

IEEE Standard for Packet-based Fronthaul Transport Network

IEEE Communications Society

Developed by the
Mobile Communication Networks Standards Committee

IEEE Std 1914.1™-2019

STANDARDS

IEEE Standard for Packet-based Fronthaul Transport Networks

Developed by the

Mobile Communication Networks Standards Committee
of the
IEEE Communications Society

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IEEE SA Standards Board

Abstract: The architecture and requirements for next generation fronthaul networks are specified in this standard. NGFI-I is defined as the next generation fronthaul network with low layer splits in a baseband station. NGFI-II is defined as the next generation fronthaul network with high layer splits in a baseband station. The requirements of fronthaul transport nodes in these networks are also specified.

Keywords: central unit, CU, distributed unit, DU, fronthaul transport node, FTN, IEEE 1914.1™, Next Generation Fronthaul Interface, NGFI, NGFI networks, NGFI-I, NGFI-II, radio unit, RU

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Introduction

This introduction is not part of IEEE Std 1914.1-2019, IEEE Standard for Packet-based Fronthaul Transport Networks.

This standard specifies the architecture and requirements for the next generation packet-based fronthaul networks. It is an integral part of the IEEE 1914™ family of standards, which facilitates the implementation of key technologies for next generation (5G) cellular services, from a transport networking perspective.

The transport networking solution for these cellular services is expected to provide, at least, the following:

- High link capacity
- High link efficiency
- Load balancing for pooled resources (Cloud-RAN)
- Latency guarantees
- Phase alignment of radio data
- Flexible mapping (e.g., different functional splits of radio data) of radio traffic for transport between radio units, aggregation points, and/or centralized baseband unit pools

Today's transport networking solutions cannot satisfy all of these expectations. On the other hand, packet-based technologies (e.g., Ethernet) have experienced steady and cost-efficient speed and capacity growth, driven by the enterprise, access, and data-center markets, and has inherent characteristics that allow it to satisfy the other expectations.

IEEE Std 1914.1™-2019 specifies details that allow packet-based fronthaul transport networks to be a flexible and efficient solution for the transport of 5G cellular services.

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Files are available in 1914.1-2019_downloads.zip in the IEEE 1914.1-2019 directory located at: <https://standards.ieee.org/downloads>.

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IEEE Standard for Packet-based Fronthaul Transport Networks

1. Overview

1.1 Scope

This standard specifies the following:

- Architecture for the transport of mobile fronthaul traffic over packet-based networks (e.g., Ethernet), including user data traffic, and management and control plane traffic
- Requirements and definitions for the fronthaul networks, including data rates, timing and synchronization, and quality of service (QoS)

The standard also analyzes functional partitioning schemes between remote radio units (RRUs) and baseband units (BBUs) that improve fronthaul link efficiency and interoperability among transport equipment, and that facilitate the realization of cooperative radio functions, such as massive multiple input multiple output (MIMO) operational modes, coordinated multi-point (CoMP) transmission, and reception.

1.2 Purpose

The fronthaul packet transport standard supports enabling the implementation of critical 5G technologies, such as massive MIMO, beamforming, carrier aggregation, CoMP, and scalable centralized/virtualized radio access network (C-RAN/V-RAN) functions.

This standard simplifies network design and operation, increases network flexibility and efficiency in resource utilization, and lowers cost by leveraging existing, mature packet-based solutions (e.g., Ethernet) for vital functions, such as QoS, synchronization, and data security.

The fronthaul architecture provides unified management and control solutions, common networking protocols, and universal network elements, thus facilitating migration to future C-RAN/V-RAN mobile networks.

This standard improves bandwidth efficiency, network scalability, timing, and synchronization performance; and preserves and enhances the ability to deploy cooperative radio functions.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is

explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 1588™-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.^{1,2}

ITU-T G.8260, Definitions and terminology for synchronization in packet networks.³

ITU-T G.8262/Y.1362, Timing characteristics of a synchronous equipment slave clock.

ITU-T G.8262.1/Y.1362.1, Timing characteristics of enhanced synchronous equipment slave clock.

ITU-T G.8264/Y.1364, Distribution of timing information through packet networks.

ITU-T G.8271.1/Y.1366.1, Network limits for time synchronization in packet networks.

ITU-T G.8271.2/Y.1366.2, Network limits for time synchronization in packet networks with partial timing support from the network.

ITU-T G.8272/Y.1367, Timing characteristics of primary reference time clocks.

ITU-T G.8272.1/Y.1367.1, Timing characteristics of enhanced primary reference time clocks.

ITU-T G.8273.2/Y.1368.2, Timing characteristics of telecom boundary clocks and telecom time slave clocks.

ITU-T G.8273.3/Y.1368.3, Timing characteristics of telecom transparent clocks.

ITU-T G.8275.1/Y.1369.1, Precision time protocol telecom profile for phase/time synchronization with full timing support from the network.

ITU-T G.8275.2/Y.1369.2, Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁴

baseband unit: A unit that processes baseband signals in telecommunication systems.

central unit: A logical node hosting the radio access network (RAN) processing functions corresponding to the high layers of baseband processing for non-real-time tasks [e.g., radio resource control (RRC), service data adaptation protocol (SDAP), and packet data convergence protocol (PDCP) layers] in a distributed base station model.

