

Standardisation for Smart Devices

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Final Report

Report Prepared for IEA 4E EDNA by Viegand Maagøe

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The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP), has been supporting governments to co-ordinate effective energy efficiency policies since 2008.

Fifteen countries have joined together under the 4E TCP platform to exchange technical and policy information focused on increasing the production and trade in efficient end-use equipment. However, the 4E TCP is more than a forum for sharing information: it pools resources and expertise on a wide range of projects designed to meet the policy needs of participating governments. Members of 4E find this an efficient use of scarce funds, which results in outcomes that are far more comprehensive and authoritative than can be achieved by individual jurisdictions.

The 4E TCP is established under the auspices of the International Energy Agency (IEA) as a functionally and legally autonomous body.

Current members of 4E TCP are: Australia, Austria, Canada, China, Denmark, the European Commission, France, Japan, Korea, Netherlands, New Zealand, Switzerland, Sweden, UK and USA.

Further information on the 4E TCP is available from: www.iea-4e.org



The EDNA Annex (Electronic Devices and Networks Annex) of the 4E TCP is focussed on a horizontal subset of energy using equipment and systems - those which are able to be connected via a communications network. The objective of EDNA is to provide technical analysis and policy guidance to members and other governments aimed at improving the energy efficiency of connected devices and the systems in which they operate.

EDNA is focussed on the energy consumption of network connected devices, on the increased energy consumption that results from devices becoming network connected, and on system energy efficiency: the optimal operation of systems of devices to save energy (aka intelligent efficiency) including providing other energy benefits such as demand response.

Further information on EDNA is available at: edna.iea-4e.org

This report was commissioned by the EDNA Annex of the 4E TCP. It was authored by Viegand Maagøe. The views, conclusions and recommendations are solely those of the authors and do not state or reflect those of EDNA, the 4E TCP or its member countries.

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The IEA, 4E, EDNA and the authors make no conclusions, endorsements or disendorsements in relation to the organisations and brands mentioned in this report.

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1 Executive summary

This report is meant to determine the most relevant Standards Developing Organisations (SDOs) currently working on EDNA areas of interest, and to identify and describe their standardisation efforts in those areas. EDNA areas of interest have been defined as standards for measuring and estimating energy consumption and energy efficiency and for communication protocols for the following product groups:

- Data centres
- Edge devices
- Networks and interconnecting equipment
- Batteries
- Smart Home and IoT

To this purpose, a broad number of SDOs were identified, from which the most relevant SDOs were selected, attending to geographical scope, membership and recent developments. This led to a group of 32 SDOs, whose working groups and technical committees working on the areas of interest were described, together with the main standards developed.

The working groups and technical committees that work on energy related aspects of the products and systems, as well as IoT and interoperability issues, have been identified as relevant, since those aspects are within the focus of EDNA. Besides, those SDOs that have been very active in the areas of interest in recent years are highlighted since this recent activity is an indicator of the organisation being involved in the current developments and innovations.

Apart from this study, EDNA will publish a report on communications protocols which overlaps with the findings of this work relating to networks, smart homes and IoT.

2 Introduction

The objective of this task defined by the RfP is to outline "lie of the land" (state of play) for standards and standardisation efforts (e.g. committees, working groups and their constitution/makeup) that relate to EDNA's work and that will allow EDNA to decide which of these it should engage with.

EDNA areas of interest have been defined as standards for measuring and estimating energy consumption and energy efficiency and for communication protocols for the following product groups:

- Data centres
- Edge devices
- Networks and interconnecting equipment
- Batteries
- Smart Home and IoT

The landscape of SDOs that currently work on these areas span multitude of organisations with different geographical scopes, and also subject matter scopes. This means that SDOs can be from generalist organisations as the European CEN or the Canadian CSA, to those as ETSI or The Green Grid whose focus area is very specific. Besides, they can be international, national or regional standards bodies or industrial associations and private companies, with different levels of openness regarding access to specifications and participation. This landscape is represented in Figure 2-1, where most of the SDOs shortlisted in the next section have been placed according to these parameters.



Figure 2-1: SDOs landscape

In the next chapters, we will explain the methodology applied to identify the relevant SDOs and standards in EDNA areas of interest, and describe the results attending to the different geographical coverage and scope of the SDOs and locating the working groups and technical committee focused on the areas.

3 Methodology

3.1 Identification of SDOs efforts

There are multitude of SDOs (Standards Developing Organisations) currently working on EDNA areas of interest, which have been defined as the following product groups:

- Data centres
- Edge devices
- Networks and interconnecting equipment
- Batteries
- Smart Home and IoT

related to standards for measuring and estimating energy consumption and energy efficiency and for communication protocols.

The methodology to identify the relevant SDOs efforts comprises the following steps:

1. Identification of a broad number of SDOs according to technical literature (SDOs longlist)
2. Selection of the most relevant SDOs according to technical literature, attending to geographical scope, membership and recent developments.
3. Identification of working groups and technical committees that work on the areas of interest mentioned above under the identified SDOs
4. Identification of main standards within the relevant working groups and technical committees identified

3.2 Criteria to identify relevant technical committees

EDNA work is heavily focused on the energy related aspects of the products and systems defined in the previous section, therefore one of the criteria is to identify technical committees, whose work should be followed more closely. These committees are marked with an **[E]** in the heading in the following.

IoT and interoperability issues are also a concern that is covered by several SDOs and their working groups. These committees are marked with an **[I]** in the heading.

Finally, some SDOs have been very active in the areas of interest in the last years, and keep producing relevant material, therefore, the level of recent activity is considered an indicator to identify relevant committees. These committees are marked with an **[R]** in the heading.

4 SDOs longlist

A long list of SDOs developing and setting standards, including national and international standards and industry bodies that are active within the areas relevant to EDNA identified in the literature search is presented in Table 1. The nature of the organisations listed in Table 1 are very diverse, some setting standards for technical specifications for communication protocols, while others are for measuring and calculating energy consumption and energy efficiency metrics and analyse and compare various standards.

Table 1: List of SDOs in alphabetical order¹

# - C	D - I	J - O	P - Z
3G Association 3GPP ABNT AFNOR AIOTI² [I, R] ANSI ARIB ASN.1 Consortium ASHRAE [I, R] ATIS [E, I, R] ATM Forum ATSC AVS BICSI Bluetooth Broadband Forum BSI Cablelabs [I] CalConnect CCSA CEA CEF CEN [E, I, R] CENELEC [E, I, R] CEPCA CCSA [E, I, R] CSA [E, R]	DIN DMTF DS DSL Forum DoE ECMA International [E, I] EEBus [I] Emerge Alliance ETIS ETSI [E, I, R] FIDO GHG PI GSM Association HL7 Home Gateway Initiative IEC [E, I, R] IEEE [I] IFTTT IHE IMTC INATBA INCITS IP/MPLS Forum IPDR Organization IPsphere Forum IPv6 Forum ITU [E, I, R] ISO ISOC/IETF [I, R]	JCP JCTEA JDCC JEDEC JEITA JISC JLabs Kantara Initiative KNX Association cvba [I] MACCSA MEF MMTA MSF NFC NIST NRO OASIS [I] OGC OIDF OIF OIPF OMA OMG OpenADR Alliance [I]	PRIME Alliance SAC SAE SCTE SDL Forum Society SMPTE SNIA The Green Grid [E, R] TIA [I] TM Forum TSDSI TTA [E, I, R] TTC ULE UNICODE UPA USB-IF W3C [I, R] Z-wave [I] Zerde ZigBee Alliance (The Connectivity Standards Alliance) [I, R]

Note: **[E]** = energy related aspects of products and systems. **[I]** = IoT and interoperability issues. **[R]** = recent activity in the EDNA areas of interest.

Some of the SDOs in the longlist are marked according to the criteria set to identify relevant work. Complementing this list, Figure 4-1 shows the group of SDOs working on energy related aspects of products and systems (green circle [E]) and those working on IoT and interoperability issues (blue circle [I]). The intersection gathers SDOs with working groups in both fields. The ones with recent activity are indicated in red font.

¹ <https://www.itu.int/en/ITU-T/extcoop/Pages/sdo.aspx> and: Anson Wu, Paul Ryan and Terence Smith, "Intelligent Efficiency for Data Centres & Wide Area Networks", May 2019, EDNA report.

