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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Mobile network transport aspects

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Characteristics of transport networks to support IMT-2020/5G

Recommendation ITU-T G.8300

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Recommendation ITU-T G.8300

Characteristics of transport networks to support IMT-2020/5G

Summary

Recommendation ITU-T G.8300 defines the requirements for the layer one transport network support for the 5G fronthaul, midhaul and backhaul networks as defined in this Recommendation.

History

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Characteristics of transport networks to support IMT-2020/5G

1 Scope

This Recommendation documents the requirements for the layer one transport network for 5G, including hard isolation between aggregated digital clients. The digital clients are the digital streams to/from the 5G entities (e.g., RU, DU, CU, 5GC/NGC) and other digital clients carried in the access, aggregation and core transport networks. The requirements and characteristics are documented for each of the fronthaul, midhaul and backhaul networks as defined in this Recommendation.

The factors addressed include:

- Relationship of 5G network architecture to transport network architecture
- Operations, administration, and maintenance (OAM) requirements
- Timing performance and time/synchronization distribution architecture
- Survivability mechanisms

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.805] Recommendation ITU-T G.805 (2000), *Generic functional architecture of transport networks*.

[ITU-T G.8271] Recommendation ITU-T G.8271/Y.1366 (2020), *Time and phase synchronization aspects of telecommunication networks*.

[ITU-T G.8271.1] Recommendation ITU-T G.8271.1/Y.1366.1 (2020), *Network limits for time synchronization in packet networks with full timing support from the network*.

[ITU-T G.8273.2] Recommendation ITU-T G.8273.2/Y.1368.2 (2019), *Timing characteristics of telecom boundary clocks and telecom time slave clocks*.

[ITU-T G.8275] Recommendation ITU-T G.8275/Y.1369 (2017), *Architecture and requirements for packet-based time and phase distribution*.

[ITU-T G.8275.1] Recommendation ITU-T G.8275.1/Y.1369.1 (2020), *Precision time protocol telecom profile for phase/time synchronization with full timing support from the network*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

5GC	5G Core
BS	Base Station
CPRI	Common Public Radio Interface
CN	Core Network
C-RAN	Cloud Radio Access Network
CU	Centralized Unit
D-RAN	Distributed Radio Access Network
DU	Distributed Unit
eCPRI	enhanced Common Public Radio Interface
eMBB	enhanced Mobile Broadband
eOEC	enhanced OTN Equipment Clock
ePRC	enhanced Primary Reference Clock
ePRTC	enhanced Primary Reference Time Clock
eSEC	enhanced Synchronous Equipment Clock
gNB	Next generation NodeB
HLS	High-Layer Split
HRM	Hypothetical Reference Model
MAC	Media Access Control layer
MBB	Mobile Broadband
mCDN	mobile Content Delivery Network
MEC	Multi-access Edge Computing
mMTC	massive Machine-Type Communication
OAM	Operations, Administration, and Maintenance
OEC	OTN Equipment Clock
OSS	Operations Support System
OTN	Optical Transport Network
PDCP	Packet Data Convergence Protocol
PHY	Physical layer
PRC	Primary Reference Clock
PRTC	Primary Reference Time Clock
PTP	Precision Time Protocol
RAN	Radio Access Network
RBU	Radio Baseband Unit
RRU	Remote Radio Unit
RU	Radio Unit

SEC Synchronous Equipment Clock

SLA Service Level Agreement

T-BC Telecom Boundary Clock

T-TC Telecom Transparent Clock

TCM Tandem Connection Monitoring

UE User Equipment

URLLC Ultra-Reliable Low Latency Communication

VN Virtual Network

5 Conventions

This Recommendation uses the following conventions:

F1 Logical interface between the CU and DU

NG Logical interface between the 5GC and gNB

Xn (Logical) Interfaces internal to the RAN ("Xn" specifically refers to one connected between two gNB nodes)

6 Reference transport network architecture for support of 5G mobile networks

The architecture of the transport network is often described in terms of metro access, metro aggregation, metro core, and backbone domains. When considering transport for 5G, an alternative description based on 5G applications is useful in understanding the requirements.

The 5G RAN architecture is described in [b-3GPP TS 38.401].

For purposes of describing the transport network for 5G, the 5G network comprises remote radio unit (RRU), distributed unit (DU), centralized unit (CU), and core network. The terms fronthaul, midhaul, and backhaul are used in this Recommendation when describing the 5G transport network support for the interfaces between these nodes.