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³ITU-T publications are available from the International Telecommunications Union (<https://www.itu.int/>).

⁴*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

distributed unit: A logical node hosting the RAN processing functions corresponding to the low layers of the baseband processing for real-time tasks [e.g., physical layer (PHY), medium access control (MAC), and radio link control (RLC) layers] in a distributed base station model.

fronthaul: Network that provides transport connectivity between a radio unit (RU), a distributed unit (DU), and a central unit (CU).

functional split: The division of radio baseband processing functions between RU and DU, and between DU and CU in a distributed base station model.

Next Generation Fronthaul Interface (NGFI): Fronthaul interface supporting various, multiple functional splits.

NGFI-I: The bidirectional transport network that provides the data plane and control plane connectivity between RU and DU where the low layer split is implemented for a base station.

NGFI-II: The bidirectional transport network that provides the data plane and control plane connectivity between DU and CU where the high layer split is implemented for a base station.

NGFI network: Any part of NGFI-I and/or NGFI-II.

radio unit: A logical node hosting the RAN functions corresponding to the radio frontend (RF and/or PHY).

remote radio head: In a distributed base station model a transceiver near the antennas integrating radio frequency (RF) unit.

time error: See “time error” definition in ITU-T G.8260.⁵

3.2 Acronyms and abbreviations

5GC	5G core network
APTS	assisted partial timing support
ARQ	automatic repeat request
BBU	baseband unit
BS	base station
BTN	backhaul transport node
cMTC	critical machine-type communication
CO	central office
CoMP	coordinated multi-point
CoS	class of service
CPRI	Common Public Radio Interface
cTE	constant time error
C-RAN	centralized radio access network
CU	central unit

⁵Information on references can be found in [Clause 2](#).

DSP	digital signal processing
dTE	dynamic time error
dTE _H	high-frequency dynamic time error
dTE _L	low-frequency dynamic time error
DU	distributed unit
{DU+CU}	integrated or co-located DU and CU
eMBB	enhanced mobile broadband
eNB	evolved NodeB
ePRTC	enhanced Primary Reference Time Clock
EPC	evolved packet core
E-UTRA	Evolved UMTS Terrestrial Radio Access
FDV	frame delay variation
FEC	forward error correction
FR1	frequency range 1 (see 3GPP TS 38.104 [B9]) ⁶
FR2	frequency range 2 (see 3GPP TS 38.104 [B9])
FTN	fronthaul transport node
FTS	full timing support
gNB	5G NodeB
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HARQ	hybrid ARQ
HRM	hypothetical reference model
IWF	interworking function
IWF P-F	interworking function from PTS to FTS
KPI	key performance indicator
LSP	label-switched path
MAC	medium access control
MA	maintenance association
MD	maintenance domain
MIMO	multiple input and multiple output
mMTC	massive machine-type communication
NGFI	Next Generation Fronthaul Interface
NR	New Radio
NRCS	NGFI requirement conformance statement
OAM	operation, administration, and maintenance

⁶The numbers in brackets correspond to those of the bibliography in Annex K.

OTDOA	observed time difference of arrival
PDCP	packet data convergence protocol
PDU	protocol data unit
PHY	physical layer
ppb	parts per billion
PRTC	Primary Reference Time Clock
PTP	Precision Time Protocol
PTS	partial timing support
PW	pseudo-wire
QoS	quality of service
RAN	radio access network
RB	resource block
RF	radio frequency
RFP	request for proposal
RLC	radio link control
RRC	radio resource control
RRH	remote radio head
RRU	remote radio unit
RU	radio unit
{RU+DU}	integrated or co-located RU and DU
SDAP	service data adaptation protocol
T-GM	telecom grand master
T-BC	telecom boundary clock
T-TC	telecom transparent clock
T-TSC	telecom time slave clock
TAE	time alignment error
TDD	time division duplex
TDM	time division multiplexing
TE	time error
TE_{ngfi}	time error caused by the NGFI network
$TE_{\text{non_ngfi}}$	time error caused by non-NGFI components
TE_{radio}	time error allowed by the radio requirements
ToD	time of day
TTI	transmission time interval
UMTS	Universal Mobile Telecommunications Service
UTRA	UMTS Terrestrial Radio Access

URLLC	ultra-reliable and low latency communications
V-RAN	virtualized radio access network
VLAN	virtual local area network

4. NGFI networks architecture and use cases

This clause provides background for the transport networks between radio unit (RU), distributed unit (DU) and central unit (CU) as well as their architecture. This clause also elaborates on a selected set of deployment models for 5G. These transport networks are collectively referred to as Next Generation Fronthaul Interface (NGFI) networks. As such, an NGFI network is any part of the transport networks.

4.1 Introduction

The 5G RAN accommodates both fronthaul and backhaul services in the same transport infrastructure. 3GPP specifies radio functional splits in release 14 (3GPP TR 38.801 [B3]) and onwards to facilitate the deployment of 5G New Radio (NR).

Depending on the split implemented across the network, different performance requirements apply. Table 1 summarizes transport network requirements based on the given RAN functional split options defined by 3GPP. Each of the functional split options leads to a respective set of requirements on the corresponding fronthaul link. Backhaul requirements are, however, out of scope of this standard.

