5G Programmable Infrastructure Converging disaggregated network and compUte REsources

D7.1 Initial Standardization Activities document

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1.0	Final version, final review and submission to the EC	Salvatore Pontarelli (CNIT) Jesús Gutiérrez (IHP)	30/11/2018

Table of Contents

List of Figures

Executive Summary

The ambition of the 5G-PICTURE project is to contribute to the area of converged fronthaul (FH)/backhaul (BH) networks, where virtualisation and data plane programmability are key enablers. This document first explains the standardisation strategy of contributing in relevant standardisation bodies for both wired and wireless communication including e.g. IEEE, ETSI, Open Networking Foundation (ONF) and the ITU-T. Then, the most relevant standardisation activities matching activities in the project is described. As part of this, contributions from the project and project partners into the standardisation bodies are explained. A large range of standardisation activities are covered, ranging from Open Networking and Network Function Virtualization (NFV) to wireless and Time Sensitive Networking (TSN) activities.

1 Introduction

The ambition of 5G-PICTURE is to contribute to the area of converged FH/BH networks, where virtualisation and data plane programmability are key enablers. This is a very vast area in which many Standard Development Organisations (SDOs) are currently contributing.

Figure 1 is the result of an ETSI White Paper on future converged FH/BH transport networks, which has resulted from the collaboration of the 5G-PPP Phase-1 projects 5G-XHaul and 5G-CROSSHAUL. In this regard, ETSI identified the future converged FH/BH space to be enabled by five main pillars, namely: Software Defined Networking (SDN), Wireless transport, Optical networks, Next-Generation (NG) FH/BH focusing on functional splits and packet based FH, and finally NFV as an overarching management paradigm. Overlaid on Figure 1 we highlight with a red diamond the particular SDOs, along with the contributing partners, targeted by 5G-PICTURE. It is worth noting that 5G-PICTURE will address all the main pillars of the future converged FH/BH space.

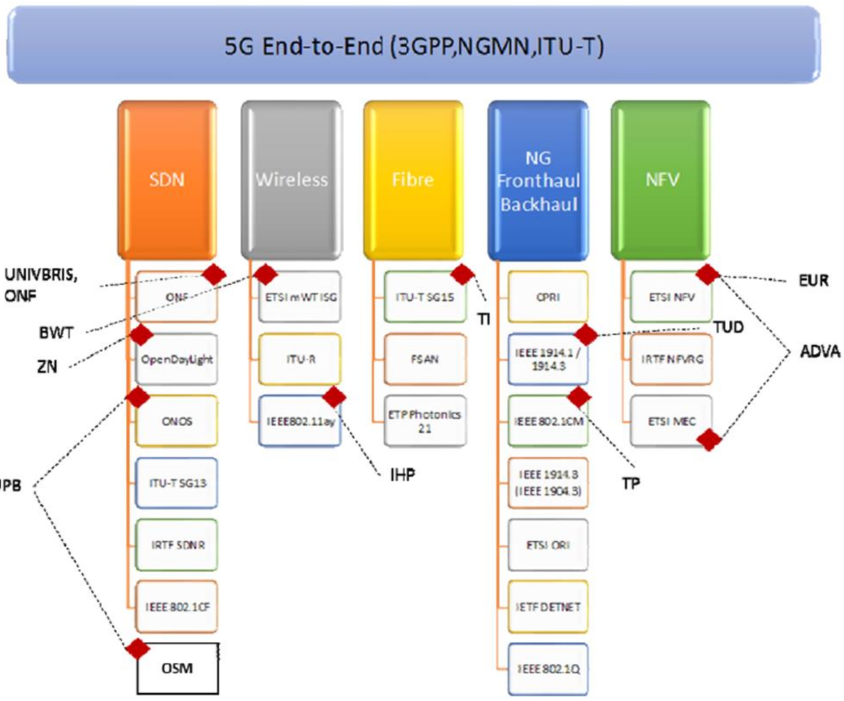

Figure 1: 5G-PICTURE planned contributions to standards.

For each pillar, the 5G-PICTURE consortium identified several thematically relevant standardisation bodies that various partners participate with the aim to influence upcoming standards and provide active contributions.

Since one of the key target of the project is to provide recommendations to improve Europe radio regulations in relation to millimeter wave (mmWave) wireless operation at 60 GHz and potentially at 70/80 GHz, some partners are actively contributing to the IEEE 802.11ay and IEEE 802.15 standards of the wireless domain.