² The Alliance for Internet of Things Innovation
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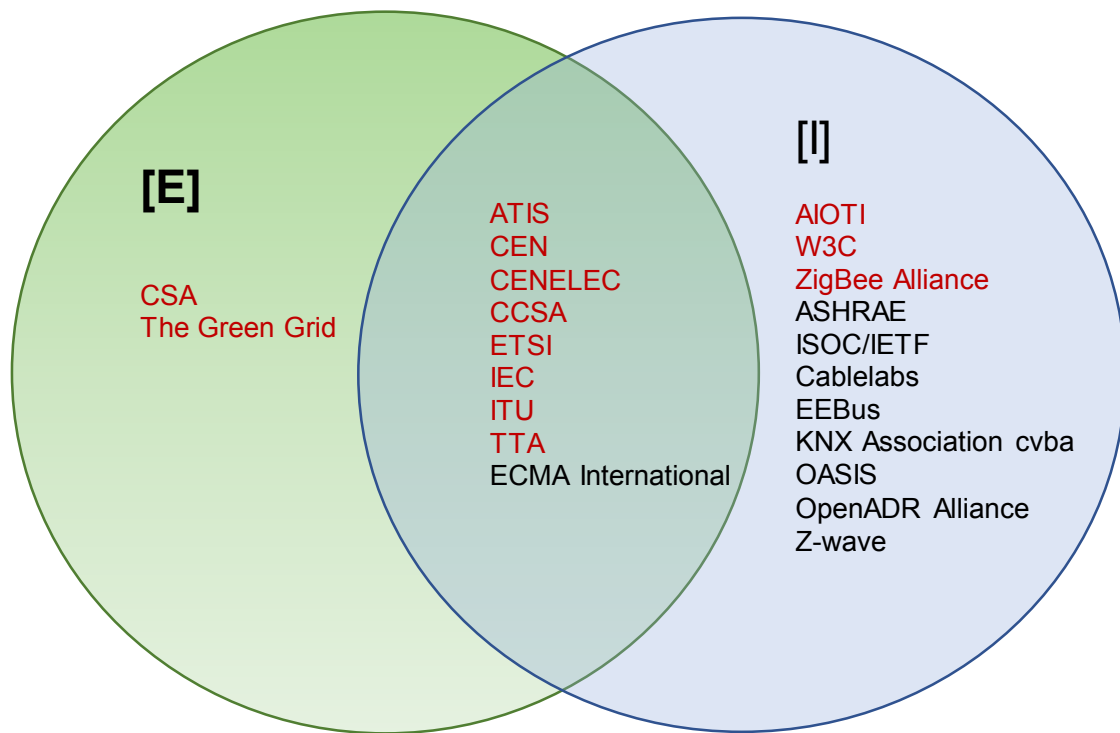


Figure 4-1: SDOs grouped according to criteria for relevant standardisation work and recent activity

5 SDOs shortlist and their working groups or technical committees

This section presents a shortlist of the most relevant SDOs and their working groups or technical committees based on our assessments.

5.1 3GPP³

5.1.1 Description

The 3rd Generation Partnership Project (3GPP) unites seven telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC). The project covers cellular telecommunications technologies, including radio access, core network and service capabilities, which provide a complete system description for mobile telecommunications. The 3GPP specifications also provide hooks for non-radio access to the core network, and for interworking with non-3GPP networks.

The original scope of 3GPP (1998) was to produce Technical Specifications and Technical Reports for a 3G Mobile System based on evolved GSM core networks and the radio access technologies that they support (i.e., Universal Terrestrial Radio Access (UTRA) both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes).

The scope was expanded to include the maintenance and development of the Technical Specifications and Technical Reports for evolved 3GPP technologies, beyond 3G.

5.1.2 Working groups or technical committees

5.1.2.1 TSG CT Core Network & Terminals

The TSG Core Network and Terminals (TSG CT) is responsible for specifying terminal interfaces (logical and physical), terminal capabilities (such as execution environments) and the Core network part of 3GPP systems.

More specifically: User Equipment - Core network layer 3 radio protocols (Call Control, Session Management, Mobility Management), signalling between the core network nodes, interconnection with external networks, O&M requirements, GPRS between network entities, Transcoder Free Operation, CAMEL, Generic User Profile, Wireless LAN - UMTS interworking and descriptions of IP Multimedia Subsystem, SIP Call Control, SDP protocols for the IM subsystem, mapping of QoS and the interfaces specific to the UMTS Open Service Access (OSA).

5.2 AIOTI⁴

5.2.1 Description

The Alliance for Internet of Things Innovation (AIOTI) was created in 2015 to promote interoperability and convergence between standards, to facilitate policy debates and to prepare a European Commission's initiative for large scale testing and experimentation, which will be funded under the Digital Europe Programme⁵. AIOTI has meanwhile been transformed and set up as a stand-alone organisation. Forging new alliances between IoT sectors, stakeholders, large companies, SMEs and start-ups help Europe get a global lead in this field and will foster a digital single market for IoT.

³ <https://www.3gpp.org/>

⁴ <https://aioti.eu/>

⁵ <https://digital-strategy.ec.europa.eu/en/faqs/testing-and-experimentation-facilities-tefs-questions-and-answers>

Among AIOTI's European largest technical and digital companies are: Alcatel, Bosch, Cisco, Hildebrand, IBM, Intel, Landis+Gyr, Nokia, ON Semiconductor, Orange, OSRAM, Philips, Samsung, Schneider Electric, Siemens, NXP Semiconductors, STMicroelectronics, Telecom Italia, Telefonica, Telit, Vodafone, Volvo, and start-ups (SIGFOX) etc.

Representatives of different industries: nanoelectronics/semiconductor companies, telecom companies, network operators, platform providers (IoT/Cloud), security, service providers, sectors: energy, utilities, automotive, mobility, lighting, buildings, manufacturing, healthcare, supply chains, cities etc.

5.2.2 Working groups or technical committees

5.2.2.1 AIOTI Working group 3 [I, R]

AIOTI Working group 3 focuses on standardization, in particular:

- Maintaining an IoT & Edge Computing standards framework landscape
- Consolidation of architectural frameworks, reference, architectures, and architectural styles in the IoT & Edge Computing space
- HLA / High Level Architecture
- IoT identifiers,
- IoT relation and impact on 5G and Beyond 5G
- (Semantic) Interoperability
- Personal data protection/privacy to the various categories of stakeholders, in the IoT & Edge Computing space (with WG Policy & Strategies)
- IoT & Edge Computing Security (with WG04 Policy & Strategies)

5.3 ARIB (Japan)⁶

5.3.1 Description

The Association of Radio Industries and Businesses (ARIB) was established to promote research and development (R&D) of new radio systems, and to serve as a Standards Development Organization (SDO) for unification of international standards and related activities in the telecommunications and broadcasting fields. The establishment was also aimed at providing quick and accurate responses to such trends as the growing internationalization, the convergence of telecommunications and broadcasting, and the need to promote radio wave use in business.

5.4 ASHRAE⁷

5.4.1 Description

ASHRAE is a global society focussed on building systems, energy efficiency, indoor air quality, refrigeration and sustainability within the industry. It develops research, standards writing, publishing and continuing education. ASHRAE was formed as the American Society of Heating, Refrigerating and Air-Conditioning Engineers by the merger in 1959 of American Society of Heating and Air-Conditioning Engineers (ASHAE) founded in 1894 and The American Society of Refrigerating Engineers (ASRE) founded in 1904.

⁶ <https://www.arib.or.jp/english/>

⁷ <https://www.ashrae.org/about>

5.5 ATIS (US)⁸

5.5.1 Description

The Alliance for Telecommunications Industry Solutions (ATIS) develops technical and operational standards and solutions for the ICT industry. The organization is accredited by the American National Standards Institute (ANSI). It is the North American Organizational Partner for the 3rd Generation Partnership Project (3GPP), a founding Partner of the oneM2M global initiative, a member of and major U.S. contributor to the International Telecommunication Union (ITU), as well as a member of the Inter-American Telecommunication Commission (CITEL).

ATIS has 150 member companies, including various telecommunications service providers, equipment manufacturers, and vendors.

5.5.2 Working groups or technical committees

5.5.2.1 STEP: Sustainability in Telecom: Energy and Protection Committee [E]

STEP helps reduce information and communications technologies' environmental impact as well as operators' energy costs and addresses industry power and protection issues by delivering industry-developed solutions. STEP deliverables are enabling vendors, operators and their customers to deploy and operate more reliable, environmentally sustainable, and energy efficient communications technologies.

5.5.2.2 WTSC: Wireless Technologies and Systems Committee

WTSC develops wireless radio access, system, and network solutions related to wireless and/or mobile services and systems. WTSC develops and continues to enhance solutions necessary to support a U.S. public warning system and wireless emergency alert system. ATIS is the 3GPP North American partner, and WTSC provides critical technical review and input for necessary contributions.

5.5.2.3 TMOC: Telecom Management and Operations Committee

TMOC develops operations, administration, maintenance and provisioning standards as well as other critical documentation related to Operations Support System (OSS) and Network Element (NE) functions and interfaces for communications networks.

5.6 BICSI (US)⁹

5.6.1 Description

BICSI is a professional association supporting the advancement of the information and communications technology (ICT) profession and currently serves more than 26,000 members and credential holders. BICSI membership spans nearly 100 countries, and it is recognized by the American National Standards Institute (ANSI).

⁸ <https://www.atis.org/standards-and-specifications/>

⁹ <https://www.bicsi.org/>

5.6.2 Working groups or technical committees

5.6.2.1 Data centres

Activities within this topic include the development and maintenance of standards related to the design, implementation, assessment and operations of data centres. These standards encompass computer rooms, computer centres and web hosting centres and may include additional information and systems applicable to other aspects of data centres, including building, mechanical and electrical infrastructure and other building systems used within the data centre environment.

5.6.2.2 Building systems

Building systems topic encompasses the numerous systems within a building that utilize network and data systems. These systems are often used within IP-enabled solutions, smart or intelligent buildings, and IoT applications.

5.6.2.3 Wireless systems

As ICT infrastructure support wireless and radio connectivity, standards and related materials are developed related to the design, implementation, and installation of the applicable infrastructure. Regulatory, code and related standards applicable to radio and wireless systems are also monitored, with relevant changes reported as needed.

5.7 Bluetooth¹⁰ [I]

The Bluetooth SIG is a global community of over 36,000 companies serving to unify, harmonize and drive innovation in the vast range of connected devices.

The Bluetooth® Core Specification defines the technology building blocks that developers use to create the interoperable devices that make up the thriving Bluetooth ecosystem. The Bluetooth specification is overseen by the Bluetooth Special Interest Group (SIG) and is regularly updated and enhanced by Bluetooth SIG Working Groups to meet evolving technology and market needs.

