eCPRI Transport Network V1.0 (2017-10-24)

Requirements Specification

Common Public Radio Interface:
Requirements for the eCPRI Transport Network

Table of Contents

1. Introduction 3
2. Transport Network Terminology and Services 4
   - 2.1. User Network Interface 4
   - 2.2. Transport Connection 4
   - 2.3. EVC Service Attributes 5
     - 2.3.1. One-way Frame Delay Performance 5
     - 2.3.2. One-way Frame Loss Ratio Performance 5
   - 2.4. EVC per UNI Service Attributes 5
3. Traffic Characterization 6
   - 3.1. Generic traffic 6
   - 3.2. Constant Bitrate traffic 6
   - 3.3. ON/OFF traffic 7
4. Requirements 8
   - 4.1. Per flow requirements 8
     - 4.1.1. Split E and splits ID, IID, IU when running E-UTRA 8
   - 4.2. Timing accuracy requirements 8
   - 4.3. Phase noise and MTIE requirements 10
     - 4.3.1. Phase noise characteristic at UNI 10
     - 4.3.2. MTIE mask at UNI 10
   - 4.4. In-order delivery 10
5. Annex A: Service Agreement considerations 11
6. List of Abbreviations 12
7. References 13
8. History 14

1. Introduction

The Common Public Radio Interface (CPRI) is an industry cooperation aimed at defining publicly available specifications for the key internal interface of radio base stations, such as eCPRI connecting the eCPRI Radio Equipment Control (eREC) and the eCPRI Radio Equipment (eRE) via a so-called fronthaul transport network. The parties cooperating to define the specification are Ericsson AB, Huawei Technologies Co. Ltd, NEC Corporation and Nokia.

The eCPRI Interface Specification [1] can be supported by Ethernet-switched or IP-routed fronthaul networks, or similar types of transport networks. This specification describes the requirements that the packet switched transport network must fulfill in order to support eCPRI services.

<u>Scope of Specification:</u>

This specification defines the details necessary to qualify and quantify the requirements on the underlying transport network needed by the eCPRI layers to provide its services to the application.

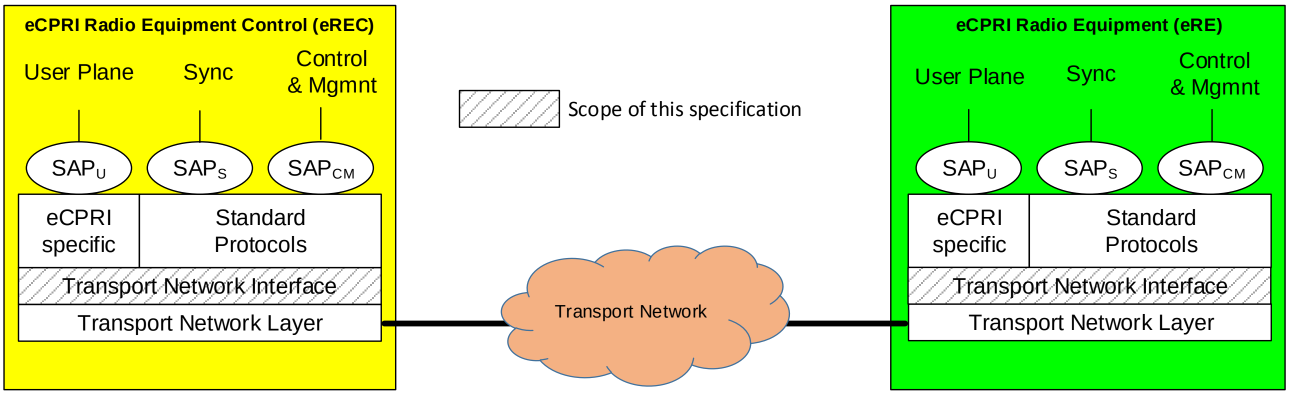

Figure 1 Scope definition

Equipment of independent vendors can share a common network. Thus, there must be no dependencies (explicit or implied) between equipment of different vendors that use the same transport network. The details of the network implementation shall be separated from the details of its users, i.e., the eCPRI equipment, by means of a Transport Network Interface. This specification provides the eCPRI requirements to enable such separation.