For the optical networking activities some project partners are following SDOs belonging to both the SDN Open Networking Foundation (ONF) and the *fibre* (ITU-T SG15) pillars.

Regarding activities related to Ethernet, time-sensitive networking (TSN) enabling low and fixed latency is another important issue for the 5G-PICTURE infrastructure. The project is actively following the IEEE Ethernet standardisation on TSN in IEEE 802.1 and contribute with respect to mechanisms enabling low latency for scalable Ethernet infrastructures for 5G. Furthermore, there is a continuous and active participation in the standardisation activity of the IEEE 1914.1, NGFI.

2 Standardisation activities

The following subsections describe one by one the different standardisation bodies that are targeted by the 5G-PICTURE project.

2.1 SDN/core Standardisation Related Activities

2.1.1 ETSI's Open Source Mano (OSM) group

The University of Bristol (**UNIVBRIS-HPN**) contributes in the ETSI's Open Source Mano (OSM) group defining the WAN Infrastructure Manager in OSM which allows the end-user to create a network service by deploying VNFs over multiple datacentres attached to the OSM. In particular, University of Bristol is working on the feature 5945[1] (to be released with OSM Rel 5). Currently OSM assume the inter-dc connectivity to be pre provisioned when an end-user creates a network service spanning across multiple datacentres. This proposed solution allows OSM to provision the underlying network automatically when a user decides to deploy VNFs in a network service across multiple datacentres. UNIVBRIS has plans to extend the functionality to cover transport networks as well.

2.1.2 ONF

ONF was maintaining the OpenFlow (OF) protocol until its merging with ON.Lab. After this merging, the P4 Language Consortium (P4.org), creator of the P4 programming language, became a project of the ONF and became part of the Linux Foundation (LF) portfolio.

The current version of OpenFlow is 1.5.1. However, version 1.6 has been available since September 2016, but accessible only to ONF's members. As of now, despite the restricted availability in draft version of OF version 1.6, we cannot predict whether it will ultimately be finalised in the form of a public standard. Indeed, one reason for such a delay (and perhaps ultimate lack of finalisation) may reside in the growing interest of the ONF community towards P4 programming models and run time control of P4 programs (P4 runtime).

These choices can have a significant impact in the 5G scenario, since they could promote the adoption of highly configurable dataplanes, enabling the deployment of efficient and scalable VNFs. However, this also forced CNIT to change the initial standardisation activity plan, which included the support of NEC (one of the leaders of the ONF) to promote the adoption of some stateful primitives inside OpenFlow. As a consequence, CNIT decided to join the P4.org consortium.

2.1.3 P4.org consortium

CNIT joined the P4.org consortium in February 2018 in order to follow the evolution of the language for programmable dataplane. CNIT plans to promote inside the P4 consortium a set of stateful primitives that allows configuring the programmable dataplane that 5G-PICTURE is developing as one of the WP3 activities.

During the least period most of the effort of the P4 consortium was focused on the definition of seamless Application Programming Interface (API) to communicate between the control plane and the underlying programmable dataplane. This effort created the P4 Runtime specification[2]. P4 Runtime is a silicon-independent and protocol-independent API that can be autogenerated from an unambiguous definition of a packet processing pipeline in P4. P4 Runtime API can be used for local or remote control plane applications.

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[1] https://osm.etsi.org/gerrit/#/c/5945/4/Release5/Enable_dynamic_connectivity_setup_in_multi-site_Network_Services.md

[2] https://s3-us-west-2.amazonaws.com/p4runtime/docs/master/P4Runtime-Spec.pdf

2.1.4 Metro Ethernet Forum (MEF)

Zeetta (**ZN**) is participating in Metro Ethernet Forum (MEF) in the Network Slicing and Lifecycle service orchestration areas to work towards standardisation of network slicing and connectivity across different domains.

2.1.5 ETSI NFV

EURECOM (**EUR**) is the member of ETSI NFV and MEC, and previously several proof-of-concepts are given based on the OpenAirInterface (OAI)[3] and Mosaic5G (M5G)[4] platforms that are majorly developed by EURECOM. Also, EURECOM put efforts on monitoring the latest ETSI open source management and orchestration (OSM) code release.