A fronthaul transport network supports the low-layer functional split point of 3GPP NG-RAN (e.g., Option 6 for MAC/PHY split or Option 7 for intra PHY split) [b-3GPP TR 38.801].

A midhaul transport network supports 3GPP NG-RAN F1 interface (between a gNB-CU and a gNB-DU), or the Xn interface that provides interconnection between different NG-RAN nodes (gNB).

A backhaul transport network supports the 3GPP NG interface (between the 5GC and the NG-RAN) or the Xn interface that provides interconnection between different NG-RAN nodes (gNB) [b-3GPP TS 38.401].

The deployment of IMT2020/5G RAN can be characterized based on the location of the DU and CU, as illustrated in Figure 6-1. Several observations can be made about the transport network based on this figure:

– A backhaul network always exists to connect the CUs to the core network.

– When DU and RU are integrated, there is no fronthaul network.

– When the DU and CU are integrated, there is no midhaul network.

Although not shown in Figure 6-1, the Xn interface between CU nodes would transit either a midhaul or backhaul network.

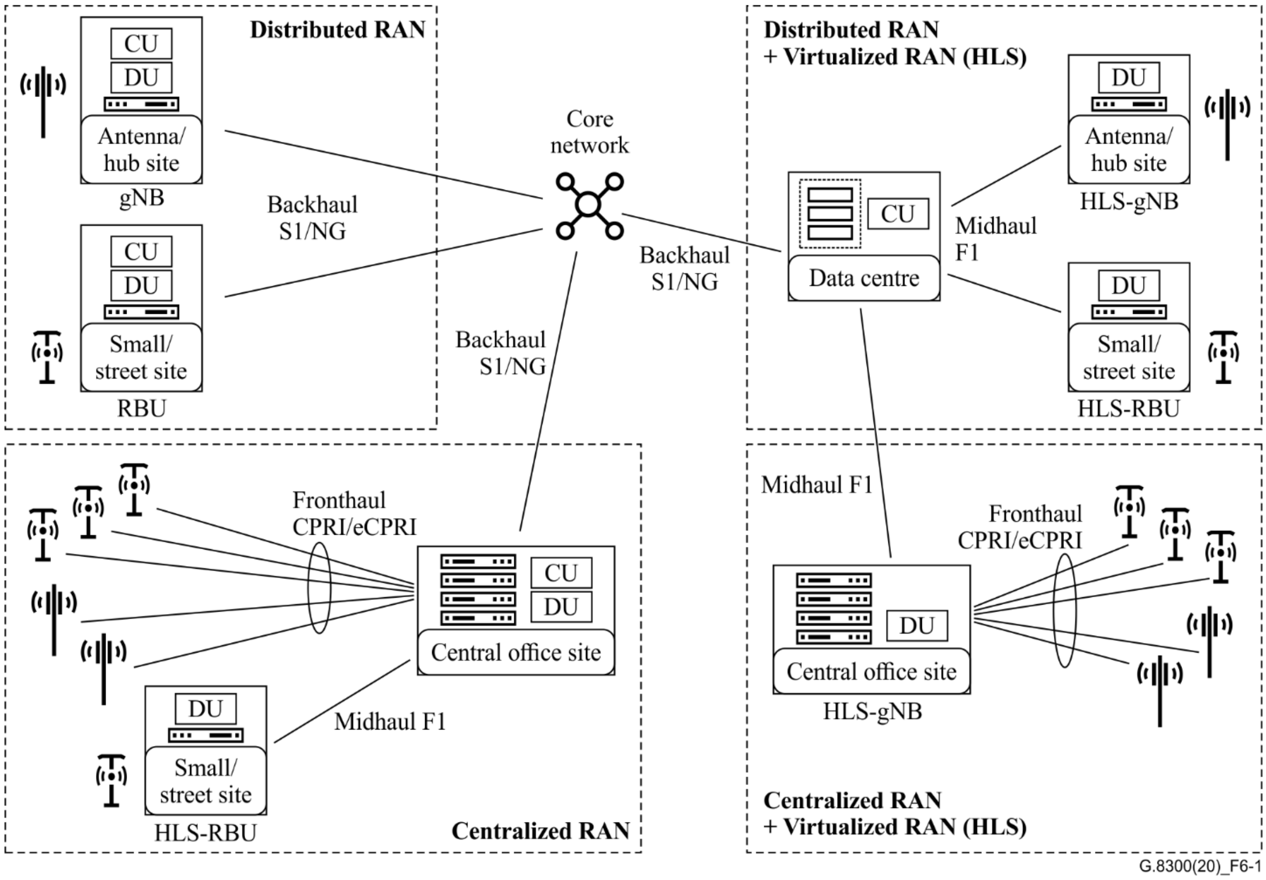

Figure 6-1 – Example overview of a 5G transport network

Table 6-1 provides a mapping of terminology used to describe the 5G transport network to the domains of the transport network.

Table 6-1 – Terminology mapping