The packet switched transport network requirements to support eCPRI are independent of the technology used by a given packet transport network supporting eCPRI, i.e., the same requirements apply to Ethernet or IP transport networks. This document refers to the Carrier Ethernet services specified by the MEF Forum, especially the Ethernet Service Attributes defined in [2]. However, Ethernet transport services are only shown as an example, which are applicable, e.g., to Ethernet-based transport networks. The requirements (and corresponding definitions) described in this document are equally applicable to other packet transport networks based on different transport technologies (e.g., MPLS or IP) that can provide transport services similar to the MEF transport services.

In MEF terminology, the Service Provider is the organization providing Ethernet Service(s) and the Transport Network illustrated in Figure 1 is a network from a Service Provider or network Operator supporting the MEF service and architecture models. The Subscriber is the organization purchasing and/or using Ethernet Services, i.e., the eRE and eREC illustrated in Figure 1 belong to a Subscriber of transport service(s). The technical specification of the service level being offered by the Service Provider to the Subscriber is referred to as Service Level Specification (SLS).

2. Transport Network Terminology and Services

This section describes terminology, services, service attributes, etc. that are widely used for transport networks. Although, this section largely refers to the terminology used by the MEF Forum, neither the transport network nor the service provided is limited to Ethernet, other technologies and services, e.g., IP can also be used.[1]

2.1. User Network Interface

The User Network Interface (UNI) is the physical demarcation point between the responsibility of the Service Provider and the responsibility of the Subscriber (section 7 in [2]). Figure 2 illustrates UNIs between eCPRI equipment (eRE/eREC) and a transport network. It may contain one or more physical termination points (e.g., Ethernet physical interfaces, see section 9.4 in [2]). Usually all physical termination points of an eCPRI unit are part of the same UNI.

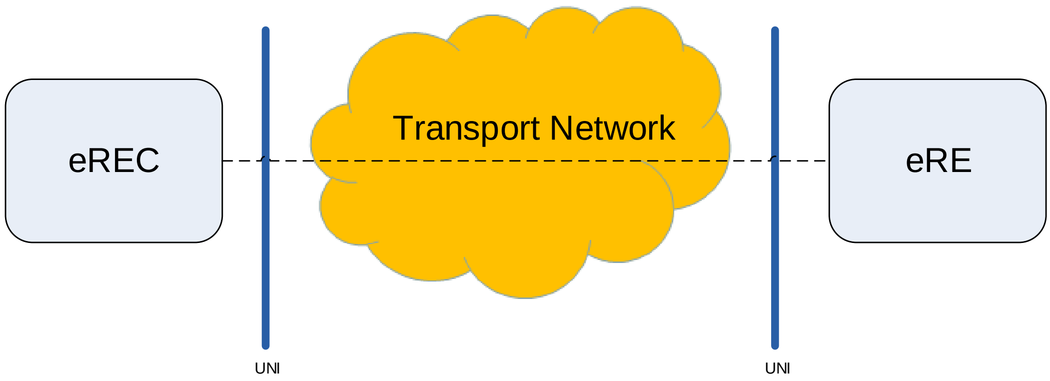

Figure 2 UNI between a eRE/eREC and a transport network

Note that the equipment on the Subscriber side of the UNI, i.e., eRE and eREC are referred to as Customer Edge (CE) in [2].

2.2. Transport Connection

The connection is the key component of the service(s) provided by a transport network.

A fundamental aspect of Ethernet Services is the Ethernet Virtual Connection (EVC). An EVC is an association of two or more UNIs. The UNIs associated by an EVC are said to be “in the EVC”. A given UNI can support more than one EVC (See section 8 in [2]). Service Frames are transmitted via a MEF UNI, where a Service Frame is from the first bit of the Destination MAC Address through the last bit of the Frame Check Sequence of an IEEE 802.3 Packet ([2]).