Table 1—Transport requirements for the defined 3GPP RAN functional split options

	Option 2 PDCP – RLC split	Option 3 Intra-RLC split	Option 6 MAC - PHY split	Option 7 Intra-PHY split
Throughput requirement	Proportional to the user data rate	Proportional to the user data rate	Proportional to the user data rate	Proportional to radio channel bandwidth, number of antenna ports, MIMO layers, and sometimes also to user data rate (when working on resource block level)
Throughput comparison	Option 2 ≤ Option 3 ≤ Option 6 < Option 7	Option 3 ≤ Option 6 < Option 7	Option 6 < Option 7 (by a factor of 5 to 10)	Option 7 < Option 8 [Common Public Radio Interface (CPRI)] (by a factor of 2 to 3)
Latency requirement	ms range	ms range	ms range	μs range
CoMP performance	Slow coordination	Slow coordination	Fast MAC scheduler coordination	Joint processing + Option 6 coordination
Data payload	RLC protocol data units (PDUs)	Automatic repeat request (ARQ) packets	Transport channels	Bit-domain or frequency-domain symbols

4.2 Reference architecture

An NGFI network is hierarchical and copes with both 4G and 5G technologies. Figure 1 shows a high-level view of its architecture, where three main network spans can be logically identified: access, aggregation, and core. In this standard backhaul is represented in grey in all figures to provide a complete view of the overall transport network. The specification of backhaul is out of scope of this standard. The access network, which is close to the radio transmission points, aggregates transport traffic from cell sites (such as macro, micro, or pico) into a hub site for centralized processing. The aggregation network further aggregates traffic from hub

sites into edge sites. Similarly, the core network collects traffic from aggregation networks. Further, at edge or hub sites, also possibly connected is a small cell network that links the pole sites for C-RAN based pico deployment. Ring network topologies are common for access, aggregation, and core networks for resilience purposes. However, other topologies are also possible. The small cell networks are often point-to-point topologies with less resilience.

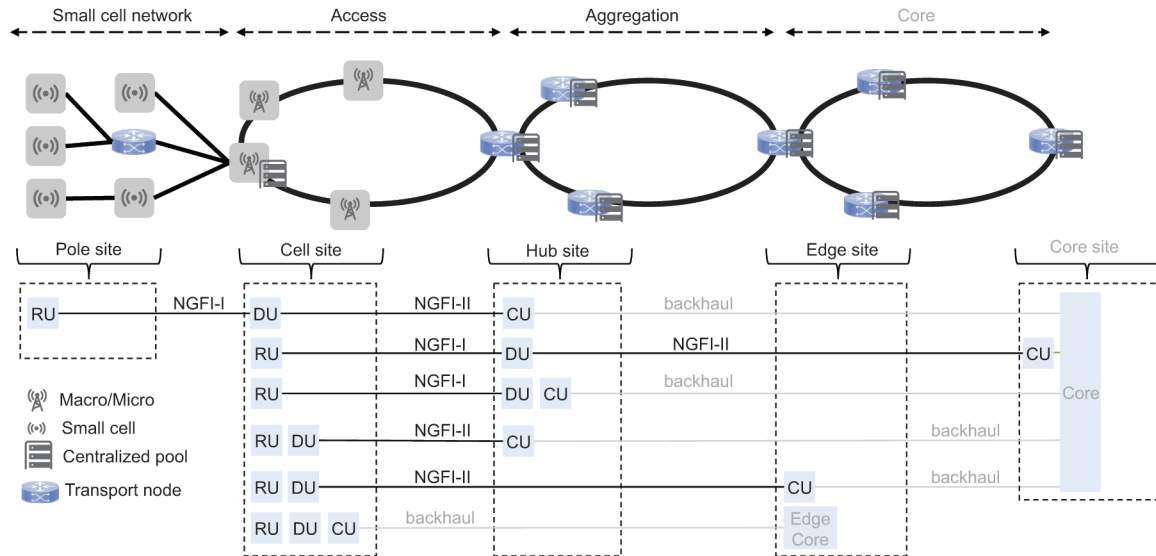


Figure 1—NGFI network reference architecture

Along the transport infrastructure, 4G/5G RAN entities, such as RU, DU, and CU, are placed at different sites according to the split options being used and the scale of the network.

Figure 1 also shows some RAN entity integration profiles: 1) independent RU, DU, and CU; 2) integrated CU and DU connected to RU; 3) integrated RU and DU connected to CU; and 4) integrated RU, DU, and CU.

Mobile core entities [e.g., evolved packet core (EPC) and 5G core network (5GC)] can be placed at either the edge site or the core site, depending on the latency requirement of the mobile services.

The NGFI reference architecture assumes that all radio deployment use cases can leverage the same transport network infrastructure. This implies that both new and legacy radio technologies can coexist in the same cell site and the transport infrastructure carries legacy backhaul, legacy fronthaul, and fronthaul with multiple functional split options to meet different requirements.

4.3 NGFI use cases

4.3.1 Massive MIMO

Figure 2 illustrates a macro base station deployment with massive MIMO and radio beamforming. This deployment model is characterized by very high end-user peak data rate. Assuming centimeter or millimeter microwave technology for massive MIMO and beamforming, with enough spectrum (e.g., moderate 400 MHz channel bandwidth), user data peak rates can be in the magnitude of one Gbps per beam. The MIMO and beamforming functions are performed in the RU/DU blocks.