5.8 CEN – CENELEC (EU)¹¹

5.8.1 Description

The European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (CENELEC) are two distinct private international non-profit organizations.

A variety of stakeholders are involved in CEN and CENELEC work, amongst others business, industry and commerce, service providers, public authorities, regulators, academia and research centres, European trade associations and interest groups representing environmentalists, consumers, trade unions as well as small and medium enterprises, and other public and private institutions.

They provide European Standards and related products and to support European competitiveness, the protection of the environment and sustainable growth for the well-being of citizens and the strengthening of the single market (European Economic Area). They also produce harmonised standards at the request from the European Commission. Manufacturers, other economic operators, or conformity assessment bodies can use harmonised standards to demonstrate that products, services, or processes comply with relevant EU legislation.

¹⁰ <https://www.bluetooth.com/specifications/bluetooth-core-specification/>

¹¹ <https://www.cencenelec.eu/>

They actively support international standardisation, and cooperate closely with the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC), in order to pursue the goal of 'one standard, one test, accepted everywhere'.

5.8.2 Working groups or technical committees

5.8.2.1 CEN-CLC/BTWG 6 'ICT standardization policy'

The objective of CEN-CLC/BTWG 6 is to deal with matters relating to ICT standardization, anticipating and keeping track of relevant strategic issues and providing advice and recommendations to the CEN and CENELEC Technical Boards in this area. BTWG 6 also mirrors the activities of the European Commission's Multi-Stakeholder Platform (MSP) on ICT standardization, which is notably responsible for the development and maintenance of the Rolling Plan on ICT standardization.

5.8.2.2 CEN/CENELEC/ETSI Coordination Group on Green Data Centres [E, R]

In 2010 CENELEC BT/WG 132-3 made the recommendation to establish a joint European coordination group with the task to manage and coordinate European activities and standardization works related to data centres energy efficiency.

The CEN/CENELEC/ETSI Coordination Group on Green Data Centres (CEN/CLC/ETSI CG GDC) is a joint activity of the three ESOs which comprises representatives of the ESOs together with stakeholders of industry and EU projects. The Coordination Group has developed and maintains two documents:

- The Review of standardization activities Energy Management and Environmental Viability of Data Centres summarizes the current standardisation landscape and references the relevant standards, both published and in preparation, in relation to data centres energy management within three ESOs. This publication is mainly targeted to management executives of data centre industries, data centre operators and data centre planners.
- The Standardisation landscape for the energy management and environmental viability of data centres is an in-depth analysis of standardisation activities relevant for data centre design and operation, as well as systems and products installed in data centres. This publication is recommended to those readers who want to get a more detailed insight into current standardization projects both within the three ESOs, both also reaching out to related international activities in ISO/IEC and ITU.

5.8.2.3 CLC/TC 215 Electrotechnical aspects of telecommunication equipment [E, R]

CLC/TC 215 works on the following topics:

- To address standardisation in the field of electrotechnical aspects of telecommunication equipment and associated infrastructures and liaise with other standardization bodies as appropriate.
- To prepare harmonised standards (EN, TS or TR) covering all aspects of generic and application-specific telecommunications cabling (e.g. ISDN, LAN and others) within all types of premises. These documents also cover the requirements and recommendations for building infrastructures related to the effective installation and operation of associated telecommunication equipment by reference to the existing or forthcoming standards provided by the relevant committees or using technical inputs from them.
- To provide contributions to ETSI standards (EN and/or other deliverables) in areas related to those detailed above. - To serve as a mediator in those cases where in accordance with the CENELEC-ETSI-Agreement ETSI indicates to CENELEC the need of standardization activities (EN/TS/TR or contributions to ETSI deliverables) of electrotechnical aspects related to its work.
- Identification of the appropriate TC within CENELEC, thereby providing proper assignment of the technical work to the responsible group of experts.

- Where an appropriate TC within CENELEC cannot be identified, TC 215 may decide to establish a Working Group to resolve a specific task.
- To review international standardisation results of ISO/IEC JTC 1 as far as telecommunication equipment with respect to Customer Premises Cabling and Energy Efficient Data Centres are concerned. This includes co-ordination of harmonization and assignment to the responsible organisation in close cooperation with CEN bearing in mind JTC 1 being a joint ISO/IEC-Committee.

5.8.2.4 CEN/CLC/ETSI/CG-SG CEN-CENELEC-ETSI Coordination Group on Smart Grids (CG-SG) (E, I)

The CG-SG advises on European standardization requirements relating to smart electrical grid and multi-commodity smart metering standardization, including interactions between commodity systems (e.g. electricity, gas, heat, water), and assesses ways to address them. This includes interactions with end-users, including consumers/prosumers.

Its aim is to promote the deployment of open and interoperable data architectures, based on European and international standards. The scope also includes any standards needed to design, operate and maintain electrical grids securely and efficiently. In the specific area of metering, its scope includes electricity, water, gas and heat/cooling metering devices and systems, and associated architectures.

Within its scope the Group will address the European requirements resulting from the Clean Energy Package, including secondary legislation, and any other relevant Commission initiatives.

The CG-SG shall also receive inputs from and provide input to the European Commission's activities related to standardization in the field of smart grids and meters.

With respect to international standardization activities on smart grids and meters, the Group shall monitor the progress of the relevant standardization activities in ISO, IEC and ITU, and promote coordination between the European activities and those at the international level and promote when needed the consideration of European requirements within international standardization.

The Group shall not develop standardization deliverables (e.g. European Standards, Technical Specifications, Technical Reports), but may develop informative material intended for the public domain after approval by the CEN and CENELEC Technical Boards (BTs) and ETSI Board.

5.8.2.5 CLC/TC 59X Performance of household and similar electrical appliances [E]

CLC/TC 59X prepares European Standards on methods of measurement of characteristics which are of importance to determine the performance of electrical appliances for household use or of electrical appliances for commercial use and that are of interest for the user. This may include associated aspects related to the use of the appliances and aspects such as the classification, accessibility and usability of appliances, ergonomic characteristics and conditions for the information provided at the point of sale. The standards are developed in order to suit the needs of EU Regulations and Directives and in the context of the European market.

5.8.2.6 CLC/TC 100X - Audio, video and multimedia systems and equipment and related sub-systems [E]

CLC/TC 100X monitors the adoption in CENELEC of the technical work from IEC/TC 100 standards in the field of audio, video and multimedia systems and equipment. These standards include specification of the performance, methods of measurement for consumer and professional equipment and their system application as well as interoperability with other systems and equipment. CLC/TC 100X ensures that any deviation from the IEC standards, such as common modifications, special national conditions and A-deviations, is only in response to a clear and justifiable European need, such as European and national legislative requirements.

In the next years, the TC will work towards mandates regarding Environmental aspects at Mandate M/451 Power consumption measurement and Mandate M/477 TV and Set top Box energy efficiency. Measurement methods for power consumption and energy efficiency are essential to define and improve the status quo, also for audio, video and

multimedia systems and equipment, related sub-systems and of networked multimedia equipment. In networked environments system interfaces and management protocols need to support settings which allow energy efficient multimedia service delivery. To this end TC 100X Focus Area 1 will consider how energy efficiency will impact the AV and multimedia systems and equipment.

5.8.2.7 CLC/TC 205 Home and Building Electronic Systems (HBES) [I, R]

CLC/TC 205 prepares standards for all aspects of home and building electronic systems in relation to the Information Society. In more detail: To prepare standards to ensure integration of a wide spectrum of control applications and the control and management aspects of other applications in and around homes and buildings, including the gateways to different transmission media and public networks taking into account all matters of EMC and electrical and functional safety. TC 205 will not prepare device standards but the necessary performance requirements and necessary hardware and software interfaces. The standards should specify conformity tests. TC 205 will perform the work in close co-operation with relevant CENELEC TCs and those in CEN and ETSI.

TC 205 aims to enable a horizontal model for applications and services creating a set of recommendations that covers issues such as

- Interoperability
- Data privacy
- IoT
- Artificial intelligence
- Cybersecurity

TC205 is in contact with ETSI Smart M2M committee, which is hosting SAREF.

5.8.2.8 CLC/TC 21X Secondary cells and batteries

CLC/TC 21X works on the following topics activities for secondary cells and batteries:

- to implement IEC/TC 21/SC 21A documents into CENELEC standards;
- to prepare Product Standards, general requirements and methods of testing included;
- to prepare Safety Standards and associated Codes of Practice;
- to consider Environmental Requirements (EC Rules) for the products.

5.9 CCSA (China)¹²

5.9.1 Description

China Communication Standardisation Association (CCSA) carries out standardisation activities in the field of information and communication technology in China.

¹² <http://www.ccsa.org.cn/english/>

5.9.2 Working groups or technical committees

5.9.2.1 TC1: Internet and Application Technical Committee [E]

TC1 is in charge of Internet infrastructure and generic technology of application, data centre, cloud computing, big data, blockchain, artificial intelligence and various applications

5.9.2.2 TC3: Network and Service Capability Technical Committee

TC3 is in charge of Information and communication network (including core network, IP network) overall requirements, architecture, functions, performance, service capabilities, equipment, protocols and related SDN/NFV and other new network technologies

5.9.2.3 TC4: Communication Power Supply and Communication Station Working Environment Technical Committee

Power supply of communication equipment, power supply of communication station, working environment of communication station

5.9.2.4 TC5: Wireless communication Technical Committee

TC5 is in charge of Mobile communication, wireless access, wireless local area network and short range, satellite and microwave, trunking communication and other wireless communication technology and network, wireless network supporting equipment and wireless security standards development, wireless spectrum, wireless new technology research

5.9.2.5 TC6: Transmission Network and Access Network Technical Committee

TC6 is in charge of Transmission networks, systems and equipment, access networks, transmission media and devices, television and multimedia digital signal transmission, etc

5.9.2.6 TC10 : The Internet of Things Technical Committee [I, R]

For IoT-related technologies, several project teams are formed to carry out targeted standard research according to the IoT-related services carried out by telecom operators, the technical solutions proposed by research institutes and production enterprises, and the application examples for specific industries.