3GPP logical interface or CPRI Name	Network name in this Recommendation	Interface description	Transport network domains
CPRI/eCPRI	Fronthaul	Interface between RRU and DU	Metro access
F1	Midhaul	Logical interface between the CU and DU	Metro- access or metro aggregation
NG	Backhaul	Logical interface between the gNB (CU) and the 5GC	Metro access, metro aggregation, metro core, or backbone
Xn	Midhaul or Backhaul	Logical interface between gNB nodes (between the packet data convergence protocol (PDCP) function of each)	Metro access, metro aggregation, metro core, or backbone

Several examples of the mapping described in Table 6-1 are illustrated in Figure 6-2.

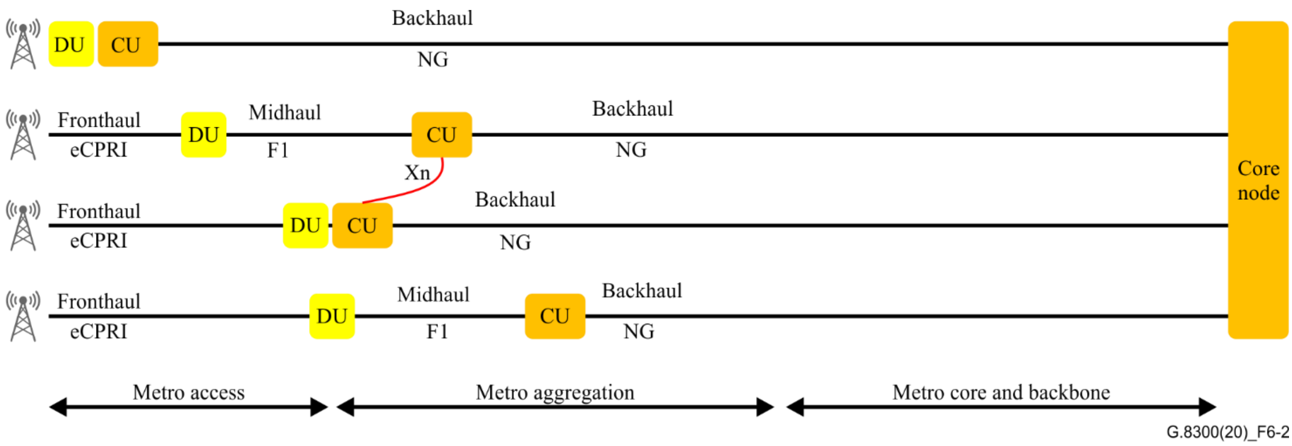

Figure 6-2 – Examples of mapping transport network domains to 5G network names

Beyond the transport plane shown in Figure 6-2, the transport network architecture also includes management and synchronization planes. Together these components enable support for the applications of 5G, multi-access Edge computing (MEC), and mobile content delivery network (mCDN) network interconnection as well as private line services. To facilitate service level agreement (SLA) guarantees, virtual network resource capabilities are supported to enable differentiated network slicing, which requires coordinated management and control of the 5G core network, transport network, and radio access network (RAN). Figure 6-3 illustrates this broader view of the transport network.