[1] The definition of IP Services is an ongoing work at MEF

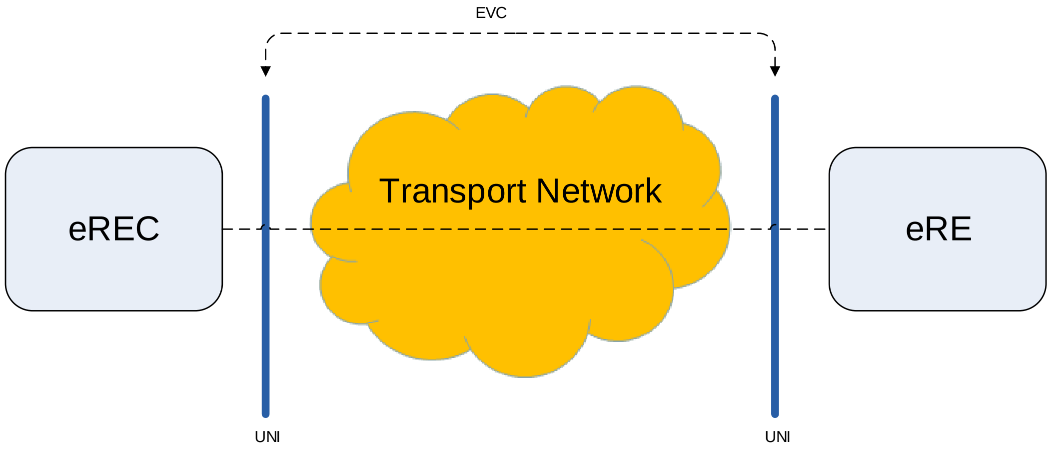

Figure 3 Example of EVC and its relation to the UNI

Note that the same packet format is used at each UNI belonging to a particular service provided by a transport network. For instance, Ethernet Service Frame on each UNI in the case of an Ethernet service. Alternatively, it can be e.g., IP packet at each UNI.

UNI Service Attributes are described in section 9 in [2].

2.3. EVC Service Attributes

A transport service is specified using service attributes. Each of these attributes defines specific information about the service that is agreed between a Subscriber and a Provider of the transport service. It is outside the scope of this document how an agreement is established between a Subscriber and a Provider. See section 5 for examples of how an agreement can be established.

EVC Service Attributes are described in section 8 in [2] and EVC per UNI Service Attributes are described in section 10 in [2].

Two EVC Performance Service Attributes are of special interest of the current release of this document.

2.3.1. One-way Frame Delay Performance

The One-way Frame Delay for an egress Service Frame in the EVC is defined as the time elapsed from the transmission at the ingress UNI of the first bit of the corresponding Service Frame until the reception of the last bit of the Service Frame at the paired UNI (section 8.8.1 in [2]).

Note that this definition of Frame Delay for a Service Frame is the one-way delay that includes the delays encountered as a result of transmission of the Service Frame across the ingress and egress UNIs as well as those introduced by the transport network.

The One-way Frame Delay Performance is described in section 8.8.1 of [2]. Only the maximum value of the One-way Frame Delay Performance is of special interest of the current release of this document.

2.3.2. One-way Frame Loss Ratio Performance

The One-way Frame Loss Ratio Performance is described in section 8.8.3 of [2].

2.4. EVC per UNI Service Attributes

The Class of Service (CoS) Identifier for Data Service Frames is an EVC per UNI Service Attribute that is of special interest for this document. The following Class of Service identification methods are of interest among the ones described in 10.2.1 of [2]:

- Class of Service Identifier based on the EVC (see section 10.2.1.1 of [2]).
- Class of Service Identifier based on the Priority Code Point Field (see section 10.2.1.2 of [2]).
- Class of Service Identifier based on Internet Protocol (see section 10.2.1.3 of [2]).

