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GSTR-TN5G

Transport network support of IMT-2020/5G

ITU-T

Summary

This technical report documents a reference model for the IMT 2020/5G transport network and a set of deployment scenarios. It captures requirements on transport networks in order to support IMT 2020/5G networks and provides details on the interfaces between the IMT 2020/5G entities and the transport network. The support of IMT 2020/5G network slicing (data plane and control plane) and Control/Management interfaces are also described.

Keywords

IMT-2020, 5G, network slicing

Change Log

This document contains Version 1 of the ITU-T Technical Report on "Transport network support of IMT-2020/5G" agreed at the ITU-T Study Group 15 meeting held in Geneva, 08 - 19 October 2018.

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Summary

This technical report documents a reference model of IMT-2020/5G network and a set of deployment scenarios. It documents requirements on transport networks in order to support IMT-2020/5G networks, particularly at interfaces between IMT 2020/5G entities and transport networks. Aspects of transport network support include network slicing (data plane and control plane), synchronization, and Control/Management.

Technical Report ITU-T GSTP-TN5G

Transport network support of IMT-2020/5G

1 Scope

This TR focuses on requirements on transport networks in order to support IMT-2020/5G networks. Aspects of how mobile traffic is directed onto transport networks are out of scope.

2 References

[1] 3GPP TR 23.501 v1.4 (2017-09) System Architecture for the 5G System, Stage 2 Release 15

[2] 3GPP TR 28.801 v15.0.0 (2017-09) Study on management and orchestration of network slicing for next generation network, Release 15

[3] 3GPP TR 38.401, “Architecture description”, v0.2.0, 2017-07

[4] 3GPP TR 38.801, “Technical Specification Group Radio Access Network; Study on new radio access technology: Radio access architecture and interfaces”, March 2017

[5] 3GPP Release 15, TS 38.470 … 475 series (NG-RAN; F1 interface)

[6] 3GPP TS 38.104, Base Station (BS) radio transmission and reception (Release 15)

[7] 3GPP TS 38.133, Requirements for support of radio resource management (Release 15)

[8] 3GPP TS 38.300, NR; NR and NG-RAN Overall Description; Stage 2

[9] 3GPP TS 38.340, Evolved Universal Terrestrial Radio Access (E-UTRA) and NR;Multi-connectivity;Stage 2

[10] 3GPP TS 36.300, Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description

[11] 3GPP TS 28.530 v0.4.0 (2018-1), Management of 5G networks and network slicing; Concepts, use cases and requirements.

[12] 3GPP TS 38.913 v14.3.0 (2017-06), Study on Scenarios and Requirements for Next Generation Access Technologies.

[13] eCPRI Specification V1.0, "Common Public Radio Interface: eCPRI Interface Specification", August 2017

[14] SCF082.09.05, Small Cell Forum (SCF) nFAPI (network functional application platform interface)

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[16] NGMN Alliance, “5G End-to-End Architecture Framework” 04-Oct-2017

[17] IEEE P1914.1/D2.0 Draft Standard for Packet-based Fronthaul Transport Networks

[18] ITU-T Recommendation G.8265/Y.1365 (2010), Architecture and requirements for packet-based frequency delivery

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[22] ITU-T Recommendation G.8271.1/Y.1366.1 (2017),] “Network limits for time synchronization in packet networks”

[23] Draft ITU-T Recommendation Y.IMT2020-MultiSL “Framework for the support of Multiple Network Slicing”

[24] Draft ITU-T Recommendation Y.IMT2020-frame “Framework of IMT-2020 network”

[25] MEF implementation agreement 22.2: Mobile Backhaul Phase 3 (January 2016)

[26] China Mobile Research Institute et al., “Toward 5G C-RAN: Requirements, Architecture and Challenges,” V. 1.0, Nov 2016. http://labs.chinamobile.com/cran/page/7/

[27] Uwe Doetsch, et al., “Quantitative analysis of split base station processing and determination of advantageous architecture for LTE,’ Bell Labs Technical Journal 18(1), 105–128 (2013)
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3 Terms and definitions

3.1 Terms defined elsewhere

None for this TR.

3.2 Terms defined here

None for this TR.

4 Abbreviations

BBU	Baseband Unit
CP	Control Plane
CN	Core Network
CPRI	Common Public Radio Interface
CU	Central Unit
DU	Distributed Unit
E2E	Edge-to-Edge
eMBB	Enhanced Mobile Broadband
EPC	Evolved Packet Core
gNB	Next generation NodeB, 5G base station name
MAC	Media Access Control
MEC	Mobile Edge Compute
MEF	MEF Forum
MIMO	Multiple Input Multiple Output
mMTC	Massive Machine Type Communication
MNSSI	Managed Network Slice Subnet Instance
NGC	Next Generation Core
NR	New Radio
NRT	Non-Real Time
NSA	Non-stand Alone
OBSAI	Open Base Station Architecture Initiative
OLT	Optical Line Terminal
ONU	Optical Network Unit
PDCP	Packet Data Convergence Protocol
PON	Passive Optical Network

PTP	Precision Timing Protocol
RAN	Radio Access Network
RF	Radio Frequency
RLC	Radio Link Control
RNL	Radio Network Layer
RRC	Radio Resource Control
RRH	Remote Radio Head
RT	Real Time
RU	Remote Unit
SA	Stand Alone
SSM	Synchronization Status Message
TNL	Transport Network Layer
UP	User Plane
URLLC	Ultra-Reliable Low Latency Communication
VN	Virtual Network

5 Reference 5G Wireless Architecture

5.1 3GPP's 5G Architecture

The 3GPP's architecture of the 5G network is shown below in Figure 5-1. It is from [9]. The NG-RAN consists of a set of gNBs connected to the 5GC (5G core network) via the NG interface. The gNBs can be interconnected through the Xn interface. A gNB may consist of a gNB-Centralized Unit (gNB-CU) and gNB-Distributed Unit (gNB-DU). The CU processes non-real time protocols and services, and the DU processes PHY level protocol and real time services A gNB-CU and the gNB-DU units are connected via F1 logical interface. One gNB-DU is connected to only one gNB-CU. For resiliency, a gNB-DU may also be able to connect to another gNB-CU (if the primary gNB-CU fails) by appropriate implementation. NG, Xn and F1 are logical interfaces.