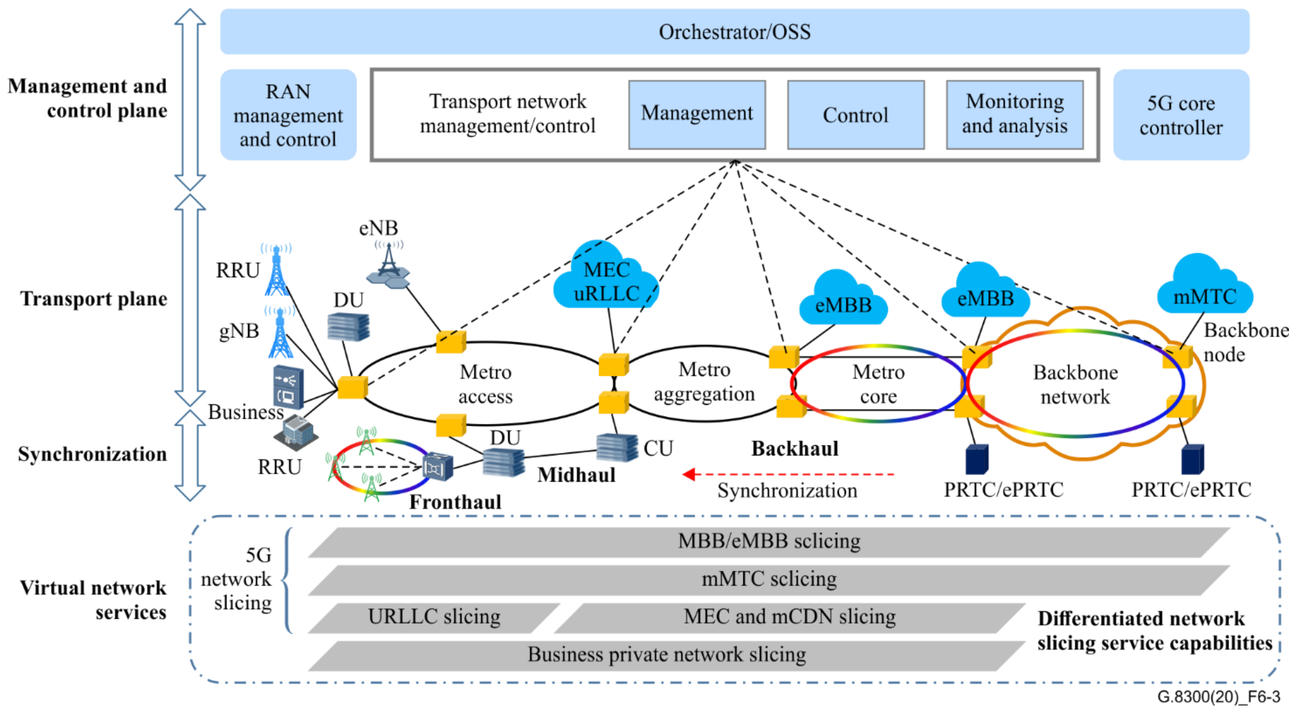

Figure 6-3 – Overview of 5G transport network

7 Transport network OAM requirements

The 5G transport network consists of both path and section layers, each having its own OAM.

7.1 Path layer OAM requirements

The transport network path layer OAM functions shall meet the following basic requirements:

1) Each path layer shall support its own suitable OAM function set.

2) Each path OAM function shall support on demand enabling or disabling commands. A disabled OAM function shall release resources that it occupied during the enabled period.

3) OAM information is inserted or extracted at the path channel end point. Both inserting and extracting operations shall have a minimum impact on latency and system complexity. Support for non-intrusive monitoring of path OAM is optional.

Support for tandem connection monitoring (TCM) and a path layer management communications channel is for further study

The path OAM functions shall support the following:

a) Continuity supervision

b) Connectivity supervision

c) Error performance monitoring

d) Remote defect and error reporting

e) Delay measurement (in-service and out-of-service)

f) Protection communications channel

g) Client signal fail indication

Each type of OAM function is activated by enable and disable commands. Some OAM information may be sent and received periodically. The periodicity could be made configurable and on -demand. In any case, the periodicity must be suitable to the type of OAM. All types of OAM functions are independent to each other.

7.1.1 Delay measurement

Both in-service and out-of-service delay measurements may be required, depending on the service. Some services may need only an out of service measurement prior to activating the service, while others may require more frequent monitoring of delay to ensure performance requirements are being satisfied.

Both one-way and two-way delay measurements are needed.

Appendix I includes additional information regarding end-to-end latency in 5G networks.

7.2 Section layer OAM requirements

The section layer OAM functions can provide the performance supervision and management, and should include the following functions:

a） Connectivity supervision, monitoring the integrity of the routing of connectivity of a connection between source and sink terminations.

b） Maintenance information, including forward and backward defect indications and backward error reporting.

c） Connection quality supervision, monitoring the performance of a connection.

d） Management communications channel.

e） Server signal fail indication.