5.10 CableLabs¹³ [I]

CableLabs is a private company that has developed sets of publicly available interface specifications to facilitate interoperability of cable devices, including cable modems, set-top boxes, digital televisions, and various telephony devices.

5.11 EEBus¹⁴

5.11.1 Description

The EEBUS Initiative e.V. with its member companies and associations is developing a common language for energy in the Internet of Things. This open, standardised networking specification allows manufacturer-independent communication between smart energy consumers, regenerative generation plants, energy managers and the Smart Grid.

¹³ <https://www.cablelabs.com/>

¹⁴ <https://www.eebus.org/about-us/>

5.12 The Green Grid¹⁵ [E, R]

The Green Grid is an affiliate membership level of the Information Technology Industry Council (ITI), an association that works to advance public policies for the tech sector. ITI's Green Grid works to improve IT and data centre energy efficiency and ecodesign around the world. It is an open industry consortium of information and communications technology (ICT) industry end-users, policymakers, technology providers, facility architects, and utility companies.

The Green Grid was founded in 2007 focusing on energy efficiency of data centres as one of the most significant issues facing technology providers and their customers, due to increases in power and cooling costs over the past few years, and the mismatch between the demand for concentrated computing and the availability of clean reliable power in many places.

In 2019 it was acquired as an affiliate member of the Information Technology Industry Council (ITI), which is a premier trade association that works to advance public policies for the tech sector. At the moment of writing this study, it was composed by the following members:

Executive Leadership Council

- AMD
- HP
- IBM
- Intel
- NetApp
- Nvidia

Contributor members

- Cisco
- CPC
- Coolit Systems
- Dell
- Google
- Microsoft
- Stulz

5.13 The Connectivity Standards Alliance¹⁶ [I, R]

The Connectivity Standards Alliance, formerly the Zigbee Alliance, was established in 2002, and it is meant to create and evolve universal open standards for the products. The Connectivity Standards Alliance board of directors is comprised of executives from Amazon, Apple, ASSA ABLOY, Comcast, Google, Huawei, IKEA, The Kroger Co., LEEDARSON, Legrand, Lutron Electronics, NXP Semiconductors, Resideo, Schneider Electric, Signify (formerly Philips Lighting), Silicon Labs, SmartThings, Somfy, STMicroelectronics, Texas Instruments, Tuya, and Wulian.

Zigbee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection. Hence, Zigbee is a low-power, low data rate, and close proximity (i.e., personal area) wireless ad hoc network.

¹⁵ <https://www.thegreengrid.org/>

¹⁶ <https://csa-iot.org/>

5.14 CSA Group (Canada)¹⁷

5.14.1 Description

CSA Group is a global organization dedicated to safety, social good and sustainability. They work on Standards Development and in Testing, Inspection and Certification in Canada, the U.S., Europe and Asia.

5.14.2 Working groups or technical committees

5.14.2.1 Electrical area [E, R]

They work on more than 700 standards, many referenced in regulation, includes standards for Energy Efficiency, Renewable Energy and the Canadian Electrical Code Parts I, II and III. These are critical resources that guide electrical safety and performance for the systems and products.

5.14.2.2 ICT area

ICT portfolio of over 1,000 standards covers the more traditional subject areas such as programming languages, software & systems engineering, and data management as well as the more current subjects of cybersecurity, privacy, and cloud computing.

They develop system-based solutions across a variety of important functional domains:

- Standardizing artificial intelligence techniques opens the door to solutions in trustworthiness, internet of things and big data;
- Tackling the world of distributed ledger technologies highlights the need for secure communication techniques that modern cryptography protocols offer; and
- Developing standards and codes for intelligent buildings

5.15 ECMA International¹⁸

5.15.1 Description

ECMA International is an industry association dedicated to the standardization of information and communication systems. The organization was founded in 1961 to standardize computer systems in Europe. Membership is open to large and small companies worldwide that produce, market, or develop computer or communication systems, and have interest and experience in the areas addressed by the group's technical bodies. It is located in Geneva.

ECMA aims to develop standards and technical reports to facilitate and standardize the use of information communication technology and consumer electronics; encourage the correct use of standards by influencing the environment in which they are applied; and publish these standards and reports in electronic and printed form. ECMA publications, including standards, can be freely copied by all interested parties without copyright restrictions. The development of standards and technical reports is done in co-operation with the appropriate national, European, and international organizations.

¹⁷ <https://www.csagroup.org/>

¹⁸ <https://www.ecma-international.org/>

5.15.2 Working groups or technical committees

5.15.2.1 TC38 Product-related environmental attributes [E]

Its scope is to identify and describe the environmental attributes related to ICT (Information and Communication Technology) and CE (Consumer Electronics) products, during their entire life cycle, from conception to end-of-life treatment.

Programme of work:

- To develop recommendations, e.g. standards, on environmental attributes and the presentation thereof for ICT and CE products.
- To monitor the development of environmental standards, regulations, conformity schemes and other requirements related to ICT and CE products.
- To promote and maintain ECMA Standards covering product-related environmental attributes. To comment on standards and regulations from outside organizations.
- To establish and maintain close liaison with other organizations and other fora working in the same or similar fields of activity.

5.15.2.2 TC51 Access systems and information exchange between systems [I]

Access System specifies a common language, architecture, interfaces and protocols for the interoperability between different (distributed) sub-systems for access to assets. Such assets may be physical such as buildings, transport means, care centres, computers or digitised assets and services e.g. health care.

The Access System specification describes a framework for existing and new systems that provide access to specific assets.

Development of standards that enable close proximity communications such as, but not limited to, Near Field Communication Systems (NFC).

Programme of work:

- To develop and maintain Standards and Technical Reports for interoperability between different sub-systems for access systems.
- To monitor related standardization activities to avoid duplication, to promote synergies and to promote complementary efforts via internal and external liaisons with – and contribute to – the work of international SDOs.

5.16 ETSI (EU)¹⁹

5.16.1 Description

ETSI is a European Standards Organization (ESO) dealing with telecommunications, broadcasting and other electronic communications networks and services. This includes supporting European regulations and legislation through the creation of Harmonised European Standards. Only standards developed by the three ESOs (CEN, CENELEC and ETSI) are recognized as European Standards (ENs).

¹⁹ <https://www.etsi.org/>

5.16.2 Working groups or technical committees

5.16.2.1 ATTM Access, Terminals, Transmission and Multiplexing [E, R]

It is responsible for the standardization of access, terminals, transmission and multiplexing. This includes cabling, radio links, installations, signal transmission and other forms of signal treatment up to digitalization, in the private and public domains, focusing on the specific technology, equipment, installations and regulatory aspects of the physical layer.

It develops tools for ICT users to monitor deployment of sustainable smart cities and the sustainable efficiency, including eco-efficiency and energy management, of their sites and networks. This also offers the means of implementing the most efficient broadband systems and physical networks.

5.16.2.2 CABLE: Integrated broadband cable and television networks (E)

It is responsible for the creation, development and maintenance of standards and other ETSI deliverables related to integrated broadband cable telecommunication network technologies including:

- network terminals e.g. cable CPE devices and network terminating devices,
- network infrastructure, including network topologies, HFC (hybrid fibre-coax) network distribution, data over cable systems, and frequency management,
- services delivered across integrated broadband cable telecommunication networks,
- energy efficiency and sustainability for integrated broadband cable telecommunication networks,
- security of integrated broadband cable telecommunication networks and services.

5.16.2.3 NTECH: Network Technologies

It is the ETSI competence centre on network technologies in current and future networks, with special focus on network interconnection. This includes maintaining and evolving the specifications of the architectures and protocols deployed in fixed networks or used in support of network interconnection, as well as monitoring relevant work on future networks technologies performed outside ETSI and provide guidelines on their applicability to ETSI compliant networks. The committee is also the ETSI's technical contact point for CEPT/ECC WG NaN (Numbering and Networks).

5.16.2.4 MSG: Mobile Standards Group (MSG)

It is responsible for the identification of European regulatory requirements for cellular systems developed by the Third Generation Partnership Project (3GPP™), and for developing Harmonised Standards and related ETSI standards for GSM™, International Mobile Telecommunications (IMT) systems for cellular and technologies evolving from them (including IMT Advanced but excluding Digital Enhanced Cordless Telecommunications (DECT™)).

It provides the regulatory standards needed to support the deployment of GSM, Universal Mobile Telecommunications System (UMTS™) and LTE™ networks in Europe.

5.16.2.5 EE: Environmental Engineering [E, R]

It is responsible for defining the equipment engineering, the bonding and grounding, the power supply interface and environmental aspects for telecommunication infrastructures and equipment.

It manages various engineering aspects of telecommunication equipment in different types of installations. These include:

- environmental conditions (climatic, thermal, active substances, acoustic, etc.);
- equipment practice (the physical requirements of racks, sub-racks and cabinets including thermal matters);

- power supply and grounding (power interface specifications, power and grounding distributions);
- eco-environmental matters (energy efficiency, environmental impact analysis, alternative energy sources);
- environmental matters associated with mobile Information and Communications Technologies (ICT) devices.