3. Traffic Characterization

This section provides a general model based on MEF's Generic Token Bucket Algorithm (GTBA) and some examples of simple traffic models. A list of performance service attributes is provided for each model as a blueprint for service agreement terms between a Subscriber and a Provider. Neither the set of models included nor each model individually is exhaustive or a perfect characterization of the real-life traffic covering all cases.

In the following sub-sections, physical bit rate refers to the physical line bit rate of the transmitting UNI.

3.1. Generic traffic

The Generic traffic profile corresponds to the Generic Token Bucket Algorithm (GTBA) as described in [12].The performance service attributes metrics for the Generic traffic profile, as defined in section 12.1 of [2] are:

- Committed Information Rate (CIR)
- Maximum Committed Information Rate (CIR_{max})
- Committed Burst Size (CBS)
- Excess Information Rate (EIR)
- Maximum Excess Information Rate (EIR_{max})
- Excess Burst Size (EBS)

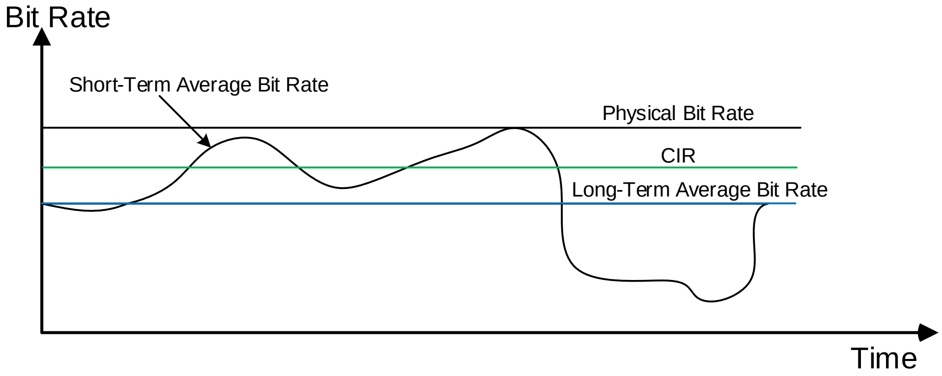

Figure 4 An illustration of data traffic behavior over time

3.2. Constant Bitrate traffic

The Constant Bitrate traffic represents a profile where traffic is transferred at an average constant bitrate: CIR as defined in [2].

Packet transmissions are separated by $t_{IP} = S_P / CIR$, where S_P is the packet size.

The performance service attribute metrics for the Constant Bitrate traffic profile are:

- CIR
- Maximum packet size, corresponding to CBS (for compatibility with the section 3.1 Generic traffic)

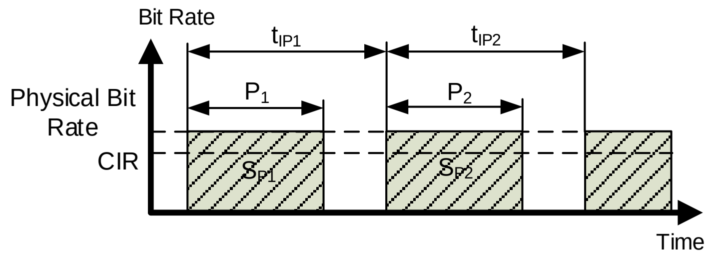

Figure 5 Constant Bitrate traffic profile

3.3. ON/OFF traffic

The ON/OFF traffic profile represents a profile where traffic is transferred only during the so-called ON-period. During the ON-period traffic is transferred at the physical bit rate. In contrast, during the so-called OFF-period no traffic is transferred at all.

ON-periods and OFF-periods are strictly alternating. The additional performance service attributes metrics for the ON/OFF traffic profile are:

- ON-period maximum time duration.
- ON/OFF-period minimum time duration.

The ON-period is defined as the time during which all packets are transferred within an ON/OFF period. The ON-period maximum time duration corresponds to CBS / ‘Physical Bit Rate’.

The ON/OFF-period time duration is defined as the time elapsed between the start of two consecutive ON-periods. The ON/OFF-period minimum time duration corresponds to CBS/CIR.