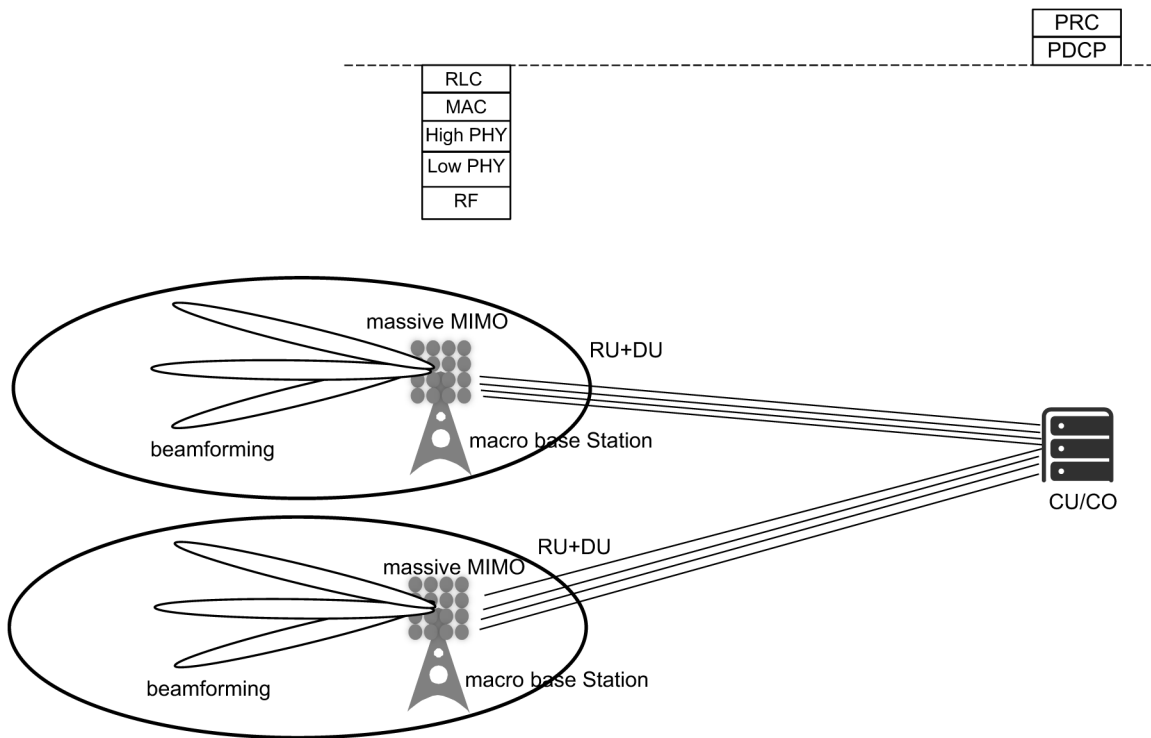


Figure 2—Illustrative massive MIMO macro base station deployment

4.3.2 URLLC

Figure 3 illustrates a typical ultra-reliable and low latency communications (URLLC) or critical machine-type communications (cMTC) deployment model. Because of the need for very low latency and high reliability (see 3GPP TS 36.211 [B8]), the RU is located close to the DU and the DU is integrated with the CU.

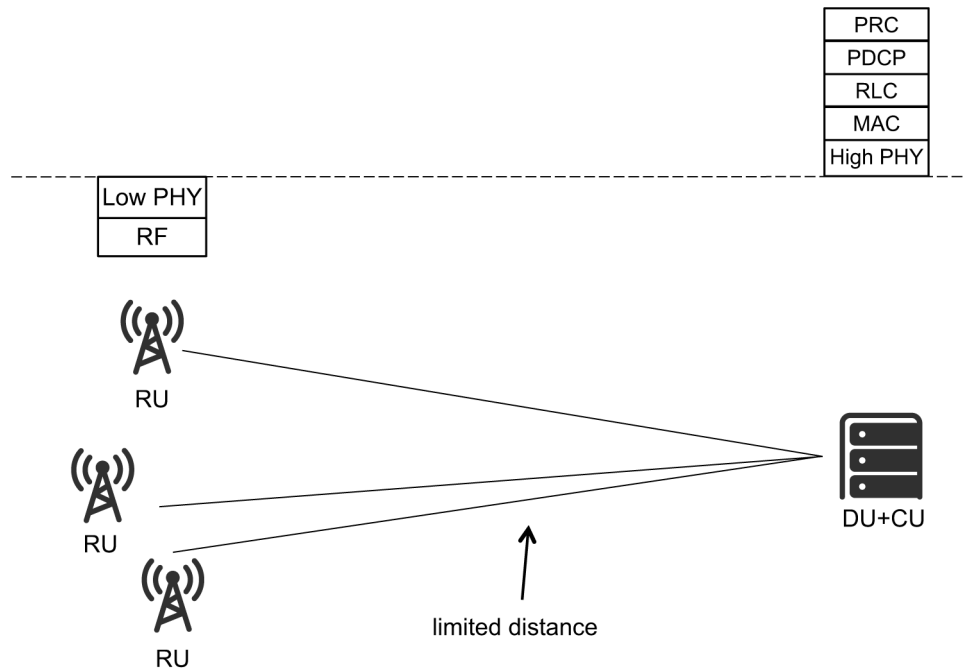


Figure 3—Illustrative URLLC or mMTC base station deployment

4.3.3 Network slicing

Network slicing enables NGFI networks to offer multiple types of end-to-end services and applications with very different service requirements in a commonly shared physical network infrastructure. Based on 3GPP Technical Specification 22.261 [B5], the key attributes of network slicing are as follows:

- To allow creation, modification, and deletion of a network slice
- To allow update of the services and capabilities in a network slice
- To allow a network slice to operate without affecting the traffic and services of other network slices
- To allow creation, modification, and deletion of a network slice with no impact or minimal impact on other network slices
- To allow scaling of a network slice, that is, adjustment of its capacity

Figure 4 illustrates a deployment model where network slicing is applied to a 5G model. This deployment model is characterized by sharing network resources among services that have different requirements. 3GPP 5G NR allows radio resources available in time, frequency, and spatial domains to be allocated to the offered services. Functional split options used by these services and network function allocation in the network nodes can differ largely based on service requirements. Because URLLC has very tight latency requirement, its core function is located closer to the edge.

Another characteristic of this deployment model is that it enables changing services flexibly. The network slices can be dynamically, or semi-dynamically, added, deleted, and modified any time depending on the deployment demands. The network resources can be repartitioned among network nodes for network performance optimization, even if the supported network slices are not altered. Figure 4 shows the example of service change from URLLC to massive machine-type communication (mMTC), where CU is moved further to the pole/cell site such that the transport traffic is changed to backhaul.

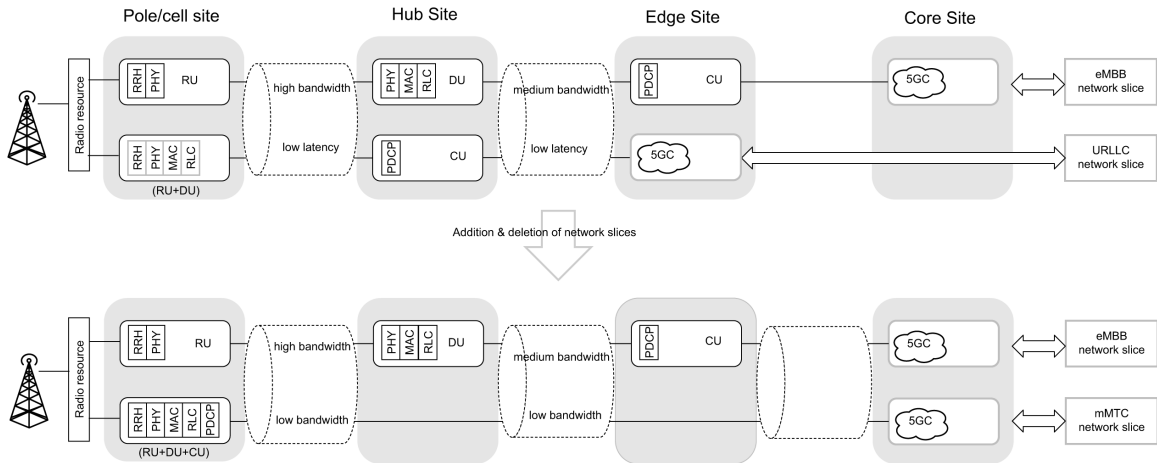


Figure 4—Network slicing applications for mobility deployment

To support network slicing, transport network and its traffic need to support the following:

- Coordination and communication between transport and RAN networks
- Multiplexing of multiple types of transport traffic flows in a commonly shared transport link with largely different transport requirements and key performance indicators (KPIs), which include latency, throughput, transmission reliability, etc.
- Different types of connectivity (point-to-point, point-to-multipoint, multipoint-to-multipoint) to provide service-dependent destinations for the transport traffic flows resulting from different functional splits and flexible partition of network resources in support of RAN operations
- Fast and flexible configuration and reconfiguration of network slices in the transport network to accommodate dynamic service needs

For detailed network slicing specification from RAN perspective, refer to 3GPP TS 38.300 [B11].

5. NGFI deployment models

This clause introduces NGFI deployment models with single and double functional splits. Possible geographical locations of equipment are addressed. Network slicing and operation, administration, and maintenance (OAM) for NGFI networks are also discussed.

5.1 NGFI general deployment

In 5G networks, for certain applications, RU, DU, and CU entities are deployed in a single node. There is no fronthaul transport network in this scenario. The discussion of this scenario is out of the scope of this standard.

For NGFI deployments based on the NGFI reference architecture in 4.2, two scenarios are identified, as follows:

- Single split: evolved NodeB (eNB)/5G NodeB(gNB) functions are split either between a RU and an integrated or co-located DU and CU ({DU+CU}) (low layer split – single split low in Figure 5) or between a CU and an integrated or co-located RU and DU ({RU+DU}) (high layer split – single split high in Figure 5).

- Double split: eNB/gNB functions are split between a RU and a DU as well as between a DU and a CU, with different split options and different DU locations.