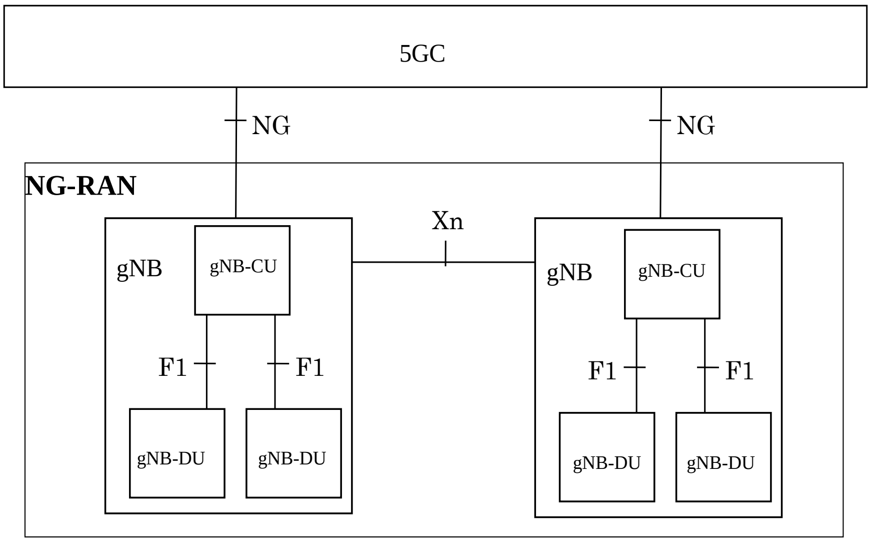

Figure 5-1: 3GPP NG-RAN architecture (Source [3][1])

Where fronthaul is the network between RRU (Remote Radio Unit) and DU (CPRI and eCPRI interfaces), midhaul is the network between DU and CU (F interface) and backhaul is the network between CU and 5G CN (NG interface) and between CUs (Xn interface). In some case, CU and DU are co-located and form gNB. In such scenario, RRU to gNB is fronthaul and gNB to 5G CN is backhaul. The fronthaul would typically be based on LL FS (low layer functional split) and the middlehaul would typically be based on HL FS (high layer functional split).

For redundancy, the following entity relationships may exist: gNB:5GC can be 1:2, and DU:CU can be 1:n.

5.2 Evolution of wireless transport architecture from 4G to 5G

Evolving from 4G/LTE to 5G New Radio (NR) transport architecture, the main change is that the original BBU function in 4G/LTE is split into three parts: Central Unit (CU), Distributed Unit (DU), and Remote Radio Unit (RRU). The motivation of this redesign is manifold [16]. For example, the new design could better facilitate radio access network (RAN) virtualization. It also allows for decreased fronthaul line rates, while meeting latency demands.

Specific functions residing in CU and DU are deployment dependent and still under discussion. Figure 2 gives one example of the evolution from 4G to a split-function architecture in 5G [26]. The RAN architecture in 4G consists of Evolved Packet Core (EPC), Baseband Unit (BBU), and Remote Radio Head (RRH). When evolving to 5G, in this example, part of the user plane (UP) functions are moved from EPC to CU and DU, Layer 2 (L2) non-real time and Layer 3 (L3) functions from BBU to CU, Layer 1 (L1)/L2 real-time functions from BBU to DU, and the rest of L1 functions from BBU to RRU. EPC functions are redistributed among the Next Generation Core (NGC), CU, and DU. The two new interfaces created are generally referred to as the high layer split point (Fronthaul-II) and the low layer split point (Fronthaul-I). Other distributions of functions between NGC, CU, DU, and RRU may also be possible. In Figure 5-2, the yellow lines indicate interfaces for transport networks and the grey or black lines with arrows illustration the migration of 3GPP functions.

Note that 3GPP considers a split base station architecture consisting of CU and DU only. In this technical report, we adopt a split architecture consisting of three elements, CU, DU and RRU.

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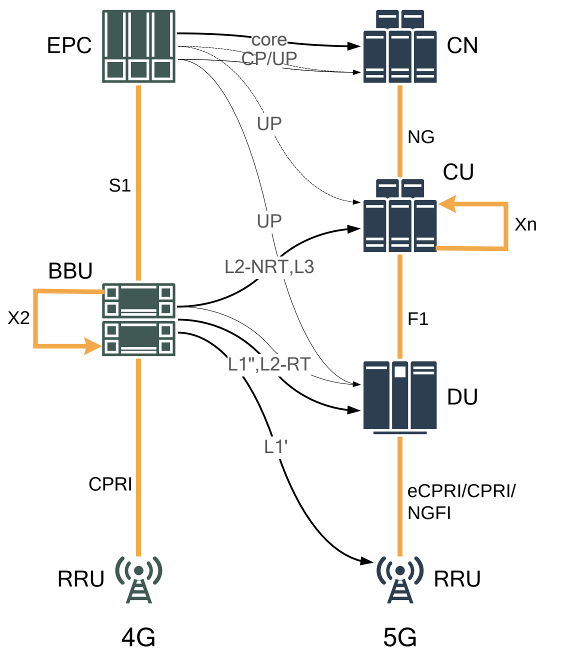

Figure 5-2. Evolving from single-node in 4G to split function architecture in 5G.

As of Dec. 2017, 3GPP has described the evolution to 5G in two options for its Release 15: non-stand alone, and stand alone. In non-stand alone, the 4G LTE base station (eNB) and the 5G NR base station are interconnected with dual connectivity. In the initial deployments, option 3 in Figure 5-3 below, the 4G Evolved Packet Core (EPC) remains the core and connected to the 4G LTE base station which is in turn connected to a 5G NR base station (called en-gNB in this case). In later deployments, the 5G NG core is deployed with connection to the 4G LTE base station (now called the ng-eNB and shown in option 7) and possibly then to the 5G NR base station (option 4). This evolution will allow the user equipment (e.g., mobile handsets) to evolve in support of the 5G radio and core functionality.