8 Considerations related to 5G network slicing

The transport network is, in general, a multi-service network and, in most cases, a common transport network infrastructure will be shared between 5G services and other types of services. It is necessary to provide isolation between each of these services. From a management perspective, the services are supported by virtual networks (VNs). The forwarding plane must ensure that the traffic from one VN is not (accidentally) delivered to a different VN. It is also necessary for the forwarding plane to provide isolation that limits the interaction between the traffic in different VNs.

9 Frequency and time synchronization in the transport network

In the 5G transport network, frequency and phase/time synchronization are needed to support requirements at the air interface of a mobile system. This clause describes 5G synchronization requirements and defines the synchronization solution for the transport network.

9.1 Synchronization requirement

Requirements for the frequency offset at the air interface of 5G RRUs are described in [b-3GPP TS 38.104].

The relevant phase/time synchronization requirements are listed in Tables II.1 and II.2 of [ITU-T G.8271].

9.2 Synchronization solution for transport network

For meeting frequency and phase/time synchronization requirements, the full timing support solution, which is defined in [ITU-T G.8275], should be used in the transport network. This solution requires that every node between the clock server and the end application node should support the synchronous equipment clock or enhanced synchronous equipment clock SEC/eSEC and the telecom boundary clock (T-BC) or telecom transparent clock (T-TC) [ITU-T G.8271.1] clock. Figure 9-1 is a generic synchronization topology for the transport network and represents one example of how such a network could be constructed.