Figure 5 shows these two scenarios and the corresponding geographical locations of the mobile elements (RU, DU, CU). These two scenarios are further analyzed in 5.2 and 5.3. The EPC/5GC and the associated core transport network in the figure provide a complete view of the overall network. Requirements and guidelines for this portion of the network are out of the scope of this standard.

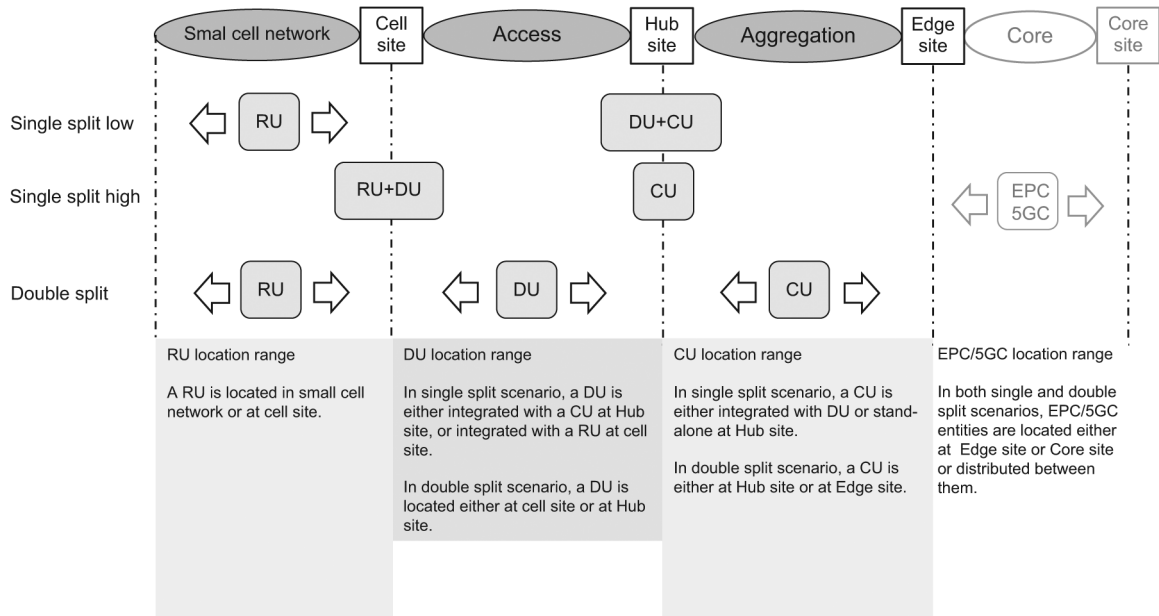


Figure 5—NGFI deployments and geographical implications

5.2 Single split

The implementations of single split deployments include scenarios as follows:

- $RU \leftrightarrow \{DU+CU\}$: Figure 6 shows a model with a single split between an RU and a $\{DU+CU\}$. The DU and the CU are implemented in a single node located at the access site while the RU implements RF functions and possibly part of PHY functions. In this case, NGFI-I connects the RU to the $\{DU+CU\}$ while NGFI-II is an internal interface instead of a network.
- $\{RU+DU\} \leftrightarrow CU$: Figure 7 shows a model with a single split between a $\{RU+DU\}$ and a CU. The RU and the DU are implemented in a single node with functional blocks from PHY to mid/high layers in a base station, while the remaining high layer functions are implemented in the CU. In this case, NGFI-I is an internal interface instead of a network while NGFI-II connects the $\{RU+DU\}$ to the CU.

The logical models in Figure 6 and Figure 7 show only one instance of each functional block or integrated functional block. In practice, multiple RU functional blocks can be connected to one DU functional block and multiple DU function blocks can be connected to one CU functional block.

In both cases, NGFI networks are logically represented with fronthaul transport nodes (FTNs). The number of FTNs and their switching technologies vary according to specific applications. Transport connectivity can also rely on different topologies (e.g., linear, ring, star). FTNs and mobile elements are either physically separated or integrated. This is implementation dependent.

Resulting transport networks are as follows:

- NGFI-I, transport connecting RU to {DU+CU}, interfacing low layers of base station processing chain
- NGFI-II, transport connecting {RU+DU} to CU, interfacing high layers of base station processing chain

In both Figure 6 and Figure 7, mobile backhaul is the transport network connecting CU to EPC/5GC. The mobile backhaul network is logically represented with a variable amount of mobile backhaul transport node(s) to provide a complete view of the overall transport network. The specification of mobile backhaul is out of scope of this standard.