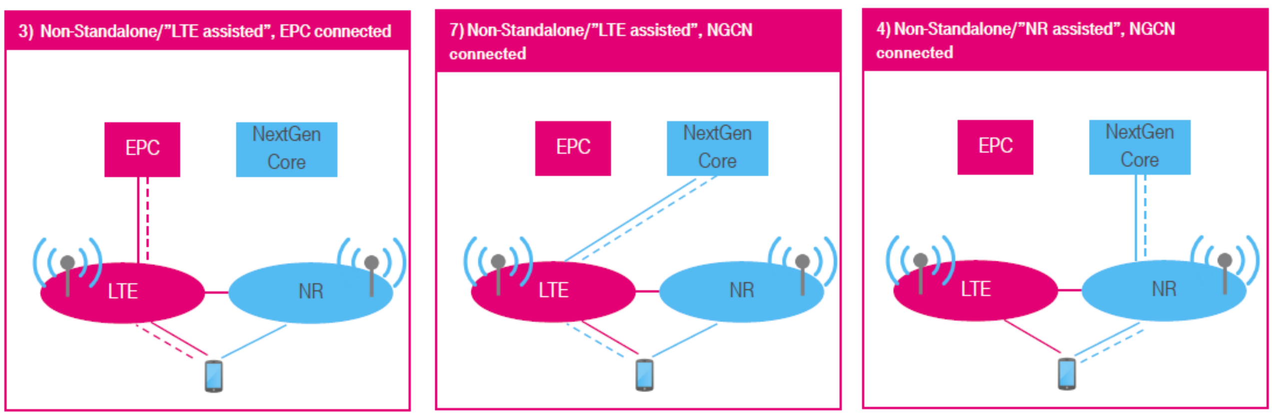

Figure 5-3 Non-stand alone configurations.

Of course, the current 4G LTE deployment is stand alone with 4G base station and core (as in option 1 in Figure 5-4) and the final target is 5G stand alone (option 2) with a 5G NR base station and NG core.

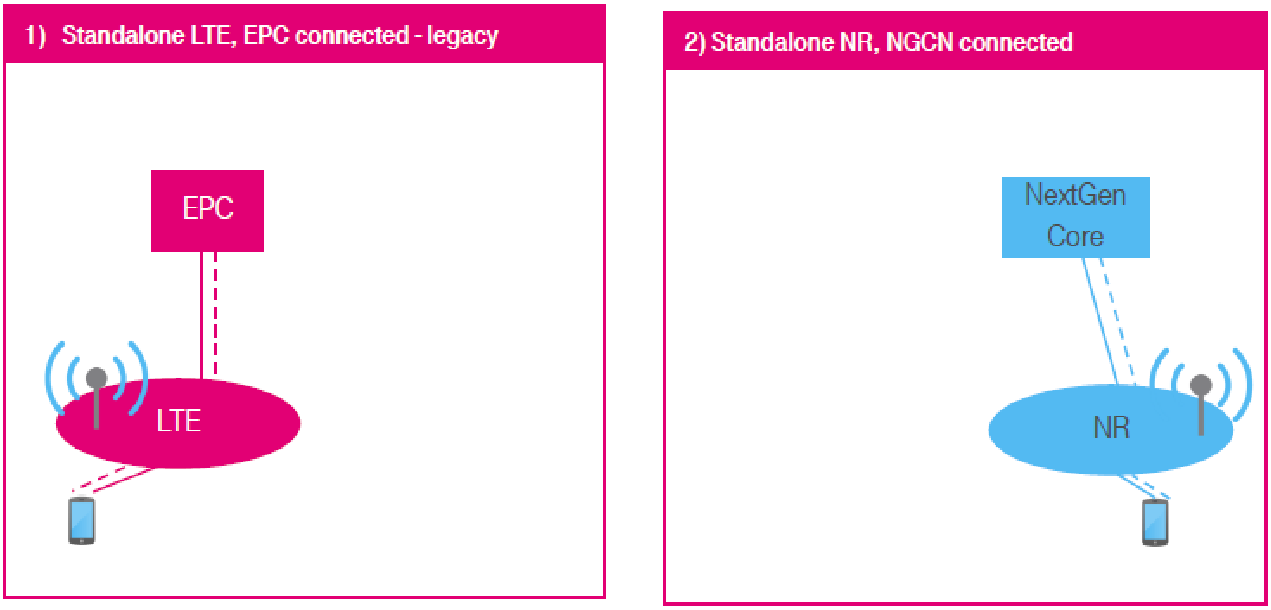

Figure 5-4 Stand alone configurations.

5.3 Functional Split in the Fronthaul Link

In both the upstream and downstream directions, the radio signals go through a series of signal processing blocks. Figure 5-5 shows these functional blocks and potential split points in both 4G and 5G wireless networks [4].

It is important to mention that traditional fronthaul using Option 8 (CPRI or OBSAI protocol), requires continuous bitrate transport whether user traffic is present or not. However, with the other split options (1-7), the amount of data to be transported scales with the user traffic. More detail of the requirements for different split options will be discussed in Section 7.

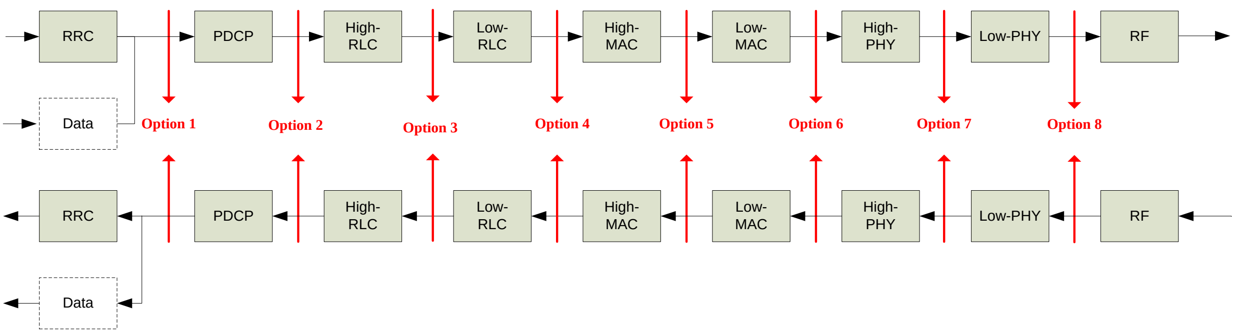

Figure 5-5. Signal processing chain of 4G and 5G wireless base stations and optional split points (Source [4][2])

5.3.1 Channel Bandwidths

Conventionally in 4G wireless network, the fronthaul link is between RF and the remaining L1/L2/L3 functions using CPRI/OBSAI protocol (Option 8 split point). This split point option

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allows the centralization of all high layer processing functions, at the expense of the most stringent fronthaul latency and bandwidth requirements.

This conventional fronthaul is based on transport of digitized time domain IQ data. For very high capacity applications, such as eMBB (enhanced mobile broadband) or for radio sites with many independent antenna elements (multi-layer MIMO), these fronthaul solutions require unreasonably high transport capacities, while allowing for transport latencies only up to a few hundred µsec.