In recent, the ETSI and the OAI Software Alliance (OSA) in association with EURECOM are planned to hold a Joint ETSI - OSA Event on open implementations and standardisation. In the first part of the event, EURECOM will provide the training on the 5G implementation on the general purpose processors (GPPs) using the OAI software stack and physical layer software. In the second part of the event, the joint workshop will bring the 5G standardisation and implementation communities together to reflect on the role of open implementations such as OAI in support of the development of standards. The event comes at a time when collaborative and open initiatives for wireless 5G are influencing how state-of-the-art wireless networks can be designed and implemented. This, in turn, is impacting the work of standards groups. Also in the event, several demonstrations of technologies will be showcased 4G and 5G features.

2.1.6 ETSI IP6 ISG IPv6 & IEEE 1918, Tactile Internet

Tactile Internet is envisioned to enable remote real-time access, control and manipulation by providing an ultra-low latency and ultra-reliable communication infrastructure. The ETSI IP6 ISG has completed the work item on IPv6-based Tactile Internet. It identifies the technical requirements and the best practices for different Tactile Internet use cases. The IEEE P1918.1 standards working group is engaged in standardizing various aspects of the Tactile Internet and its core activities can be broadly classified as: (i) definitions and use-cases, (ii) haptic codecs, and (iii) reference architectural framework. The IEEE P1918.1 reference architecture consists of tactile edges and a network domain. Tactile edges contain the tactile device, which can be actuators, sensors, or human system interface for haptic feedback. The network domain provides end-to-end connectivity between the tactile edges. Since the 5G-PICTURE project is developing a future-proof transport network, ETSI IP6 ISG and IEEE P1918.1 standardisation activities are being closely monitored to identify the transport network requirements to support Tactile Internet applications.

2.1.7 Broadband Forum (BBF)

HWDU contributed in BBF SD-406.The work is relevant to the investigation of the concept of network slicing with respect to the BBF architecture and transport network layer. Network slicing is considered as a fundamental enabler to migrate “one architecture fits all” to the logical “network per service”. Network slicing will enable value creation for vertical segments that lack physical network infrastructure, by offering network and cloud resources. In particular, this project had the following objectives that are aligned with the objectives of 5G-Picture: a) investigate business requirements for network slicing in the broadband architecture and transport network; b) Identify and analyse potentially technical enhancements relevant to network slicing with respect to the BBF MSBN; c) document and analyse the state of the art on network slicing considering other standardisation bodies including 3GPP SA2/SA5, ITU, MEF and IETF enabling collaboration via the means of liason activities.

This study explored network slicing customised to address specific business demands. With respect to the goals of 5G-PICTURE, BBF work brought an industry insight into the use case and business requirements of flexible function base station split considering slicing into the transport network considering support for

[3] http://www.openairinterface.org/

[4] http://mosaic-5g.io

Fronthaul/Midhaul/Backhaul types. The network slicing related orchestration and management operations are considered including instantiation, run-time and decommissioning taking into account dynamic and intelligent closed loop operations for service assurance as well as multi-domain support. We have brought certain industry aspects and experience into the design and development of a more disruptive 5G-OS proposed by the 5G-PICTURE project. In particular, based on the work delivered in BBF SD-406 the following input was provided to the design of the 5G-OS: identification of relevant business entities, identification of relevant network slicing new entities and/or functions and assess their architectural impact, identification of transport and routing related operations, e.g. flexibility, on-demand provision, QoS, etc. Furthermore, another relevant input focuses on mapping a slice request arriving from the mobile network to the underlying transport network considering data models for exposing the capabilities of the transport network and the means to provide the configuration and management of the underlying transport network resources.

2.2 Fibre Standardisation Related Activities

2.2.1 IEEE 1914.1 Next Generation Fronthaul Interface (NGFI)

The NGFI group is focused on fronthaul (FH) activities with two main activities:

1) Architecture for the transport of mobile FH traffic (e.g., Ethernet-based), including user data traffic, and management and control plane traffic.
2) Requirements and definitions for the FH networks, including data rates, timing and synchronisation, and quality of service. The standard also analyses functional partitioning schemes between Remote Radio Units (RRUs) and Base-Band Units (BBUs) that improve FH link efficiency and interoperability on the transport level, and that facilitate the realisation of cooperative radio functions, such as massive Multiple-Input-Multiple-Output (massive MIMO) operational modes, Coordinated Multi-Point (CoMP) transmission and reception.