Much of our work on energy efficiency supports European Commission (EC) policies, regulation or legislation.

5.16.2.6 SmartM2M [I, R]

It develops standards to enable M2M services and applications and certain aspects of the Internet of Things (IoT). They are a partner in oneM2M and help to produce the specifications to enable users to build platforms by which devices and services can be connected, regardless of the underlying technology used.

Their work enables connected devices to exchange information through SAREF, our smart applications reference ontology that runs with oneM2M-compliant communication platforms. With SAREF, SmartM2M is promoting oneM2M Base Ontology with extensions in many IoT domains.

They develop Smart Cities requirements. SmartM2M is the home of the first Smart Agriculture oneM2M/ITS Pilot. They investigate virtualized IoT architectures, identifying new elements that are required to support a virtualized IoT service layer. They support the ETSI role in AIOTI (www.aioti.eu) WG03 (IoT Standardization) in collaboration with the H2020 IoT Large Scape Pilot and IoT Platforms.

5.16.2.7 ONE MACHINE-TO-MACHINE PARTNERSHIP PROJECT (ONEM2M) [I, R]

oneM2M is the global standards initiative that covers requirements, architecture, API specifications, security solutions and interoperability for Machine-to-Machine and IoT technologies.

Formed in 2012 it consists of eight of the world's preeminent standards development organizations: ARIB (Japan), ATIS (USA), CCSA (China), ETSI (Europe), TTA (USA), TSDSI (India), TTA (Korea), and TTC (Japan), together with two industry fora or consortia (GlobalPlatform, OMA SpecWorks) and over 200-member organizations.

oneM2M specifications provide a framework to support applications and services such as the smart grid, connected car, home automation, public safety, and health.

5.17 IEC²⁰

5.17.1 Description

The IEC is a global, not-for-profit membership organization, whose work underpins quality infrastructure and international trade in electrical and electronic goods. The IEC brings together more than 170 countries and provides a global, neutral and independent standardization platform to 20 000 experts globally. It administers 4 conformity assessment systems, whose members certify that devices, systems, installations, services and people work as required.

The IEC publishes around 10 000 IEC International Standards which together with conformity assessment provide the technical framework that allows governments to build national quality infrastructure and companies of all sizes to buy and sell consistently safe and reliable products in most countries of the world. IEC International Standards serve as the basis for risk and quality management and are used in testing and certification to verify that manufacturer promises are kept.

²⁰ <https://www.iec.ch/homepage>

5.17.2 Working groups or technical committees

5.17.2.1 TC 59 Performance of household and similar electrical appliances [E]

TC 59 prepares International Standards on methods of measurement of characteristics which are of importance to determine the performance of electrical appliances for household use or of electrical appliances for commercial use and that are of interest for the user. This may include associated aspects related to the use of the appliances and aspects such as the classification, accessibility and usability of appliances, ergonomic characteristics and conditions for the information provided at the point of sale.

5.17.2.2 ISO/IEC JTC 1/SC 39 Sustainability, IT and data centres [E, R]

They work on standardization of assessment methods, design practices, operation and management aspects to support resource efficiency, resilience and environmental sustainability for and by information, data centres and other facilities and infrastructure necessary for service provisioning.

5.17.2.3 ISO/IEC JTC 1/SC 6 Telecommunications and information exchange between systems

Since SC6 was established in 1964, SC6 has worked on standardization in the field of telecommunications dealing with the exchange of information between open systems, including system functions, procedures, parameters as well as the conditions for their use. This standardization encompasses protocols and services of lower layers including physical, data link, network, and transport as well as those of upper layers including but not limited to Directory and ASN.1: MFAN, NFC, PLC, Future Networks and OID.

5.17.2.4 ISO/IEC JTC 1/SC 25 Interconnection of information technology equipment [I]

SC 25 works on the following topics:

- Standardization of microprocessor systems, interfaces, protocols, architectures and associated interconnecting media for information technology equipment and networks to support embedded and distributed computing environments, storage systems and other input/output components.
- Standards for home and building electronic systems in residential and commercial environments to support interworking devices (IoT-related) and applications such as energy management, environmental control, lighting, and security.
- Cabling system standards for information and communication technology (ICT), in all types of residential, commercial and industrial environments for the design, planning and installation, test procedures, automated infrastructure management systems and remote powering.

5.17.2.5 ISO/IEC JTC 1/SC 41 Internet of Things and Digital Twin [I, R]

SC1 works on the following topics:

- Standardization in the area of Internet of Things and Digital Twin, including their related technologies.
- Serve as the focus and proponent for JTC 1's standardization programme on the Internet of Things and Digital Twin, including their related technologies.
- Provide guidance to JTC 1, IEC, ISO and other entities developing Internet of Things and Digital Twin related applications.

5.17.2.6 TA 18 Multimedia home systems and applications for end-user networks

TA18 develops international publications for the requirements and functions of multimedia home systems and applications, as well as specifications addressing total system connected in end-user networks.

This includes system, application, and protocol specifications for connected equipment, home servers, and internet/cloud service applications; as well as power and data control interface specifications for personal computing and CE devices.

End-user networks include all personal networks of connected equipment, such as home networks, controlled by an individual for multimedia applications and services.

5.17.2.7 TC 100 Audio, video and multimedia systems and equipment [E]

TC 100 prepares international publications in the field of audio, video and multimedia systems and equipment.

These publications mainly include specification of the performance, methods of measurement for consumer and professional equipment and their application in systems and its interoperability with other systems or equipment.

5.17.2.8 SC 21A Secondary cells and batteries containing alkaline or other non-acid electrolytes

SC 21A prepares standards regarding product and test specifications for all secondary cells and batteries of sealed and vented designs containing alkaline or other non-acid electrolytes. To support other technical committees standardizing application-oriented systems using secondary cells and batteries.

5.17.2.9 TC 21 Secondary cells and batteries

TC21 provides standards for all secondary cells and batteries related to product (dimension and performance), safety (including marking and labelling), testing, and safe application (installation, maintenance, operation) irrespective of type or application or configuration (hybrid, stand alone, module). Main applications are:

- automotive (car, motorcycle, truck) for starting, lighting, ignition, start/stop
- industrial (telecom, UPS, reliable power supply and traction)
- electrical vehicles (full electrical vehicle, hybrid car, bicycle)
- portable (computer, tool, lamp)
- onboard batteries (aircraft, railway, ship, motor-home)
- energy storage (renewable, on- grid and off-grid).

All electrochemical systems are considered such as Lead acid, Nickel based (NiMH, NiCd) and Lithium based. New battery technologies and chemistries such as flow batteries and High temperature batteries (e.g. sodium sulfur, sodium nickel chloride) are included. The work is shared between TC 21 and SC 21A according to technologies and applications. For standardization of applications and system integration, TC 21 is cooperating with the responsible Committees, TC 9, TC 34, TC 69, TC 82, TC 105, TC 116, TC 120 and ISO TC22/SC21.

5.18 IEEE²¹

5.18.1 Description

The Institute of Electrical and Electronics Engineers (IEEE) is a professional association for electronic engineering and electrical engineering (and associated disciplines). It was formed in 1963 from the amalgamation of the American Institute of Electrical Engineers and the Institute of Radio Engineers. IEEE is a leading developer of international standards that underpin many of today's telecommunications, information technology, and power-generation products and services.

²¹ <https://www.ieee.org/>

Often the central source for standardization in a broad range of emerging technologies, the IEEE Standards Association has an active portfolio of nearly 1,200 standards and more than 900 projects under development. This includes the prominent IEEE 802® standards for local, metropolitan, and other area networks, including Ethernet and Wireless LAN (commonly referred to as Wi-Fi®).

5.19 IETF²²

5.19.1 Description

The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.

The IETF divides its work into a number of areas, each comprised of working groups that relate to that area's focus.

5.19.2 Working groups or technical committees

5.19.2.1 Internet Area (int)

The primary technical topics covered by the Internet Area include IP layer (both IPv4 and IPv6), implications of IPv4 address depletion, co-existence between the IP versions, DNS, DHCP, host and router configuration, mobility, multi-homing, identifier-locator separation, VPNs and pseudo wires along with related MPLS issues, and various link layer technologies. The Internet Area is also responsible for specifying how IP will run over new link layer protocols

5.19.2.2 Operations and Management Area (ops)

The primary technical areas covered by the Operations & Management (OPS) Area include Network Management, AAA, and various operational issues facing the Internet such as DNS operations, IPv6 operations, operational security and Routing operations.

The Operations & Management area is divided into two separate functions: Network Management and Operations.

The Network Management function covers Internet management and AAA, and the related protocols, including but not limited to NETCONF, SNMP, RADIUS, Diameter, and CAPWAP, and of data modelling and data modelling languages used in management such as SMI and YANG. Another important role of the Management function is to identify potential or actual management issues regarding IETF protocols and documents in all areas, and to work with the other areas to resolve those issues.

The Operations function is largely responsible for soliciting operator feedback and input regarding IETF work. Another important role of the Operations function is to identify potential or actual operational issues regarding IETF protocols and documents in all areas, and to work with the other areas to resolve those issues.

5.19.2.3 Routing Area (rtg)

The Routing Area is responsible for facilitating the operation of the Internet routing system by maintaining and improving the scalability and stability characteristics of the existing routing protocols and developing new protocols, extensions, and bug fixes. Forwarding methods (such as destination-based unicast and multicast forwarding, MPLS, and pseudo wire) as well as associated routing and signalling protocols (such as OSPF, IS-IS, BGP, RSVP-TE, LDP, PIM, RPL, and VPNs at Layer 2 and Layer 3), and both centralized and distributed routing architectures (to address, for

²² <https://www.ietf.org/>

example, virtualization, service chaining, traffic engineering, and data centre routing) are within the scope of the Routing Area. The interactions of routing systems with configuration and orchestration platforms (for example, routing-related YANG models and path computation engines) are handled in the Routing Area as well.