Table 1 shows the time domain IQ data fronthaul capacities (CPRI rates without line coding) needed to support various radio frequency bandwidths and numbers of antenna ports in 5G wireless network using parameter ranges defined by 3GPP in [4]

Table 1: Required fronthaul bandwidth in 5G wireless network (Source [4] [3])

Number of Antenna Ports	Radio Channel Bandwidth			
	10 MHz	**20 MHz**	**200 MHz**	**1GHz**
2	1 Gbps	2 Gbps	20 Gbps	100 Gbps
8	4 Gbps	8 Gbps	80 Gbps	400 Gbps
64	32 Gbps	64 Gbps	640 Gbps	3,200 Gbps
256	128 Gbps	256 Gbps	2,560 Gbps	12,800 Gbps

The values in Table 1 are approximate net data rates (without line code) as calculated by Equation 1 below [27]. The calculation shows that transmission over the CPRI (Option 8) interface requires a net data rate of 491.52 Mbps per 10MHz radio bandwidth and per antenna port.

$$B_{CPRI} = A \cdot f_s \cdot b_s \cdot 2 \cdot (16/15) \qquad (1)$$

Here, A is the number of antennas per sector; f_s represents the sample rate (15.36 MS/s per 10 MHz radio bandwidth) and b_s the number of bits per sample (15 for LTE). The remaining factors take into account the separate processing of I and Q samples (factor 2), and the additional overhead information (factor 16/15).

5.3.2 New Functional Split Options in 5G wireless network

The increase in data rates in 5G makes it impractical to continue with the conventional CPRI fronthaul implementation. Moving towards a higher layer split (Fig. 5-5) would relax the latency and bandwidth requirements, but then fewer processing functions can be centralized. It is thus critical that the new functional-split architecture take into account technical and cost-effective tradeoffs between throughput, latency, and functional centralization.

Several standards bodies have hence moved to identify different split points in the radio processing chain (Fig. 5-5) that allow for substantially reducing the transport bit rate requirements in C-RAN architectures compared to the current approach. The choice of optimal 5G NR split points depends on specific deployment scenarios. In April 2017, 3GPP announced the selection of Option 2 (PDCP/high RLC) as the high layer split point (called the F1 Interface), while postponing the decision of the low layer split point between two contenders (Option 6 for MAC/PHY split and

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Option 7 for intra-PHY split with three different variants 7-1, 7-2, 7-3) to a later time [5]. Here we use F_X as the notation for the low layer split point for convenience. Cascaded split architecture is also considered to allow for additional flexibility.

In July 2017, the Small Cell Forum has extended its specification for the Functional API (FAPI) multi-vendor platform interface, which has led to accelerated deployments of small cells, to a virtualized small cell architecture, with the addition of nFAPI [14]. The nFAPI is a set of interfaces for supporting a virtualized MAC/PHY split (Option 6) to enable a smooth evolution path to 5G.

The mapping of these functional split options to CU/DU/RU is illustrated in Fig. 5-6. Here we adopt a split architecture consisting of three elements, CU, DU and RU, each of which can host any of the signal processing functions. As existing 4G deployments will continue to be supported, the terminology for BBU and RRH is renamed to CU/DU and RU in the future.

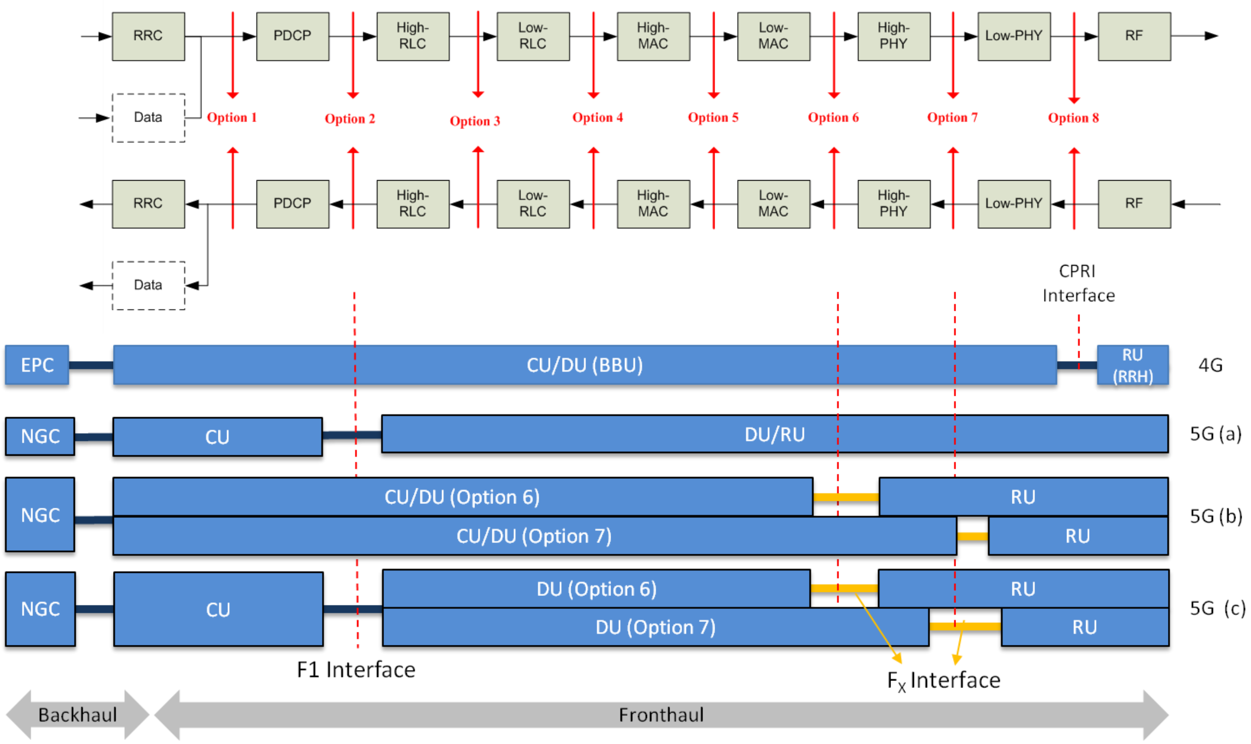

Figure 5-6. Mapping of CU and DU functions according to the split points. 5G(a) high layer split (F1); 5G(b): low layer split (F_X); 5G(c) cascaded split (Source [4][4]).

