

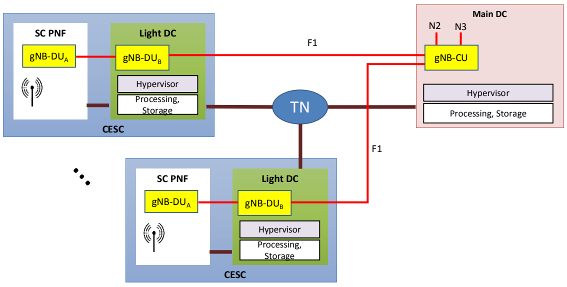

Fig. 1. Example 1: gNB-CU at the Main DC and gNB-DU at the CESC

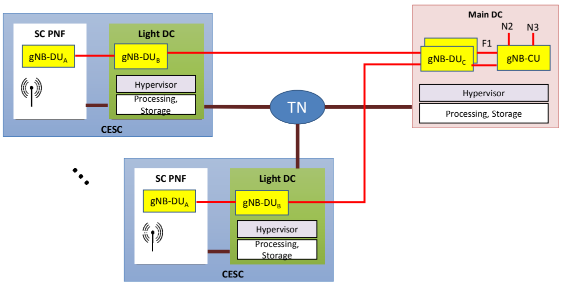

Fig. 2. Example 2: gNB-CU at the Main DC and gNB-DU split between the CESC and the Main DC

The example of Fig. 1 considers the 3GPP functional split option 2 in which the gNB-CU runs at the main DC and incorporates the SDAP, PDCP and RRC protocols (thus hosting RAC, RBC and CMC functionalities), while the gNB-DU runs at the CESCs. In this case, taking advantage of the light DC, the gNB-DU is further split into two parts, the gNB-DU$_A$, which executes the physical layer and is implemented at the SC PNF, and gNB-DU$_B$, which executes the MAC and RLC layers and runs at the local microservers of each CESC composing the light DC. In this example, the PS functionality, which runs at the MAC layer, will be distributed at each CESC. In contrast, the example of Fig. 2 assumes also the functional split option 2 but considering that the MAC functionality is further split between the gNB-DU$_B$ running at the light DC and hosting the lower level MAC, e.g. Hybrid Automatic Repeat reQuest (HARQ) process, and the gNB-DU$_C$, running at the main DC and hosting the PS and RLC level. With this example, a coordinated scheduling for multiple cells can be implemented at the main DC. Similarly, this approach would facilitate the implementation of techniques such as Coordinated Multi-Point (CoMP) and will facilitate InterCell Interference Coordination (ICIC). In addition to the gNB-DU$_C$ function, the Main DC also hosts the gNB-CU. The separation between the two, through the standardised interface F1, enables e.g. that each function could be implemented by a different vendor.

As another example, Fig. 3 assumes the MAC-PHY functional split. In this case, the gNB-DU includes the physical layer and is executed at the SC PNF, while the gNB-CU includes the MAC layers and above and is executed at the main DC. Like in the previous example, also in this case the MAC scheduling function can have a coordinated vision of multiple cells. It is worth mentioning that, in this example, the interface between the gNB-DU and the gNB-CU would be the one defined by 3GPP when specifying the lower layer split, since current interface F1 is just for the split option 2.

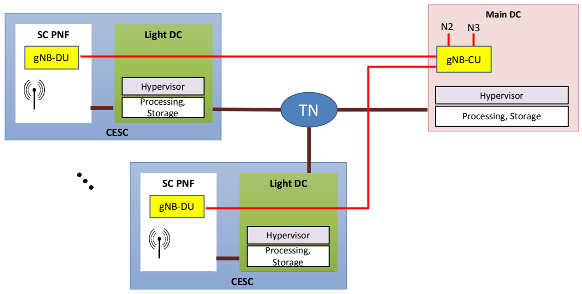

Fig. 3. Example 3: Support of MAC-PHY functional split.

Finally, to further illustrate the versatility of the 5G ESSENCE architecture, Fig. 4 shows another example in which both the gNB-DU and gNB-CU functions are hosted at the Light DC assuming split option 2. Specifically, the gNB-DU functions of the different small cells are split between the SC PNF (gNB-DU$_A$) and the light DC (gNB-DU$_B$) of the deployed CESCs. In turn, the gNB-CU function will run also in one of the microservers composing the Light DC. This approach could be adequate e.g. in case of small deployments with a reduced number of small cells, in which the associated computational complexity of the gNB-CU can be supported by the Light DC without the need of a Main DC.

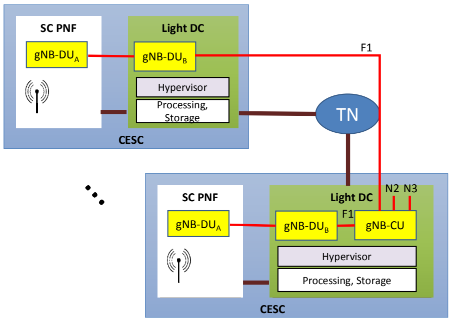

Fig. 4. Example 4: Both gNB-DU and gNB-CU at the Light DC

IV. CONCLUSIONS

As a means to flexibly support small cell as a service and edge cloud computing, 5G ESSENCE architecture proposes the use of a two-tier virtualised execution environment composed by a Light DC that combines a number of micro servers hosted at the cloud enabled small cells and a centralized Main DC. This paper has shown how these two tiers provide a high degree of flexibility to support different deployment options aligned with the functional split of a gNB in a centralized and a decentralized unit as currently standardized for the NG-RAN.

REFERENCES

[1] http://www.5g-essence-h2020.eu/

[2] 3GPP TS 38.401 v15.0.0, "NG-RAN; Architecture description; Stage 2 (Release 15)", December, 2017.

[3] 3GPP TR 38.801 v14.0.0, "Study on new radio access technology: Radio access architecture and interfaces (Release 14)", March, 2017.

[4] 3GPP TR 38.816 v15.0.0, "Study on CU-DU lower layer split for NR (Release 15)", December, 2017.