The Routing Area also works on Generalized MPLS used in the control plane of optical networks, and the security and manageability aspects of the routing system. The Routing Area Working Groups cover a wide range of data plane technologies (Layer 1, Layer 2, Layer 3) and control protocols.

The Routing Area intersects most frequently with the Internet Area, the Operations and Management Area, and the Security Area. Interaction with the Internet Area concentrates mainly on IP forwarding and encapsulation. Ongoing work with the Operations and Management Area is on developing YANG models and considering the management and operation of the routing infrastructure. With the Security Area, the ongoing focus is on routing protocol security and its impact on the Internet's infrastructure security.

Work in the Routing Area often overlaps with work in other standards development organizations (SDOs). In particular, there have been interactions with Broadband Forum, IEEE, and ITU-T.

5.19.2.4 Transport Area (tsv)

The transport and services area - usually just called "transport area" or "TSV area" - covers a range of technical topics related to data transport in the Internet.

The Transport Area works on mechanisms related to end-to-end data transport to support Internet applications and services that exchange potentially large volumes of traffic at potentially high bandwidths. A key focus are mechanisms to detect and react to congestion in the Internet, such as the congestion control algorithms in Internet transport control protocols such as TCP, SCTP, MPTCP, and DCCP.

Current and new transport work includes congestion signalling and reporting, forward error correction, multicast, QoS and reservation signalling, DiffServ and congestion control for unresponsive flows, NAT regularization and specification, storage protocols for the Internet, peer-to-peer streaming, performance metrics for Internet paths, experimentation with congestion control schemes developed in the IRTF, multipath extensions to existing transport protocols, congestion control for "background" bulk transfers, and extensions to the IETF protocols for multimedia transport.

5.20 ITU²³

5.20.1 Description

The International Telecommunication Union (ITU) is the United Nations specialized agency for information and communication technologies – ICTs.

Founded in 1865 to facilitate international connectivity in communications networks, they develop the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs to underserved communities worldwide.

5.20.2 Working groups or technical committees

5.20.2.1 ITU-T Study Group 5 – Environment and circular economy [E, R]

ITU-T Study Group 5 (SG5) is responsible for studies on methodologies for evaluating ICT effects on climate change and publishing guidelines for using ICTs in an eco-friendly way. Under its environmental mandate SG5 is also responsible for studying design methodologies to reduce ICTs and e-waste's adverse environmental effects, for example, through recycling of ICT facilities and equipment.

²³ <https://www.itu.int/es/Pages/default.aspx>

In addition to its climate-focused activities, the ITU-T Recommendations, handbooks and other publications produced by SG5 have four main objectives:

- To protect telecommunication equipment and installations against damage and malfunction due to electromagnetic disturbances, such as those from lightning. In this field, SG5 is one of the world's most experienced and respected standardization bodies.
- To ensure safety of personnel and users of networks against current and voltages used in telecommunication networks.
- To avoid health risks from electromagnetic fields (EMFs) produced by telecommunication devices and installations.
- To guarantee a good quality of service (QoS) for high-speed data services by providing requirements on characteristics of copper cables and on the coexistence of services delivered by different providers.

5.20.2.2 ITU-T Study Group 9 - Broadband cable and TV

ITU-T Study Group 9 (SG9) carries out studies on the use of telecommunication systems in the distribution of television and sound programs supporting advanced capabilities such as ultra-high definition and 3D TV. This work also covers the use of cable and hybrid networks – primarily designed for the distribution of television and sound programs to the home – as integrated broadband networks to provide interactive voice, video and data services, including Internet access.

5.20.2.3 ITU-T Study Group 15 - Networks, Technologies and Infrastructures for Transport, Access and Home

The international standards (ITU-T Recommendations) developed by Study Group 15 detail technical specifications giving shape to global communication infrastructure. The group's standards define technologies and architectures of optical transport networks enabling long-haul global information exchange; fibre- or copper-based access networks through which subscribers connect; and home networks connecting in-premises devices and interfacing with the outside world.

This includes the development of standards for the optical transport network, access network, home network and power utility network infrastructures, systems, equipment, optical fibres and cables and the related installation, maintenance, management, test, instrumentation and measurement techniques, and control plane technologies to enable the evolution toward intelligent transport networks, including the support of smart-grid applications.

5.20.2.4 ITU-T Study Group 13 – Future networks, with focus on IMT-2020, cloud computing and trusted network infrastructure

Study Group 13 has led ITU's standardization work on next-generation networks and now caters to the evolution of NGNs, while focusing on future networks and network aspects of mobile telecommunications.

Broadly speaking, next-generation network (NGN) refers to the worldwide move from circuit-switched to packet-based network. The migration to NGNs has reduced service providers' CAPEX and OPEX costs and enabled the rollout of a rich variety of services. As is common practice in ITU-T, reduced energy consumption was a priority addressed early in the development of NGN standards and in this respect, NGNs have proven far superior to traditional networks.

NGNs have been critical to fixed-mobile convergence (FMC) and telecom-broadcasting convergence exemplified by such innovations as Internet Protocol Television (IPTV). NGNs are also underpinning the convergence of ICT and other industry sectors, such as the automotive industry in support of intelligent transport systems (ITS). SG 13 will continue studying NGN evolution; standardizing enhancements to NGNs as new services and applications emerge.

Today, SG13 focuses on future networks (FNs) – networks of the future beyond NGN – expected to enjoy early realization sometime around 2020 in prototyping or phased deployments. The group is standardizing FNs with the objectives of service, data, environmental and socio-economic awareness. This study resulted in the completion of standardization efforts to support network virtualization, energy saving for FNs, and an identification framework. Future plans are to develop different facets of the smart ubiquitous network, requirements of network virtualization for FNs, framework of telecom SDN (software-defined networking) and requirements of formal specification and verification methods for SDN.

Cloud computing is an important part of SG13 work and the group develops standards that detail requirements and functional architectures of the cloud computing ecosystem, covering inter- and intra-cloud computing and technologies supporting XaaS (X as a Service). This work includes infrastructure and networking aspects of cloud computing models, as well as deployment considerations and requirements for interoperability and data portability. Given that cloud computing relies on the interplay of a variety of telecom and IT infrastructure resources, SG13 develops standards enabling consistent end-to-end, multi-cloud management and monitoring of services exposed by and across different service providers' domains and technologies.

SG13's standardization work also covers network aspects of the Internet of Things (IoT), additionally ensuring support for IoT across FNs as well as evolving NGNs and mobile networks. Cloud computing in support of IoT is an integral part of this work.

The group also looks at network aspects of mobile telecommunications. This work includes IMT-2000 and IMT-Advanced (ITU-R standards commonly referred to as 3G and 4G, respectively); wireless Internet; mobility management; mobile multimedia network functions; internetworking; and enhancements to existing ITU-T Recommendations on IMT

5.20.2.5 ITU-T Study Group 20 - Internet of Things, smart cities and communities [I, R]

Study Group 20 is working to address the standardization requirements of Internet of Things (IoT) technologies, with an initial focus on IoT applications in smart cities and communities (SC&C).

SG20 develops international standards to enable the coordinated development of IoT technologies, including machine-to-machine communications and ubiquitous sensor networks. A central part of this study is the standardization of end-to-end architectures for IoT, and mechanisms for the interoperability of IoT applications and datasets employed by various vertically oriented industry sectors.

An important aspect of SG20's work is the development of standards that leverage IoT technologies to address urban-development challenges.

IoT is a key enabler of the Information Society and offers an opportunity to transform city infrastructure, benefiting from the efficiencies of intelligent buildings and transportation systems, and smart energy and water networks. SG20 will assist government and industry in capitalizing on this opportunity, providing a unique platform to influence the development of international IoT standards and their application as part of urban-development master plans.

ITU put forward a vision of IoT in the landmark "Internet of Things" report published in 2005 as part of a series of ITU reports on the Internet. The foundations of the new Study Group are provided by ITU-T's experience in the development of IoT standards and the findings of the ITU-T Focus Group on Smart Sustainable Cities (FG-SSC), which concluded its activities in May 2015 with the release of 21 technical reports and specifications.

The decision to create SG20 was made by the Telecommunication Standardization Advisory Group (TSAG) at its meeting at ITU Headquarters in Geneva, 2-5 June 2015, exercising TSAG's authority to modify ITU-T's structure and work programme between quadrennial World Telecommunication Standardization Assemblies.

5.21 JEITA (Japan)²⁴

5.21.1 Description

The objective of the Japan Electronics and Information Technology Industries Association (JEITA) is to promote the healthy manufacturing, international trade and consumption of electronics products and components in order to contribute to the overall development of the electronics and information technology (IT) industries.

5.21.2 Working groups or technical committees

The following boards have been identified a potentially relevant, though no further information in English has been found:

- Audio-visual and Communication Board
- Smart Home Board
- Display devices board
- Environment Board

5.22 KNX Association²⁵

5.22.1 Description

In May 1999 members of the following associations founded KNX Association cvba:

- EIBA (European Installation Bus Association)
- EHSA (European Home Systems Association)
- BCI (BatiBUS Club International)

KNX Association is a non-profit-oriented organisation governed by Belgian Law. Members are manufacturers developing devices for several applications for home and building control based on KNX like lighting control, shutter control, heating, ventilation, air conditioning, energy management, metering, monitoring, alarm/intrusion systems, household appliances, audio/video and lots more. Next to manufacturers also service providers (utilities, telecom, etc.) can become a member of the KNX Association.