Meanwhile the CPRI Cooperation has focused its work on intra-PHY splits with data transport over packet networks, thus creating a de facto standard for the low layer split [13]. They introduced two possible splits in downlink (I_D, II_D) and one in uplink (I_U), which allow for configurations roughly corresponding to 3GPP Options 7-2 and 7-3.

Both the 3GPP and the eCPRI specification refer to Ethernet based transport requirements as defined by MEF. MEF published its 3rd phase mobile backhaul implementation agreement in January 2016 (MEF 22.2 [25]) and is working on phase 4 MEF 22.3, which includes next generation fronthaul definitions. IEEE P1914.1 [17], that is expected to become a standard in 2019 aims to provide specifications how to support data transport at other split points over Ethernet networks. The details of this specification are, however, not yet defined.

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5.4 RAN deployment scenarios

Generally, a 5G transport network may contain fronthaul, midhaul and backhaul networks. However, different operators may use different deployment scenarios. Four RAN deployment scenarios have been identified.

1) Independent RRU, CU and DU locations

In this scenario, there are fronthaul, midhaul and backhaul networks. The distance between an RRU and DU is in the range of 0-20 kilometers while the distance between the DU and CU is up to tens of kilometers.

2) Co-located CU and DU

In this scenario, the CU and DU are located together, consequently there is no midhaul.

3) RRU and DU integration

In this scenario, an RRU and DU are deployed close to each other, maybe hundreds of meters, for example in the same building. In order to reduce cost, an RRU is connected to a DU just through straight fibre and no transport equipment is needed. In this case, there are midhaul and backhaul networks.

4) RRU, DU and CU integration

This network structure may be used for small cell and hot-spot scenarios. There is only backhaul in this case.

The above four application scenarios above are based on current wireless network deployments and anticipated functional splits described by wireless SDOs. However, the final application scenarios will be defined by wireless specifications, applications (i.e. eMBB vs URLLC), transport technology availability, and operators' deployment requirements.

6 Synchronization

6.1 Synchronization distribution Architecture

6.1.1 Frequency synchronization architecture

Two main methods have been defined for distributing frequency synchronization over the network: physical layer-based synchronization (e.g. Synchronous Ethernet) and packet-based synchronization (e.g. PTP). In the case of physical layer-based synchronization, the frequency reference signal is distributed through the physical layer and it can provide high-accuracy The clock quality level information (SSM code) is carried in the corresponding channel (e.g., ESMC in the case of synchronous Ethernet).

For packet-based synchronization, the packet network distributes the frequency reference signal by means of PTP packets.

Requirements on performance and management of the frequency synchronization are defined in the ITU-T G.826x series of recommendations. ITU-T G.8265 describes the architecture and requirements for packet-based frequency distribution in telecom networks and ITU-T G.8261 provides the network architecture and requirements related to physical layer-based frequency synchronization.

ITU-T G.8262.1 has been developed to define enhanced performance requirements of the physical layer clock, and this clock can be used in supporting a more accurate time synchronization.

6.1.2 Time synchronization architecture

Requirements on performance and management of time synchronization are defined in the ITU-T G.827x series of recommendations. The general time synchronization architecture is defined in ITU-T G.8275. Time synchronization requirements and network reference models have been defined by ITU-T G.8271 and ITU-T G.8271.1. The network reference models have been defined for the purpose of analysing and deriving the time synchronization objectives in different parts of the network. One example of the network reference models is shown in Figure 6-1. (note: the End Application is shown in the figure, but ITU-T does not specify the clock of the End Application in case of mobile base stations).

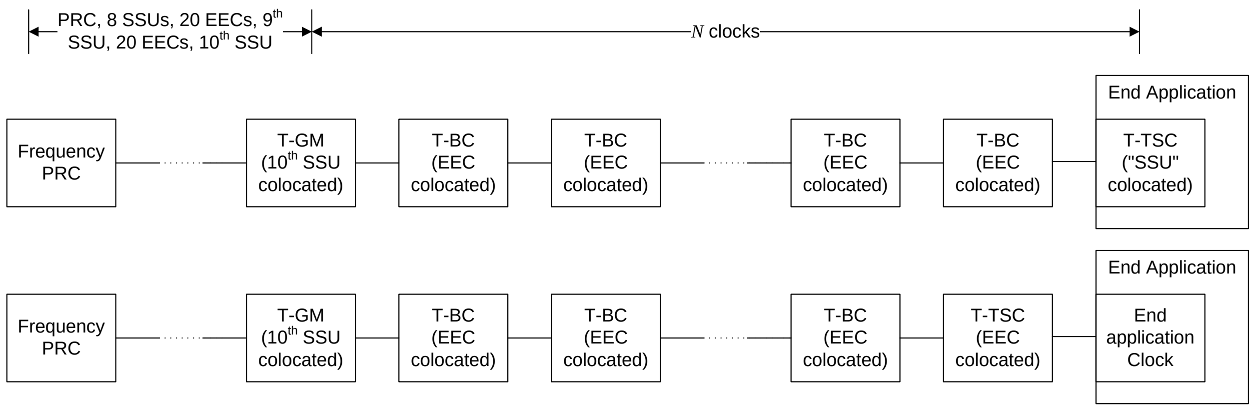

Figure 6-1: Copy of Figure II.3/G.8271.1, HRM-2 with physical layer frequency support – congruent scenario

6.2 Synchronization requirements

6.2.1 Time synchronization

Solutions currently defined in the ITU-T G.827x series address end-to-end time synchronization requirements of +/-1.5 microseconds. This is based on requirements that have been defined in 3GPP for the support of TDD (Time Division Duplex) operations.

For 5G, the relevant requirements are also being defined by 3GPP. As specific to fronthaul, relevant requirements as defined by the CPRI TWG can also be considered.

3GPP has agreed that for 5G TDD operations, the cell phase synchronization accuracy measured at BS antenna connectors shall be better than 3 µs (see 3GPP TS 38 133, ref. [7]). This translates into a network-wide requirements of +/-1.5 microseconds.

The full list of the synchronization requirements applicable to 5G (and to earlier releases of the mobile technologies) is provided in Table II.1 and Table II.2 of G.8271.

Work is ongoing concerning specific fronthaul synchronization requirements and related synchronization network guidelines.

For this topic, it is also possible to refer to the analysis made by the CPRI TWG who released a document on the eCPRI transport network requirements (see **Error! Reference source not found.**) where the requirements are based on 3GPP (e.g., to support MIMO or TX diversity transmissions and carrier aggregation). In the current version these are mostly based on LTE mobile generation. Also, it is important to highlight that the most stringent requirements would generally concern co-located antennas, therefore with no need to distribute time synchronization information over the transport network.