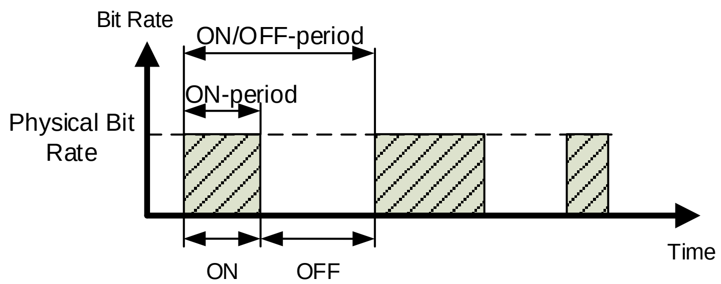

Figure 6 ON-period and ON/OFF-period

4. Requirements

4.1. Per flow requirements

4.1.1. Split E and splits ID, IID, IU when running E-UTRA

Table 1 is applicable for the functional decompositions splits E and I_D, II_D, I_U as defined in [1].

Table 1 Split E and splits I_D, II_D, I_U requirements

CoS Name	Example use	One-way maximum packet delay	One-way Packet Loss Ratio
High	User Plane	100 µs	10^{-7}
Medium	User Plane (slow), C&M Plane (fast)	1 ms	10^{-7}
Low	C&M Plane	100 ms	10^{-6}

4.2. Timing accuracy requirements

In the case where the transport network is used for synchronization, it shall provide adequate timing accuracy. Four timing accuracy categories are defined for different use cases depending on which 3GPP features are to be supported by a specific eCPRI node. The transport network shall provide required timing accuracy |TE| at the edge of the transport network (i.e. at the UNI). Depending on the use case, the accuracy requirements for |TE| apply relative to a global reference for the whole network (e.g. GNSS) or relative between UNIs of a local cluster. This is illustrated in Figure 7.

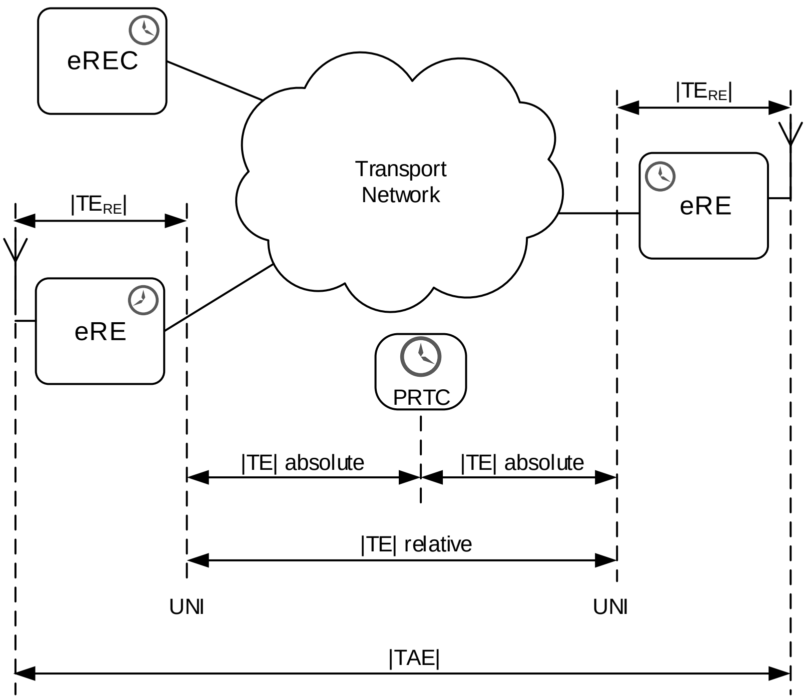

Figure 7 Timing accuracy definitions

Transport network synchronization may be implemented via standard mechanisms like e.g. IEEE1588 with or without SyncE, such that the timing accuracy at the UNI is fulfilled. The maximum timing errors at the UNI for different categories are shown in Table 2.