The objectives of KNX Association are oriented towards the development and promotion of an international communication standard for Home and Building Automation by:

- Developing a single stable and affordable system technology with the goal to improve overall market acceptance and expand the today's market (mostly in commercial buildings) into the residential market.
- Defining and improving the KNX Specifications related to:
 - Protocol (including Security).
 - Different media.
 - Configuration modes
 - Application specifications
 - Extending the KNX Technology towards the Internet of Things.

²⁴ <https://www.jeita.or.jp/english/>

²⁵ <https://www.knx.org/knx-en/for-professionals/index.php>

In respect of its coherence in communication interworking amongst devices and interoperability between applications.

- Standardising system requirements, including test methods.
- Managing the relevant system related intellectual property rights, establishing trademarks and issuing trade-mark licenses.
- Setting-up an appropriate certification system to enable certification of “products” (hardware, software, components) and services in order to guarantee system compatibility, interworking and interoperability.
- Introducing this standard into the common international HBES/BACS standardisation bodies and actively promoting it to become THE NORM.
- Managing (including development, sales support of) an appropriate common Engineering Tool Software (ETS) and other KNX related tools.
- Promoting Certified KNX training for professional users such as contractors, designers and installers.
- Defining the long term KNX strategy.
- KNX activities related to the standard (corporate image, market surveys, trade fairs, conferences, journal, website, flyers, etc.).
- Ensuring cooperation with the scientific world.
- Organisation of KNX Working Groups.
- Technical development support related to the KNX Standard.
- Winning new partners from industry, training and science.
- Founding of KNX user-clubs and national groups.

5.23 OASIS²⁶

5.23.1 Description

The Organization for the Advancement of Structured Information Standards (OASIS) is a non-profit consortium that works on the development, convergence, and adoption of open standards for cybersecurity, blockchain, Internet of things (IoT), emergency management, cloud computing, legal data exchange, energy, content technologies, and other areas.

OASIS was founded under the name “SGML Open” in 1993. It began as a consortium of vendors and users devoted to developing guidelines for interoperability among products that support the Standard Generalized Markup Language (SGML). The consortium changed its name to “OASIS” in 1998 to reflect an expanded scope of technical work.

In 1999, OASIS and UN/CEFACT, the committee of the United Nations dealing with standards for business, jointly launched a new set of specifications for electronic business. This initiative was called “ebXML” and after three years, UN/CEFACT and OASIS agreed to divide the remaining work between the two organizations and to coordinate the completion of the work through a coordinating committee. In 2004 OASIS submitted its completed ebXML specifications to ISO TC154 where they were approved as ISO 15000.

²⁶ <https://www.oasis-open.org/org/>

5.24 OMA SpecWorks²⁷

5.24.1 Description

OMA SpecWorks, previously the Open Mobile Alliance (OMA) is a standards organization which develops open, international technical standards for the mobile phone industry. It is a non-profit non-governmental organization (NGO), not a formal government-sponsored standards organization

5.24.2 Working groups or technical committees

5.24.2.1 Architecture and Communications

The ARCOM Working Group is responsible for:

- OMA SpecWorks API program that provides standardized interfaces to the service infrastructure residing within communication networks and on devices.
- Service layer standardization of communications related technologies, including areas such as Messaging, Push-to-talk over Cellular, Presence, Contact Information and Address Book, Media and Data Management, Enhanced Visual Voice Mail and Spam Reporting.

5.24.2.2 Content Delivery

The CD Working Group is chartered to define the basic delivery mechanisms, bi-directional exchange mechanisms, and the processing of key content formats, including the semantics and user agents, behaviour and programming interfaces.

5.24.2.3 Device Management

The DMSE Working Group specifies protocols and mechanisms to achieve the management of mobile devices, services access and software on connected devices for mobile networks and the Internet of Things (IoT).

5.24.2.4 Interoperability

The IOP Working Group produces high quality test specifications, facilitating testing of implementations of OMA SpecWorks specifications and, in some cases, producing TTCN test code for the validation of specifications.

5.24.2.5 IPSO Smart Objects

IPSO Smart Objects – Now a part of OMA SpecWorks, the IPSO charter is to define and support Smart Objects with an emphasis on object interoperability, protocol and data layers and of Identity and Privacy technologies.

5.24.2.6 Location

The LOC Working Group develops specifications to ensure the interoperability of Location Services on an end-to-end basis and provides technical expertise and consultancy on Location Services for other working groups across OMA SpecWorks.

²⁷ <https://omaspecworks.org/>

5.25 OpenADR Alliance²⁸

5.25.1 Description

The OpenADR Alliance was formed 2010 by industry stakeholders to support the development, testing, and deployment of commercial OpenADR and facilitates its acceleration and widespread adoption. This approach needs to engage service providers (such as electric utilities and systems operators) within the domain of the Smart Grid that publish OpenADR signals, as well as the facilities or third-party entities that consume them to manage electric loads. The OpenADR Alliance will enable all stakeholders to participate in automated DR, DER management, dynamic pricing, and electricity grid reliability.

The OpenADR Alliance activities include, among others, the following:

- Develop a conformance, certification, and testing process/program for OpenADR, coordinated with entities such as standard development organizations (SDOs), utility user groups, and other Smart Grid initiatives.
- Collaborate with SDOs and user groups for the continued enhancements of the OpenADR profile specification.
- Collaborate with the U.S. Department of Energy (DOE), Federal Energy Regulatory Commission (FERC), National Association of Regulatory Utility Commissioners (NARUC), and other government agencies to expand the adoption of OpenADR.
- Collaborate with other international alliances and organizations on global partnership opportunities.
- Conduct and provide education and training sessions to help facilitate the development and adoption of OpenADR products and programs.
- Facilitate OpenADR programs among utilities and system operators through case studies, specifications and industry best practices.
- Provide resources to developers to facilitate the development, testing, and demonstration of OpenADR certified products.

5.26 TIA (US)²⁹

5.26.1 Description

The Telecommunications Industry Association (TIA) is accredited by the American National Standards Institute (ANSI) as a standards developing organisation (SDO). TIA's engineering committees create standards and technical documents based on guidelines established by the ANSI Essential Requirements.

TIA operates nine engineering committees that develop guidelines for private radio equipment, cellular towers, VOIP equipment, structured cabling, satellites, telephone terminal equipment, accessibility, data centres, mobile device communications, vehicular telematics, smart device communications, and smart utility mesh networks. More than 1,000 individuals - representing network equipment manufacturers, service providers, government entities, and end users - currently serve on TIA's Engineering committees.

To ensure that these standards become globally established, TIA collaborates with the International Telecommunication Union (ITU), the International Organization for Standardization (ISO), and the International Electrotechnical Commission (IEC).

²⁸ <https://www.openadr.org/>

²⁹ <https://tiaonline.org/>

5.26.2 Working groups or technical committees

5.26.2.1 TR-51 I SMART UTILITY NETWORKS [I]

Engineering Committee TR-51 is developing air-interface, network, and conformance standards in support of Smart Utility Networks. The committee will focus on air-interface and network standards with wireless mesh network topology, optimized for Smart Utility Network applications.

Smart Utility Networks standards are intended to provide solutions for two-way data transmission between devices and back-office systems of the utility provider with a focus on improving services. The committee will develop standards for OSI layers 1 through 4, leveraging applicable existing standards.

5.26.2.2 TR-50 I M2M – SMART DEVICE COMMUNICATIONS [I]

Engineering Committee TR-50 M2M – Smart Device Communications is responsible for the development and maintenance of access agnostic interface standards for the monitoring and bi-directional communication of events and information between machine-to-machine (M2M) systems and smart devices, applications or networks. These standards development efforts pertain to but are not limited to the functional areas as noted: Reference Architecture, Informational Models and Standard Objects, Protocol Aspects, Software Aspects, Conformance and Testing, and Security.

TR-50 is developing an M2M Smart Device Communications framework that can operate over different underlying transport networks (wireless, wired, etc.) and can be adapted to a given transport network by means of an adaptation/convergence layer. The TR-50 framework will make its functionality available to applications through a well-defined Application Programming Interface (API) that is agnostic to the vertical application domain (eHealth, Smart Grid, Industrial Automation, etc.)

5.26.2.3 TR-45 I MOBILE AND POINT-TO-POINT COMMUNICATIONS STANDARDS

Engineering Committee TR-45 develops performance, compatibility, interoperability and service standards for mobile and personal communications systems. These standards pertain to, but are not restricted to, service information, wireless terminal equipment, wireless base station equipment, wireless switching office equipment, ancillary apparatus, auxiliary applications, inter-network and intersystem operations, interfaces, and wireless packet data technologies.

5.27 TTA (South Korea)³⁰

5.27.1 Description

The Telecommunications Technology Association (TTA) covers telecommunications, information technology, radio communications and broadcasting. The Association establishes industry standards and has been instrumental in creating the current Korean Information and Communication Standards. TTA also collaborates with international and national standards organizations, such as ITU and other organizations.

5.27.2 Working groups or technical committees

5.27.2.1 Wired Communication Technical Committee (TC2)

TC2 covers the following tasks:

- Wired communication and transport technology standardization:
 - Transport and Communication network technology (optical transport, ethernet, routing, Internet address resource, network facility, network management, QoS, etc.)