It can be noted that for some of the mobile applications (e.g., as related to fronthaul applications), the control of relative time error is generally sufficient (i.e., no need to guarantee control of time error with respect to an absolute time source such as GNSS). For further information refer to Appendix VII in G.8271.1 (see Figure 6-2).

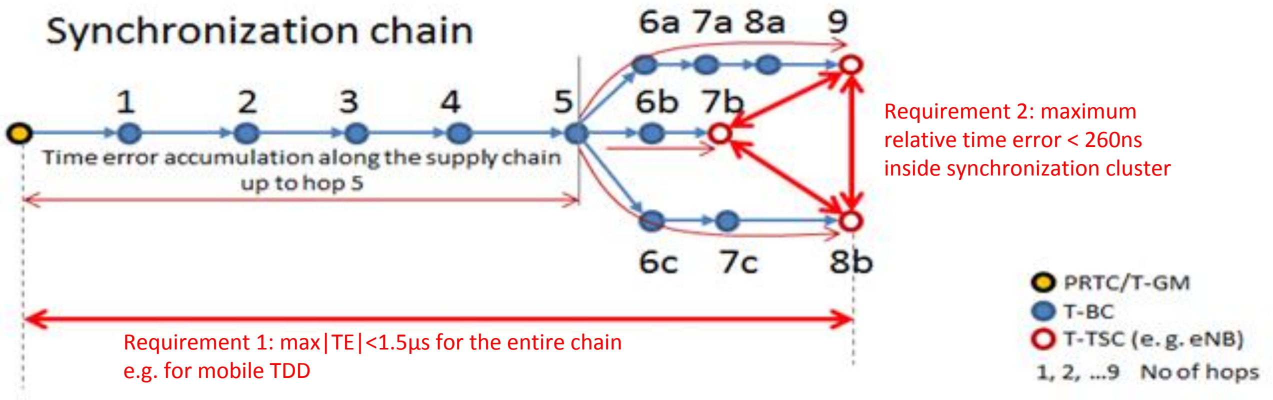

Figure 6-2 Copy of Figure VII.1/G.8271.1 – Illustration of Relative Time Error

Note: based on requests by some of the operators, studies are ongoing on the feasibility of solutions targeting end-to-end time synchronization requirements (absolute or relative) on the order of +/- 100 ns to +/- 300 ns to address specific applications or potential future requirements, therefore not necessarily related to 3GPP 5G requirements. For these applications it will also be important to select a synchronization interface that can support the relevant accuracy.

6.2.2 Frequency synchronization

Requirements for 5G frequency synchronization have been defined by 3GPP. These are aligned with the LTE requirements (50 ppb / 100 ppb). The following is a copy of Table 6.5.1.2-1 from TS 38.104 **Error! Reference source not found.**, providing specification for frequency error minimum requirement that is expressed in terms of accuracy of the modulated carrier frequency of each NR carrier observed over 1 ms:

Table 2- Frequency error minimum requirement

BS class	Accuracy
Wide Area BS	±0.05 ppm
Medium Range BS	±0.1 ppm
Local Area BS	±0.1 ppm

7 Interfaces

This clause provides more details on the 5G interface characteristics that would place requirements on transport networks supporting the interface.

Interfaces to the transport network from 5G/IMT2020 networks are used to request transport services. Various parameters of those requests include capacity and latency to support between interface users. These are consolidated in the following tables.

7.1 Capacity

Table 7-1 Capacity requirements

At F1 interface	From [4], option 2 DL ***4016 Mb/s;*** ***UL 3024 Mb/s***
At Fx interface	From [4], option 7a, 7b DL: ***10.1~22.2 Gb/s*** ***37.8~86.1 Gb/s*** ***UL:*** ***16.6~21.6 Gb/s*** ***53.8~86.1 Gb/s***
At Xn interface	25Gb/s-50Gb/s
At NG interface	For CU: 10Gb/s-25Gb/s For CN: 100+Gb/s
Fronthaul	Dependent on number of CPRI and eCPRI interfaces. See also Table 1 in 5.3.1. 10Gb/s-825Gb/s
Midhaul and Backhaul	Varies with number of interfaces. 25Gb/s-800Gb/s
Base station (gNB)	These relate to a combination of NG and Xn interfaces, and reflects the capacity based on a gNB for 3 cells with 64T 64R antennas for low frequency and 2T 2R for high frequency. Peak: 6.14Gb/s for 5G LF (low frequency) 19.8Gb/s for 5G HF (high frequency) Average: 2.97Gb/s for 5G LF; 9.9Gb/s for 5G HF

7.2 Latency

Figures are for one way delay, not round trip.

Table 7-2: Latency requirements

At F1 interface	From [4] option 2 1.5 ~10 msec
At Fx interface	100, 125, 250 and 500 μsec (a few hundred μsec)
Fronthaul	< 100 μsec
UE-CU（eMBB)	4ms, from [12]
UE-CU（uRLLC)	0.5ms, from [12]

7.3 Network Reach

The ranges will vary greatly between different network operators. The follow values are based on contributions received by SG15 to date.

Table 7-3 Network reach requirements

Fronthaul	1~20km
Midhaul	20~40km
Backhaul	1~10km Aggregation: 5-80km Core: 20~300km

8 Management and control

An example of the interaction between the 3GPP management system and the transport network management system is shown in Figure 8-1 below.

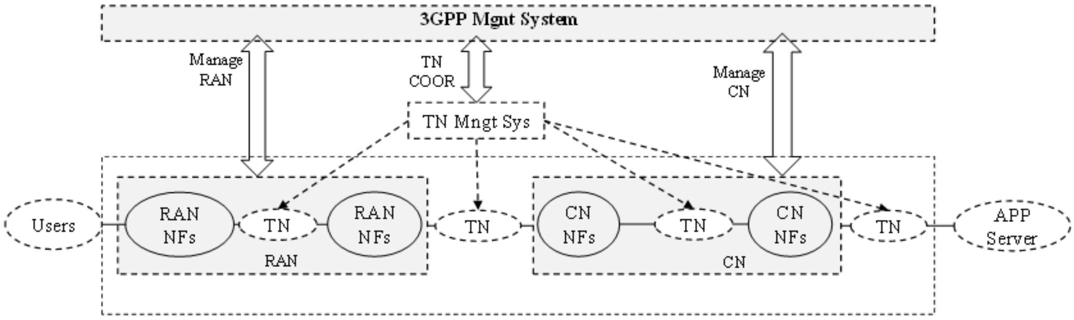

Figure 8-1 Example of the interaction between the 3GPP management system and the transport network management system (Source [11][5])

The support for a 3GPP network slice in the transport network is described in section 10.