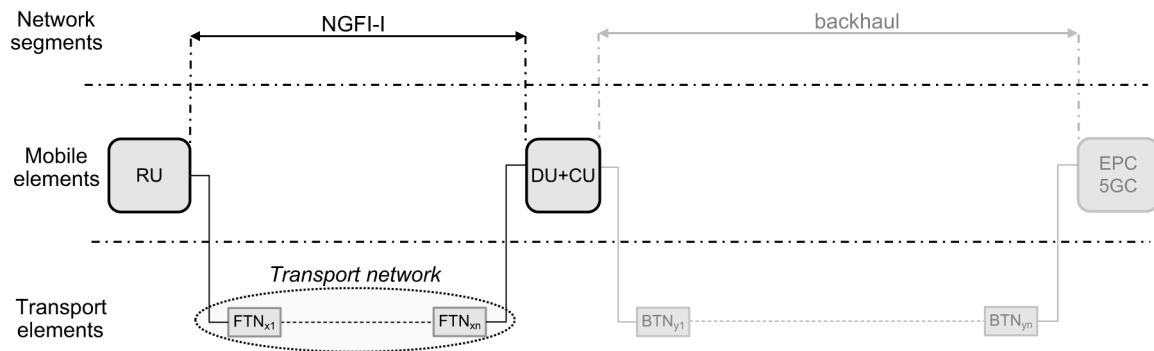


Figure 6—Single split network model: RU ↔ {DU+CU}

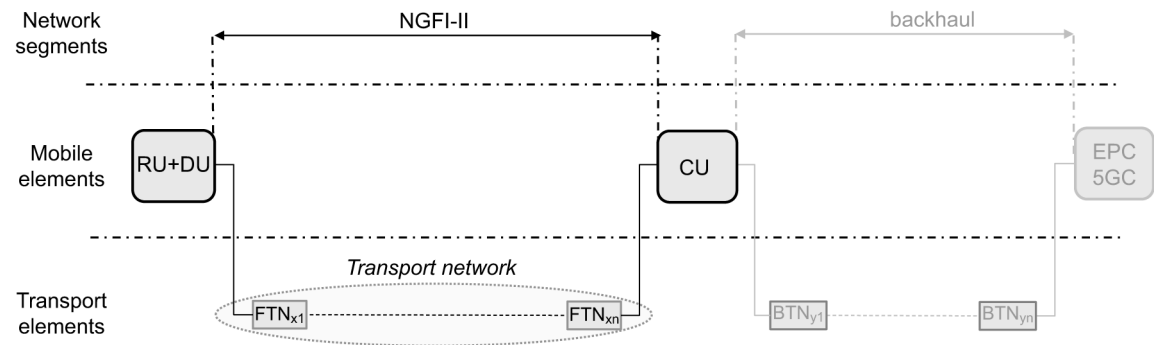


Figure 7—Single split network model: {RU+DU} ↔ CU

5.3 Double split

Figure 8 shows the generic model for double split fronthaul networks. The RU implements RF and possibly part of PHY functions, while the DU is a first level of functions centralization, possibly taking care of time-sensitive coordinated radio scheduling and MAC level retransmission functions. The less time-sensitive layers may be implemented in the CU with a further level of functions centralization.

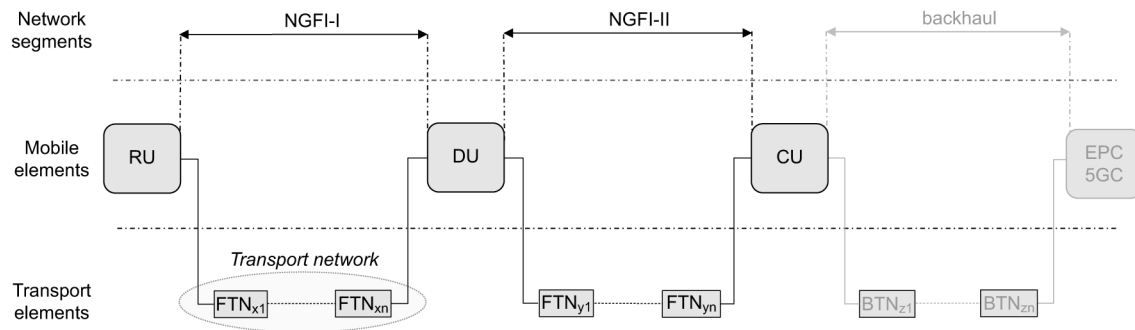
Figure 8 shows the generic model for double split fronthaul networks, as follows, where:

- NGFI-I is the transport connecting RU to DU
- NGFI-II is the transport connecting DU to CU

This logical model in Figure 8 shows only one instance of each functional block. In practice, multiple RU functional blocks can be connected to one DU functional block and multiple DU functional blocks can be connected to one CU functional block.

Double split NGFI networks are logically represented with FTNs. The number of FTNs and their switching technology vary according to the specific application. Transport connectivity can also rely on different topologies (e.g., linear, ring, star). FTNs and mobile elements are either physically separated or integrated. This is implementation dependent.

In Figure 8 the mobile backhaul is shown to provide a complete view of the overall transport network. The specification of mobile backhaul is out of scope of this standard.



NOTE—FTNs in NGFI-I and NGFI-II do not necessarily share the same characteristics.

Figure 8—Double split network model

5.4 Network slicing

NGFI networks support network slicing. Two network slicing modes apply to NGFI networks: network slice-unaware and network slice-aware modes. They are differentiated by the awareness level of the RAN traffic.

5.4.1 Network slice-unaware mode

In this mode, NGFI networks are unaware of how the fronthaul traffic flows from RAN are multiplexed and does not identify them to optimize their transport. Instead, NGFI networks are provisioned to provide enough fixed capacity for the worst-case network slicing scenario known to the network slicing orchestrator and are not expected to communicate with the network slicing orchestrator for any operation, including provisioning and reporting KPIs.