Within activity 1), the Ethernet Time Sensitive Networking approach in 5G-PICTURE, enabling bounded and low latency, has been informed to the standardisation group. Within activity 2), the 5G-PICTURE work on "5G and Vertical Services, use cases and requirements" has been brought to the attention of the group.

2.2.2 IEEE 1914.3 Radio over Ethernet framing

The activity in 1914.3 has been followed, and the standardisation group has now an approved version of the 1914.3 standard defining how to frame CPRI into Ethernet frames.

2.2.3 IEEE 802.1, Time Sensitive Network Mechanisms for e.g. 5G fronthaul

2.2.3.1 Network slicing

This standardisation activity addresses mechanisms for achieving low and fixed latency in Ethernet. Also network slicing will be addressed within this activity. Network slicing may be hard or soft. While soft slicing allows statistical multiplexing and common resource pools to be shared, hard slicing relies on dedicated resources. How "hard" this hard slicing may be, i.e. if any interference between the slices can be allowed, is however not clearly defined. There is an on-going discussion within the standardisation group with respect to network slicing, the service providers and operators needs when deploying and operating their network and which mechanisms that may be suitable for hard slicing. Based on the requirements formulated in the 5G-PICTURE project, as well as the Ethernet mechanisms being studied in the project, input will be given to discussions within the network slicing topic.

2.2.3.2 Asynchronous mechanisms for bounded delay transmission in Ethernet networks

There is an ongoing work on a standard for Asynchronous Traffic Shaping, IEEE 802.1Qcr. Within 5G-PICTURE, mechanisms with the same purpose, achieving bounded delay in Ethernet networks without the use of a synchronisation mechanism, is explored. Based on TransPacket (**TP**) FUSION mechanisms, new approaches found beneficial will be communicated to the IEEE 802.1 standardisation group.

2.2.4 ITU-T SG15 Optical tech. and arch.

The integrated physical network infrastructure used in the 5G-PICTURE project is based on optical and radio technologies and components defined in WP3. With particular reference to the optical technologies, among the others, 5G-PICTURE WP3 is considering a passive optical solution based on Wavelength Division Multiplexing – Passive Optical Network (WDM-PON) that has been adopted by ITU-T SG15 in the standardisation of a bi-directional low-cost DWDM system suitable for access and metro application. This system has been specified in the Recommendation ITU-T G.698.4 (ex. G.Metro.), approved in March 2018, named "Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces". ITU-T G.698.4 provides optical parameter values for metro DWDM interfaces in a "Head End - Tail End" system architecture, where the remote transmitters can automatically adapt their DWDM channel frequency to the optical port of the passive filter they are connected to (saving OpEx), using a feedback mechanism based on a signal injected by the Head End Equipment. All the connections between the Head End Equipment, passive filters (Optical Mux/Demux and OADM) and the Tail End Equipment are bi-directionals, with both of the propagation directions sharing the same optical fibre (saving CapEx).

Even if 5G-PICTURE does not directly address the standardisation process of the ITU-T G698.4, we consider as a fundamental step to adopt standard solutions in order to make possible an easy and fast deployment of the solutions envisaged by the process. For this reason WP7 is going to continuously monitor SG15 (Q6) activities in order to avoid that the project outputs are far from what ITU-T has standardised, making them difficult to use in field.

2.3 Wireless Standardisation Related Activities

2.3.1 IEEE 802.11ay

IEEE 802.11ay is the successor to the IEEE 802.11ad standard for operation in the V-band (57-66 GHz). It supports channel bonding and Multiple-Input Multiple-Output (MIMO). There are also many changes in the MAC and PHY to enhance the performance for infrastructure applications. At the July 2018 plenary the draft 2 specification D2.0 was generated. The target date for final approval by the European Commission (EC) of IEEE 802 is November 2019.

The mmWave-related work developed by **IHP** will be proposed to the 802.11 working group as a candidate for 802.11ay.

2.3.2 IEEE 802.11 Next Generation V2X Study Group

At the interim meeting in Hawaii (September 2018) it was agreed to form the Project Authorisation Request (PAR) to support the optional inclusion of V-band IEEE 802.11-2016 technologies for V2X applications.

2.3.3 IEEE 802.15

This group works on Wireless Speciality Networks. They have recently formed an interest group on High-rate rail communications (IG hrrc). In the past they have presented papers on mmWave BH for trains (but not in the V-band favoured by 5G-PICTURE). See for example [1].