For the purposes of this TR the following assumptions are made:

- The transport network management system is implemented by an SDN controller.
- To support the network shown in Figure 8-1 each of the transport networks (TNs) will be presented as an independent set of virtual networks (VNs). Note that a TN (and its corresponding set of VN instances) is disjoint from the other TNs.
- The transport network is directly visible to the 3GPP management system (as shown in Figure 8-1) and each VN instance may be viewed by the 3GPP management system as a Managed Network Slice Subnet Instance (MNSSI).
- The 3GPP management system will request a transport network VN instance for each type of 3GPP service (e.g., uRLLC, eMBB, etc.).
- Each transport network VN instance will provide a (logically) separate management interface.
- Transport network VNs will be configured during the preparation or commissioning phase.
- The transport network VN instances will not be aware of the E2E slice instances because of the differences in granularity. Therefore, each transport network VN will support zero or more E2E slice instances.

An interface to a client context is used to provide visibility to transport network resources (a VN) to a client, for example a 3GPP management system. In the case that the VN is used in the context of an IMT-2020/5G network, the 3GPP network management system interfaces to a client context in a transport network controller. The 3GPP management system may view the resources in an instance of a VN as supporting a 3GPP network slice instance. The assignment of 3GPP services to a slice/VN instance is not visible to the TN management system.

The requirements for coordination between a TN management system and a 3GPP management system are provided below:

1) The TN management system should be able to receive from the E2E 5G slice management system (i.e., 3GPP management system) 3GPP E2E 5G slice instance specific requirements (e.g., information rate, performance, security etc.) for the connectivity to be provided by the TN. The TN management system should, in response to the request, provide resources that can be used for the appropriate transport network VN instance. The templates for the transport network VN can be designed in advance in which case the request from the 3GPP management system would include a reference to a specific template. Once the appropriate transport network VN instance is set up, the association between the transport network VN instance and the E2E 5G

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slice instance will be established and may be managed either by the transport network management system or by the E2E 5G manager.
2) The TN management system or VN manager should be able to receive a request for an inventory of the capabilities (e.g., topology, capacity, type of clients supported etc.) of the TN and provide the requested information.
3) The TN management system should be able to modify the transport VN instance (e.g., add or remove resources) based on requests from the E2E 5G slice management system.
4) The transport network VN manager (SDN controller) should be to able to modify the configuration of the resources in a VN based on requests from the E2E 5G slice management system.
5) The transport network VN manager (SDN controller) should be able to receive a request for the configuration and activation of performance monitoring, performance thresholds and failure supervision and provide spontaneous reports of performance threshold alarms and failure alarms and on request reports of the results of performance monitoring for the connectivity provided by the transport network VN instance.
6) The TN management systems' Client Context has the properties of control isolation between contexts. Thus, the interfaces between a 3GPP management system to transport network management system have control independence from each other.

9 Multiservice support

For 5G, transport networks should support multi-service capability. The following types of services can be supported:

1) Non-stand Alone (NSA) and Stand Alone (SA) deployment of 5G wireless services including eMBB (enhanced Mobile Broadband), mMTC (massive Machine Type Communications) and URLLC (Ultra-Reliable and Low Latency Communications) defined by 3GPP
2) Legacy 2G/3G/4G wireless (CPRI) service
3) Fix broadband services for enterprise such as E-line, E-LAN & E-tree services defined by MEF
4) Residential broadband services, such as OLT uplink
5) Data Center interconnection

10 Support of 5G Slicing in the transport network

The transport network is, in general, a multi-service network and it can be expect that, in some cases, the common transport network infrastructure will be shared between 5G services, different 3GPP services (e.g., uRLLC, eMBB, etc.), and non-3GPP services. It is necessary to provide isolation between each of these services. From a management perspective the services supported by virtual networks (VNs) are established as described in section 8. The forwarding plane must ensure that the traffic from one VN is not (accidentally) delivered to a different VN.

All traffic is at some point is encapsulated in IP packets that contend for a resource. Therefore, all communications at some point may be impacted by resource contention. The description of traffic isolation in this TR only address the additional impact caused by the transport network. The transport network provides two types of resources as described below:

- **Circuit switched resources**: The transport network guarantees that it will have no additional impact on delay variation. The traffic loading on any other VN has no impact on the traffic in this VN, including QoS effects. A circuit switched is supported by a dedicated resource that is assigned when the connection is established. Examples of a dedicated resource are a wavelength or time slot. However, use of a circuit switched VN prevents the VN from sharing resources and potentially offering higher capacity (and lower delay) when high demand is encountered.

- **Packet switched resources:** The transport network will have some additional impact on the delay variation since the traffic loading of one VN may have an impact on the QoS provided to the traffic in other VNs.
  A packet switched VN is implemented by statistically multiplexing the traffic from two or more VNs onto a common circuit switched connection using a packet technology (e.g., Ethernet VLAN, MPLS tunnel). The impact on the QoS provided by one VN caused by the traffic on other VNs may be constrained by traffic engineering including, for example, limiting the statistical multiplexing ratio or traffic policing on each VN. However, since a packet switched VN shares its resources it can potentially offer higher capacity (and lower delay) depending on the traffic carried by other VNs that share those resources.

As described in section 8 it is expected that the 3GPP manager will request the configuration of Managed Network Slice Subnet Instances (MNSSIs) to support the different 5G services (e.g., uRLLC, eMBB, etc.). The characteristics (e.g. bandwidth, type of isolation, latency) of each MNSSI will be defined (by the 3GPP manager) to address the needs of each 5G service. A MNSSI will be supported by a VN. In the fronthaul network only one MNSSI is required since all services are carried between the RRU and DU in a common eCPRI encapsulation.

Annex 1
Architecture of transport network for 5G

In clause 5.4, the architecture in Midhaul and Backhaul of 5G network is described. According to deployment difference of CU, DU and RU, the architecture of 5G Fronthaul and Midhaul network was classified as four RAN deployments. Corresponding to different RAN deployments, the transport architecture may be different to meet specific requirements.

Figure A-1 shows the transport network architecture for independent CU and DU deployment. Fronthaul transport is between RRUs and DUs, midhaul transport is between DUs and Cus, and backhaul transport between CUs and CNs.