The figures for |TE| in Table 2 are the maximum timing error provided by the transport network relative to an absolute time reference (e.g. GNSS engine) in case of category C or relative between UNIs of a local cluster for categories A+, A and B. The underlying 3GPP requirements are defined as timing error between transmitter antenna ports (relative).

Table 2 Timing accuracy requirement

Category (note 1)	Time error requirements at UNI, |TE|			Typical applications and time alignment error (TAE) requirements at antenna ports of eREs (for information)	
	Case 1 (note 2)		Case 2 (note 3)	Typical applications	TAE
	Case 1.1 (note 4)	Case 1.2 (note 5)			
A+	N.A.	N.A.	20 ns (relative)	MIMO or TX diversity transmissions, at each carrier frequency	65 ns (note 6)
A	N.A.	60 ns (relative) (note 7)	70 ns (relative)	Intra-band contiguous carrier aggregation, with or without MIMO or TX diversity	130 ns (note 6)
B	100ns (relative) (note 7)	190 ns (relative) (note 7)	200 ns (relative)	Intra-band non-contiguous carrier aggregation, with or without MIMO or TX diversity, and Inter-band carrier aggregation, with or without MIMO or TX diversity	260 ns (note 6)
C (note 8)	1100 ns (absolute) (note 9)		1100 ns (absolute) (note 9)	3GPP LTE TDD	3 us (note 10)

Note 1) In most cases, the absolute time error requirements (Category C) are necessary in addition to the relative time error requirements (Category A+, A and B)

Note 2) Interface conditions for Case 1

- T-TSC is integrated in eRE, i.e. PTP termination is in eREs
- Refer to “deployment case 1” in Figure 7-1 of [10]

Note 3) Interface conditions for Case 2

- T-TSC is not integrated in eREs, i.e. PTP termination is in T-TSC at the edge of transport network
- The phase/time reference is delivered from the T-TSC to the co-located eREs via a phase/time synchronization distribution interface (e.g. 1PPS and ToD)
- Refer to “deployment case 2” in Figure 7-1 of [10]

Note 4) In this case the integrated T-TSC requirements are the same as standalone T-TSC Class B as defined in [11].

Note 5) In this case the enhanced integrated T-TSC requirements assume a total maximum absolute time error of 15 ns.

Note 6) TAE, section 6.5.3.1 of [7]

Note 7) Network access link delay asymmetry error is included

Note 8) The same requirements as "class 4" listed in Table 1 of [9]

Note 9) The same value as the network limits at the reference point C described in section 7.3 of [10]

Note 10) Cell phase synchronization requirement for wide area BS (TDD), Table 7.4.2-1, section 7.4.2 of [8], |TE| at the antenna ports shall be less than TAE/2

4.3. Phase noise and MTIE requirements

The following subsections define the phase noise/MTIE characteristics at the eRE UNI with a view to enable eRE synchronization by means of cost-optimized TCXOs/VCXOs.

These phase noise/MTIE requirements are applicable only to this specific use case and should not be understood as general transport network requirements.

4.3.1. Phase noise characteristic at UNI

For further study.

4.3.2. MTIE mask at UNI

For further study.

4.4. In-order delivery

During normal operation, the transport network shall provide guarantee of in-order delivery of the UNI service frames within the same EVC, with the same requested priority (or Class of service identifier) and for the same combination of VLAN classification, destination address, source address, and flow hash, if present (see clause 6.5.3, 8.6.6 in [6]). Only a negligible rate of reordering is permitted under exceptional circumstances, such as network reconfiguration (see Annex P in [6]).

5. Annex A: Service Agreement considerations

This is a non-exhaustive list of how an agreement between a Subscriber and a Provider on the attributes of a network service can be established:

- The Provider mandates a value for each attribute.
- The Subscriber selects from a set of options specified by the Provider.
- The Subscriber requests a value for each attribute, and the Provider indicates whether they can provide the service based on these attributes.
- The user and the Provider negotiate to reach a mutually acceptable value for all parameters.