Therefore, the addition, deletion, or modification of a network slice at the network slicing orchestrator level has no effect on the network slicing-unaware NGFI networks. The network slices neither adapt nor perform reconfiguration process for optimization of the transport network.

5.4.2 Network slice-aware mode

In this mode, NGFI networks are aware of how fronthaul traffic flows from RAN are multiplexed and identify them to optimize their transport. Optimization consists in mapping the flows into separated traffic groups according to similar transport KPI requirements when QoS is used for network slicing purposes.

NGFI networks provide control and management capabilities for coordination with the network slicing orchestrator to support network slices. The transport network resources supporting a given network slice

should be implemented and configured to be viewed as a subnetwork instance under the management of the network slicing orchestrator.

NGFI networks provide visibility to the network slicing orchestrator by monitoring and reporting KPIs, execution, and resource utilization status.

The addition, deletion or modification of a network slice at the network slicing orchestrator level results in the network slice-aware NGFI networks seamlessly reconfiguring as needed to support this added, deleted, or modified network slice.

NGFI networks help ensure the isolation of network slices by fulfilling minimum service guarantees on traffic flows.

5.4.3 High-level view

Figure 9 illustrates a high-level view of connectivity and interface of the transport network to other network elements, where service orchestrator and related controllers are essential to perform coordination between RAN and transport network to provide the required network slicing services.

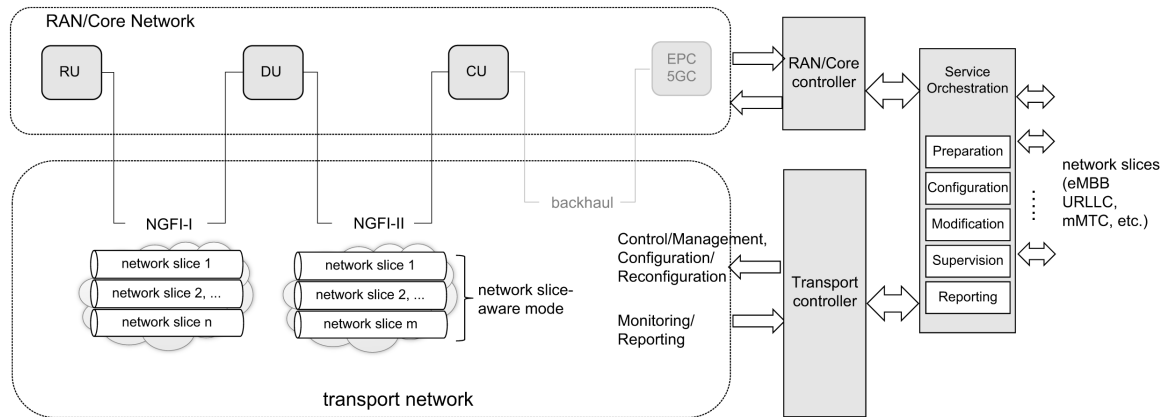


Figure 9—High-level view of the transport modes under network slicing

The network slice-aware mode implies the identification of different network slices whose scope is linked to the actual services termination points (sink/source) in RAN/Core elements.

Slices can be dynamically configured, as follows:

- “per NGFI CoS”, where a set of logical and physical network resources ensuring specific network performance (e.g., ultra-low latency) is allocated to a single service or a bundle of services requiring same requirements.
- “per transport user”, where a set of logical and physical network resources is allocated within network slices. For example, classification and scheduling is performed so that services with different class of service (CoS) are managed within a transport network slice.

When considering NGFI-I span in both “per NGFI CoS” and “per transport use” slice types, the finest slice granularity is driven by the actual split option implemented and, consequently, by the nature of the interface signal exchanged between RU and DU.

Conversely, in NGFI-II span, due to the implementation of functional split at high layers, the identification of the single service at transport nodes is possible [e.g., via virtual local area network (VLAN) or pseudo-wire (PW)/label-switched path (LSP)], and a finer network slice granularity is applicable. [Annex D](#) provides examples for the two network slicing modes.

Different network slices may have different geographical extent. For example, CU user plane instances in network slice-aware mode could be placed at different geographic locations serving the same DU. Similarly, different topology requirements may apply to the different network slices.

5.5 NGFI OAM

[Figure 10](#) provides an overview of NGFI networks with the multiple organizations involved in providing end-to-end service. The organizations are as follows:

- Mobile operator is the organization obtaining the transport service from a service provider. It owns or controls all the elements necessary to sell and deliver services to an end user.
- Service provider is the organization providing transport service to a mobile operator. It owns or controls the end-to-end network.
- Operator is the organization that monitors and maintains the end-to-end operation of one portion of the network.

Individual operators own the physical network and are responsible for OAM of their part of the network. The service provider is responsible for OAM of the end-to-end service to the mobile operator. The service provider can also be an operator. In this case, it owns whole or part of the physical network. If the mobile operator owns the whole network, it is the only player. Note that CU and DU entities in [Figure 10](#) belong to the mobile operator, not to the service provider or any operator.

Both NGFI-I and NGFI-II should support configuration from orchestrator as well as report statistics to statistics collecting blocks for further processing. The orchestrator and statistics collecting block are not shown in the model and they are out of scope of this standard.