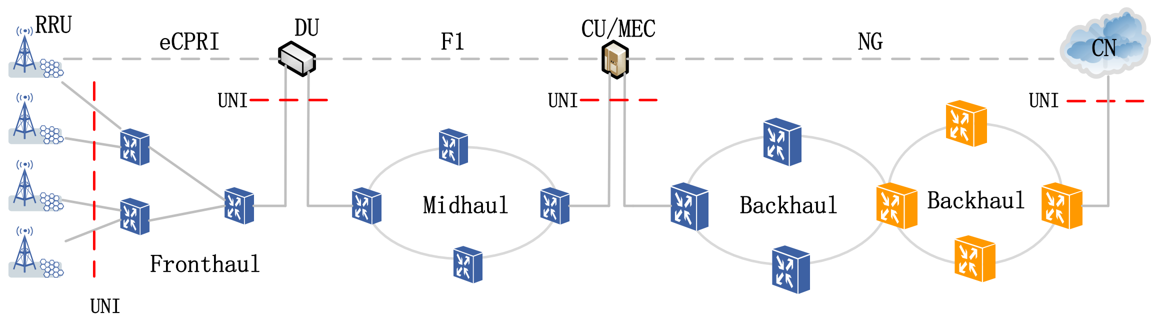

Figure A-1: Transport network architecture for Independent CU and DU deployment

The service of the backhaul transport is multipoint to multipoint. And for fronthaul and midhaul transport network, the service is point to point with assumption that DU only belongs to one CU at a specific time and RRU only belongs to one DU. Furthermore, both the fronthaul and midhaul transport network need provides a reasonably low latency to satisfy requirements of latency sensitive services such as uRLLC.

The network topology between fronthaul, midhaul and backhaul transport networks:

— For fronthaul transport networks, a star or ring network topology may be used.
— For midhaul transport network, a ring topology is normally used.
— For backhaul transport network, both ring and mesh topology are used.

For other RAN deployments described in clause 5.4, the transport architecture could be as follow:

— For co-located CU and DU deployment, these will be no midhaul transport network, remained fronthaul and backhaul together carry 5G traffic.
— For RRU and DU integration deployment, which means that there is no need of fronthaul transport network, remained midhaul and backhaul transport carry traffics between RRU/DU to CU and CU to CN separately.
— For RRU, DU and CU integration deployment, only backhaul transport network was left and transport network architecture is almost same with 4G scenario.

One thing should be noted is that transport network architecture should meet requirements of all or subset of four RAN deployments for specific operator and specific traffic planning. The transport network architecture should be smoothly upgraded to support more RAN deployments step by step with development of network and traffic evolution.

One example of transport network architecture for 5G C-RAN deployments is shown in following figure:

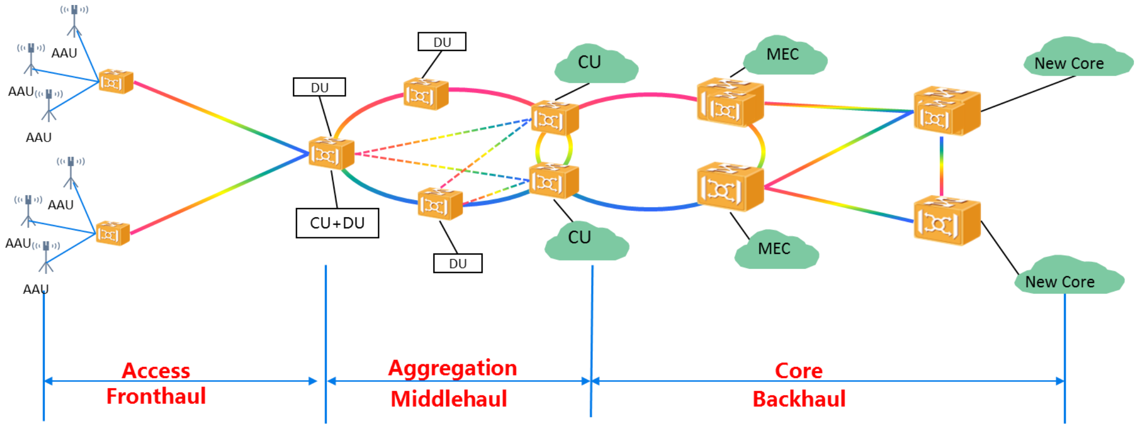

Figure A-2：An example of unified transport network architecture for 5G transport

Another example is for a D-RAN deployment as shown below in Figure A-3

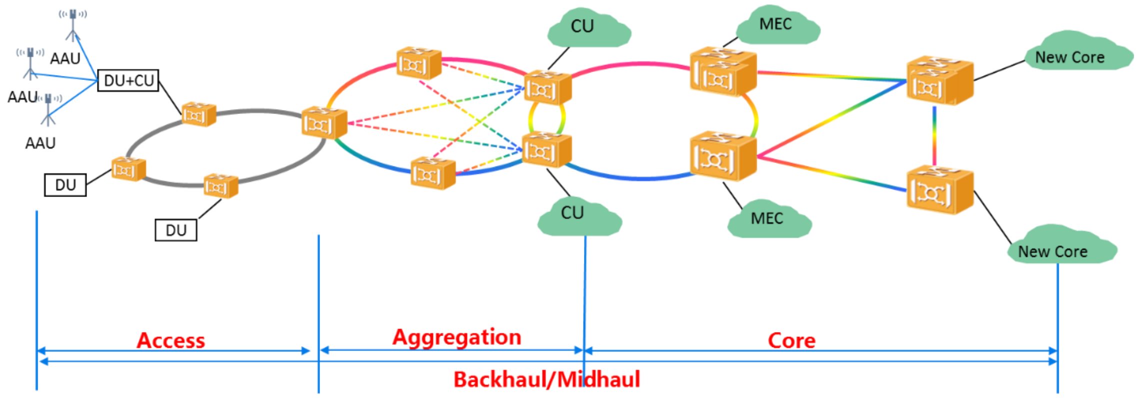

Figure A-3：A 2nd example of unified transport network architecture for 5G transport

Consider the importance of MEC in 5G, the backhaul transport network should consider MECs application and should provide flexibility and low latency for services between MECs and CU too.

The candidates of transport network technologies could be PON, OTN, SPN, Ethernet, G.Metro etc.

Annex 2
Terminology mapping

Equivalent terms

Term	SDO	Term	SDO
Fronthaul-I	3GPP	NGFI-I	IEEE 1914.1
Fronthaul-II	3GPP	NGFI-II	IEEE 1914.1