2.3.4 ETSI mWT ISG and CEPT SE19

In 2017, ETSI mWT ISG made recommendations to CEPT on the use of beamforming antennae in the V-band [2]. The document concluded that:

- It is possible to run a network with only one frequency channel.
- High density networks can be deployed at low interference level by using beamforming antennas and interference mitigation protocols (e.g. listen-before-talk (LBT)).
- Provided that systems have max EIRP = 40 dBm and a minimum antenna gain of 20 dBi (achievable with beamforming antennas).

This triggered CEPT SE19 [6] to start a new work item on regulation of the V-band – see following paragraph. In 2018, the mWT ISG has progressed its work on mmWave BH by publishing a white paper [3] and is working on a follow-up document ETSI GR mWT 012 [4]. This discusses many aspects of "Xhauling" including deployment aspects, performance requirements and functional splits considered in 3GPP and eCPRI.

The work on the performance of V-band BH using ray tracing was concluded in April 2018 [5]. This concluded that "The simulation results, reported in the present document, upon the Mesh network model for FWA, provide a positive feedback to deploy this outdoor application in V-Band." The Mesh network model for fixed wireless access (FWA) is that defined by IEEE 802.11ay using beam-steering devices. The report states that FWA links operating in V-Band can coexist well by using the same frequency channel (i.e. reuse-1) provided proper timing synchronisation, assignment of TX/RX roles and working transmit power control (TPC). Furthermore, outdoor coexistence studies between FWA and FS (fixed services – backhaul links using non-steerable dish antennae) applications are presented and collocated FWA links affect FS links in relatively small percent of cases (mostly below 10 %).

In August, CEPT SE19 finalised their submission to WG SE for approval and public consultation the draft ECC Report on the "Conditions for the coexistence between Fixed Service, Multi-gigabit wireless systems (MGWS) and other envisaged outdoor uses/applications in the 57-66 GHz range". This includes summaries of many simulation studies, including those performed by ETSI mWT ISG. The report suggests uncoordinated coexistence is possible given the maximum EIRP, given the antenna gain, meets one of the curves below in Figure 2. Note for typical patch phased-array antennae today (gain 20-30 dBi) the maximum EIRP is 40 dBm. This aligns with FCC regulation in the USA.

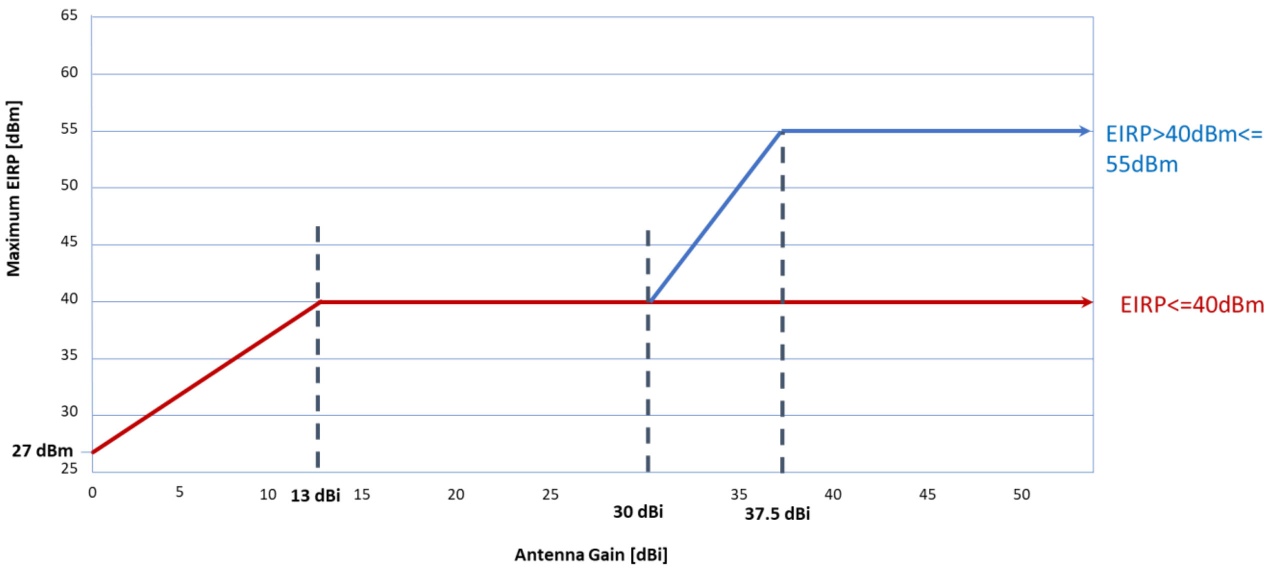

Figure 2: Maximum EIRP vs Antenna Gain characteristics – proposal from CEPT SE19 [6].