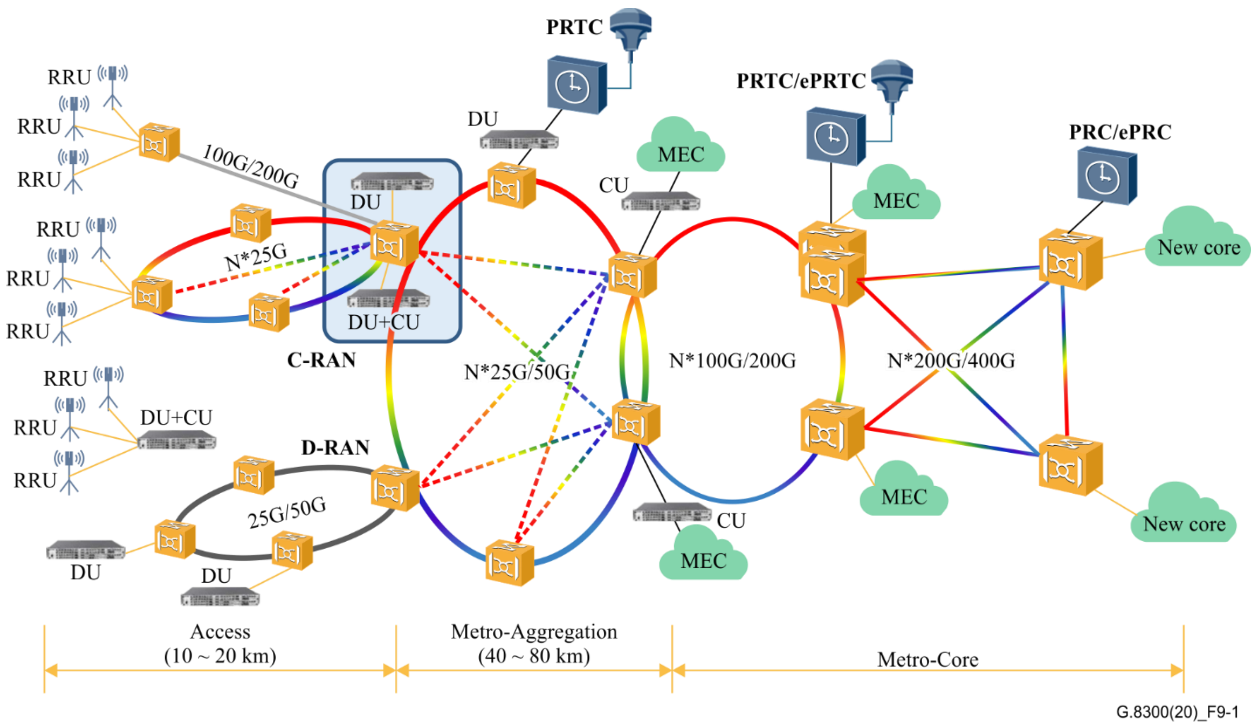

Figure 9-1 – Example of synchronization transport network topology

Generally, the frequency reference master primary reference clock PRC/ePRC is deployed in the core network, and the phase/time master primary reference time clock or enhanced primary reference time clock PRTC/ePRTC is deployed in the access, aggregation, or core network. The deployment position is limited by the number of hops from the clock server to the RRU, which is described in the hypothetical reference models (HRMs) of [ITU-T G.8271.1].

For the frequency synchronization solution, the transport nodes between the PRC/ePRC and RRU shall support the appropriate SEC or eSEC physical layer clock.

For the phase/time synchronization solution, the transport nodes between the PRTC/ePRTC and RRU shall support the T-BC precision time protocol (PTP) layer clock. The clock specification is [ITU-T G.8273.2] and the network limit is defined in [ITU-T G.8271.1], and the PTP full timing support profile is [ITU-T G.8275.1.

NOTE – Optical layer nodes without optical protection/restoration are not required to support the OTN equipment clock (OEC), enhanced OTN equipment clock (eOEC) or T-BC. This is because these nodes do not affect the accuracy of the transport synchronization network.

10 Survivability techniques in transport networks to support 5G

General characteristics of transport protection mechanisms are described in the ITU-T G.808.x series of Recommendations.

Protection or restoration mechanisms should be used in the 5G transport network as necessary to meet the requirements of the services being carried over the 5G network. In order to allow for deployment of survivability mechanisms in multiple layers, any new protection or restoration mechanisms should support the use of hold-off timers.

Appendix I

End-to-end service latency in 5G networks

(This appendix does not form an integral part of this Recommendation.)

End-to-end service latency is an important characteristic of 5G networks. Table I.1 summarizes requirements for end-to-end latency for some types of services based on [b-3GPP TR 38.913].

Table I.1 – End to end latency requirements for selected service types

Service type		Latency requirement
eMBB	User plane (UE- CU/MEC)	4 ms
	Control plane (UE-CN)	10 ms
URLLC	User plane (UE-CU/MEC)	0.5 ms~1 ms
	Control plane (UE-CN)	10 ms

Figure I.1 illustrates an example of how the end-to-end latency budget could be allocated to different nodes and transport networks within the 5G architecture.

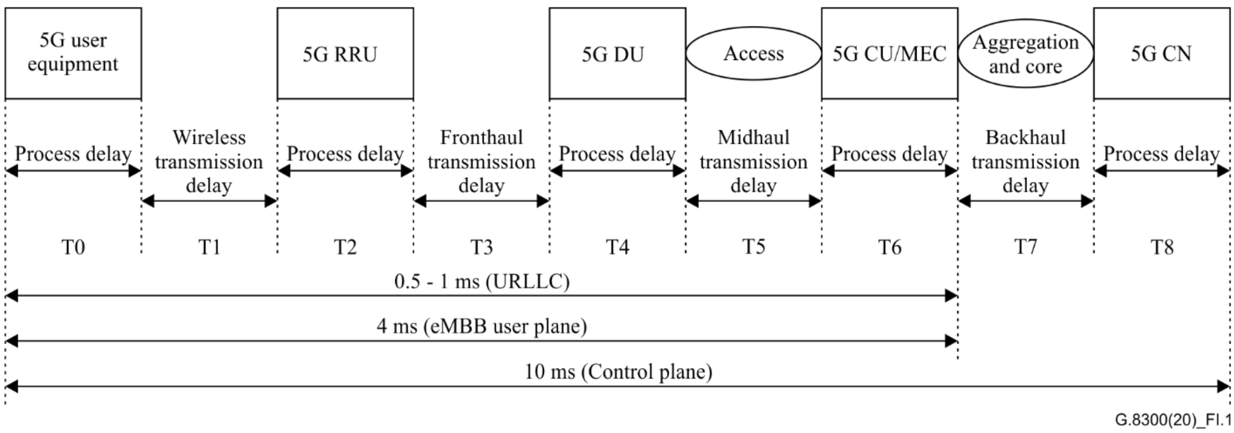

Figure I.1 – Example allocation of end-to-end latency

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