An agreement can be established manually (e.g. on a piece of paper) or automatically, i.e. through API provided by the network Provider.

6. List of Abbreviations

3GPP	3rd Generation Partnership Project
CBR	Constant Bit Rate
CBS	Committed Burst Size
CE	Customer Edge
CIR	Committed Information Rate
CoS	Class of Service
CPRI	Common Public Radio Interface
EBS	Excess Burst Size
EIR	Excess Information Rate
eRE	eCPRI Radio Equipment
eREC	eCPRI Radio Equipment Control
EVC	Ethernet Virtual Connection
GNSS	Global Navigation Satellite System
GTBA	Generic Token Bucket Algorithm
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
LTE	Long Term Evolution
MAC	Media Access Control
MEF	Metro Ethernet Forum
MIMO	Multiple Input Multiple Output
MTIE	Maximum Time Interval Error
N/A	Not Applicable
PPS	Pulse Per Second
PRTC	Primary Reference Time Clock
QoS	Quality of Service
SLS	Service Level Specification
SyncE	Synchronous Ethernet
TAE	Time Alignment Error
TCXO	Temperature Compensated Crystal Oscillator
TDD	Time Division Duplex
ToD	Time of Day
T-TSC	Telecom Time Slave clock
UNI	User Network Interface
VCXO	Voltage Controlled Crystal Oscillator
VLAN	Virtual LAN

7. References

[1] eCPRI Specification V1.0, Tech. Rep. Aug. 2017, http://www.cpri.info/
[2] Technical Specification MEF 10.3 Ethernet Services Attributes Phase 3 October 2013
[3] IEEE Std 802.3™-2015 IEEE, New York, USA, 3 December 2015
[4] RFC 791- INTERNET PROTOCOL, September 1981
[5] RFC 2460 - Internet Protocol, Version 6 (IPv6) Specification, December 1998
[6] IEEE Std. 802.1Q™-2014 IEEE, New York, USA, 3 November 2014
[7] 3GPP TS36.104," E-UTRA; Base Station (BS) radio transmission and reception"
[8] 3GPP TS36.133, "E-UTRA; Requirements for support of radio resource management"
[9] ITU-T G.8271, "Time and phase synchronization aspects of packet networks", August 2017
[10] ITU-T G.8271.1, "Network limits for time synchronization in packet networks", August 2013
[11] ITU-T G.8273.2, "Timing characteristics of telecom boundary clocks and telecom time slave", January 2017
[12] Technical Specification MEF 41 Generic Token Bucket Algorithm October 2013

8. History

Version	Date	Description
D 0.1	2017-08-30	First Draft
V 1.0	2017-10-24	Summary of Section 2.4 updates: • The whole section is updated. • Section 2.4.1 is deleted. • Section 2.4.1.1 is deleted. • Section 2.4.1.2 is deleted. • Section 2.4.1.3 is deleted. Section 3 added Summary of Section 4 updates: Section 4.2: • Figure 4 is updated • Case 1 sub-cases are added :Case 1.1 and Case 1.2 • Note 9 associated to sub-case 1.1 is added • Note 10 associated to sub-case 1.2 is added • Note 3 editorial correction: (‘is” replaced by “are”) • Note 8 precising link assymetry assumption is added. • All TBD are replace by values or N.A. Section 4.3: • New section 4.3 “Phase noise and MTIE requirements” is added • “In-order delivery” is moved to 4.4 Summary of Section 6 updates: • MTIE added Summary of Section 7 updates: • New reference: [11] ITU-T G.8273.2], “Timing characteristics of telecom boundary clocks and telecom time slave [12] Technical Specification MEF 41 Generic Token Bucket Algorithm October 2013 Summary of Section 8 updates: • Section 2.4 updates are refered • Section 4.2 updates are refered • Section 4.3 “Phase noise and MTIE requirements” section insertion is refered and previous section 4.3 “In-Order delivery” move is refered.