2.3.5 Telecom Infra Project

The Telecom Infra Project (TIP) is a collaborative telecom community. Launched in February 2016, TIP was started with the goal of accelerating the pace of innovation in the telecom industry [7].

BWT is tracking the mmWave Group, and attended the 2017 summit in Santa Clara. The mmWave Group is studying cost economics, validation, network planning, customer premises equipment (CPE), channel modelling and installation best practices. The use cases are fixed mobile access, mobile (broadband) backhaul and smart city applications. The group is led by Deutsche Telekom and Facebook.

Also **ZN** is participating in TIP in the network slicing and disaggregated optical networks area, contributing to Open Line Systems (OLS) and implementing OpenRoadm/OpenConfig based integration.

2.3.6 IEEE 802.11az, Efficient positioning methods for multi user dense scenarios

IHP will contribute to IEEE 802.11az Next Generation Positioning (NGP) working group meetings. The obtained solutions and results regarding positioning in 5G will be presented in this group. Depending on the interests of the members, these solutions can be added or motivate introduction and addition of similar solutions to the standard.

2.3.7 3GPP

3GPP has already released the important technical report (TR) and technical standardisation (TS) documents on the high-level functional split between DU and CU in TS38.401 (5G new radio) and TR36.756 (4G LTE). In that sense, EURECOM (**EUR**) carefully follows up-to-date 3GPP activities to implement necessary functional split in the OAI as majorly stated in the WP4 activities, i.e., F1AP interface as recently standardised by 3GPP in TS38.470/TS38.473 between CU and DU. To this end, 5G-PICTURE project can leverage the latest development by EURECOM to demonstrate different split to be applied in the disaggregated RAN deployment. Moreover, 3GPP also working on the low-level splits in TR38.816 and EURECOM also follow their latest document update to make sure the low-level split implementations of OAI (e.g., split option 8 and 7-1) is adoptable to the latest standardisation activities.

2.3.8 ORAN

Open radio access network (ORAN) alliance is formed early this year from xRAN forum and C-RAN alliance in order to provide a carrier-lead effort to derive openness to the radio access network. Based on some previous release standards by xRAN forum, EURECOM has monitored their activities on the FH interface definition. More specifically, their focus is on the low-level functional splits, i.e., between physical layer processing in the RAN protocol stack for control plane, user plan and synchronisation plane. To this end, EURECOM aims to follow their latest standardisation activities to by in-sync with the OAI implementation of RoE FH transportation and synchronisation approach. Last but not least, EURECOM also plans to leverage the developed FlexRAN5 as the control plan protocol for the OAI development.

[5] http://mosaic-5g.io/flexran/

3 Summary and Conclusions

This deliverable provides an overview of standardisation activities being addressed by the project. Main activities include open networking, NFV, tactile Internet, Next Generation Fronthaul Interface (NGNI), Time Sensitive Networking (TSN) and mmWave wireless communication. The project and the project partners' contributions in the relevant activities and bodies are explained. The results from the project are expected to give significant contributions in relevant standardisation bodies that will have long-term impact.

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[7] https://telecominfraproject.com/

5 Acronyms

Acronym	Description
BBF	Broadband Forum
BH	Backhaul
CPE	customer premises equipment
EC	European Commission
FWA	fixed wireless access
GPP	general purpose processor
LF	Linux Foundation
MEF	Metro Ethernet Forum
MGWS	Multi-gigabit wireless systems
NFV	Network Function Virtualisation
OAI	OpenAirInterface
OLS	Open Line Systems
ONF	Open Networking Foundation
ORAN	Open Radio Access Network
OSM	Open Source Mano
NGP	Next Generation Positioning
PON	Passive Optical Network
SDN	Software Defined Networking
SDO	Standard Development Organisation
TIF	Telecom Infra Project
TPC	transmit power control
TR	Technical Report
TS	Technical Standardisation
TSN	Time Sensitive Networking
WDM	Wavelength Division Multiplexing