³⁰ <http://tta.kr/eng/index.do>

- Future network, future internet and home network technology, etc.
- Wired/Wireless inter-networking technology and wired network-based convergence service (wired network application services such as smartwork, IPTV, digital signage, trust networking service, etc.)
- Conformance/interoperability standardization of Wired communication and transport technology
- Wired communication and transport technology standards maintenance

5.27.2.2 Smart home Project Group (PG214) [I]

PG214 is part of TC2 and covers the following tasks:

- Standardization Technologies
 - Smart home platform technology (architecture, function, performance, control and management, external interworking, etc.)
 - Smart home networking technology (physical layer access, middleware, etc.)
 - Intelligent information home appliance technology (Interoperability and user interface, application service, etc.)
 - Energy home/building technology (management and interface, etc.)

5.27.2.3 ICT Convergence Technical Committee (TC4) [E]

Within TC4, Green ICT Project Group (PG424) is the most relevant, which covers the following tasks:

- Green ICT standardization
 - technologies against climate change (including e-waste management, environmental regulations correspondence, eco-rating & eco-specifications, etc.)
 - Greenhouse gas emission reduction and energy saving technologies (methodologies for the assessment of environmental impact of ICT)
 - Green data centre installation/ operation/evaluation technologies
 - ICT and climate change adaptation
 - Eco-friendly and sustainable technologies (smart water management, smart city, smart factories, etc.)
- Conformance/ interoperability standardization of Green ICT

5.27.2.4 Radio/Wireless Communication Technical Committee (TC9)

TC9 covers the following tasks:

- Standardization Technologies
 - Radio/Wireless communication system technology (Wireless PAN/LAN/MAN, Radio resource, public safety communication, underground/underwater/maritime/aeronautical/satellite communication)
 - Radio/Wireless communication service technology (LBS, ITS/Automotive/Railway ICT, Smart power transfer/transmission)
 - Interworking technology based on radio/wireless communication
 - Convergence technology based on radio/wireless communication
- Standardization Relationships

5.27.2.5 Intelligent information TC(TC010) [I, R]

TC 010 covers the following projects:

- IoT/Smart City Platform PG(PG1001)
- oneM2M Task Group (WG10011)
- IoT networking PG(PG1002)

5.28 TTC (Japan)³¹

5.28.1 Description

The Telecommunication Technology Committee (TTC) is a private non-profit organization certified by the Ministry of Internal Affairs and Communications of Japan.

TTC is an incorporated association that contributes to standardization activities in the field of information and communication technology (ICT) by developing and disseminating standards for information and communications networks. It thus participates in the creation of a safe and comfortable society supported by the rapid development of ICTs.

5.28.2 Working groups or technical committees

5.28.2.1 ICT Applications

IoT Smart City: This committee is aimed to share information and discuss IoT (Internet of Things) and smart cities. They also promote proposals to international standards for ITU-T SG20 on the broad issues of IoT smart city.

5.28.2.2 Platforms

In cooperation with ARIB's response group, they discuss the policy for dealing with the oneM2M Steering Committee (SC) meeting, and share information and exchange opinions among members on technical issues. They work downstream to establish the technical specifications created by oneM2M as TTC specifications.

5.28.2.3 Protocols, NW Management and QOS/QOE

They contribute to network management related standardization activities and information dissemination of the latest technology.

The committee is composed of two SWGs and mainly focuses on the downstream and research of the recommendations of ITU-T WP2 / SG2 and SG12.

5.28.2.4 Architecture

They work on information sharing and exchange on 3GPP standardization, among the specifications developed in 3GPP related to services, architecture and protocols, an interface between wireless network and core network which is not dependent on wireless specification, between terminal and core network. It has established as a TTC standard the capability to provide IP-based multimedia services to mobile communication systems called IMS (IP Multimedia Subsystem).

5.28.2.5 IoT Area Network

They define the network between an IoT device and an IoT gateway as an IoT area network (IoTA NW), and conduct technical research, studies and standardization activities on communication methods and device / data management models between the IoT device and IoT gateway.

³¹ <https://www.ttc.or.jp/>

5.29 TSDSI (India)³²

5.29.1 Description

TSDSI is an autonomous, membership based, SDO for Telecom/ICT products and services in India. They develop standards for access, back-haul, and infrastructure systems, solutions and services that best meet India specific Telecom/ICT needs, based on research and innovation in India. They work closely with global standards' bodies to reflect Indian requirements into international telecom/ICT standards.

5.29.2 Working groups or technical committees

5.29.2.1 Study Group (SG)-Networks

SG-Networks is responsible for standardization activities for the following:

- Wireless communication systems including Radio-based access and Mobile core networks, the functional elements constituting these networks and the interfaces between these networks.
- Overall system architecture as well as the protocol interface between various user equipment or customer premises equipment and the elements in the access network e.g. base stations, relay stations, etc.
- Software defined networking (SDN) aspects and Network function virtualization (NFV) of the access and core networks.
- Backhaul using wireless & wireline, microwave, optical and/or packet-based transport networks and related SDN & NFV aspects, systems, equipment, optical fibre cables, along with the related control plane, network management, performance monitoring & reporting, synchronization, interfaces, multi-layer optimization techniques and testing aspects.
- Spectrum studies related to the above areas, and technical recommendations.
- Interference studies including co-channel, adjacent channel, and inter-system interference.

SG-Networks is also responsible for liaison for regulatory aspects between TSDSI and external govt. agencies on the above topics as required, in coordination with TSDSI secretariat

5.29.2.2 Study Group (SG)-Services & Solutions

SG-Services & Solutions is responsible for standardization activities for the following:

- Definition of requirements for telecom industry and related services and applications, including:
 - Service level requirements and features for various domains and applications (e.g. IoT/M2M, automotive, public safety, health).
- Development of end-to-end service capabilities and architecture, based on the requirements, including:
 - Technical specifications for application layer functional elements and interfaces.
 - System aspects such as QoS, interoperability, etc.
 - Data management aspects such as schemas, analytics, provisioning, etc.
 - Localization components in services and systems e.g. Indian languages.
- Security and privacy aspects in the end-to-end telecom networks. It includes:

³² <https://tsdsi.in/>

- Determining the security and privacy requirements for telecom networks including the mobile cellular and fixed-line networks across user equipment, access network, transport network, core network and service layer security aspects.
- Specifying the related security architectures and protocols.
- Energy performance for telecommunication networks including access, user equipment, aggregation, core including the underlying transport systems, including:
 - Setting the energy performance related requirements across the end-to-end network
 - Benchmarking network energy performance
 - Energy optimization for networks
 - Energy performance testing
- Recommendations of test requirements and evaluation methodologies for any service level conformance testing activities.

SG-Services & Solutions is also responsible for liaison for regulatory aspects between TSDSI and external govt. agencies on the above topics as required, in coordination with TSDSI secretariat

Recommendations of test requirements and evaluation methodologies for any service level conformance testing activities.

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5.30 USB-IF³³

5.30.1 Description

USB Implementers Forum, Inc. is a non-profit corporation founded by the group of companies that developed the Universal Serial Bus specification. The USB-IF was formed to provide a support organization and forum for the advancement and adoption of Universal Serial Bus technology. The Forum facilitates the development of high-quality compatible USB peripherals (devices), and promotes the benefits of USB and the quality of products that have passed compliance testing.

5.31 W3C³⁴

5.31.1 Description

The World Wide Web Consortium (W3C) is an international community where Member organizations, a full-time staff, and the public work together to develop Web standards

The W3C mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web.

5.31.2 Working groups or technical committees

5.31.2.1 Web of Things Working Group [I, R]

The Web of Things seeks to counter the fragmentation of the IoT through standard complementing building blocks (e.g., metadata and APIs) that enable easy integration across IoT platforms and application domains.

³³ <https://www.usb.org/>

³⁴ <https://www.w3.org/>

5.32 Z-Wave Alliance³⁵ [I]

5.32.1 Description

Established in 2005, the Z-Wave Alliance is comprised of industry leaders throughout the globe that are dedicated to the development and extension of Z-Wave as the key enabling technology for 'smart' home and business applications.

Z-Wave is a wireless communications protocol used primarily for home automation. It is a mesh network using low-energy radio waves to communicate from appliance to appliance, allowing for wireless control of residential appliances and other devices, such as lighting control, security systems, thermostats, windows, locks, swimming pools, and garage door openers. Like other protocols and systems aimed at the home and office automation market, a Z-Wave system can be controlled via the Internet from a smart phone, tablet, or computer, and locally through a smart speaker, wireless keyfob, or wall-mounted panel with a Z-Wave gateway or central control device serving as both the hub controller and portal to the outside

³⁵ <https://z-wavealliance.org/>

6 Standard longlist and shortlist

Based on the information collection and assessments presented in the previous sections and specifically related to the criteria defined in Section 3.2, we have identified the main relevant standards within the areas of interest for EDNA. The collection of these standards together with a description of their content is provided in an accompanying Excel file ('EDNA Studies - Connection with standardisation - List of standards.xlsx'). The standards can be filtered by SDO and technical committee or working group, and according to categories that cover the products and systems and the criteria defined, as follows:

- ICT (general product for standards with a broad scope): energy efficiency, energy consumption and performance
- Data centres: energy, KPI and environment
- Edge devices (ED): energy efficiency and power consumption
- Interconnecting equipment (IE): energy efficiency and power consumption
- Batteries
- Smart Home
- IoT
- Applications
- Communication

They can also be filtered attending to the criteria set to identify relevant standardisation work:

- [E]: energy related aspects of products and systems.
- [I]: IoT and interoperability issues.
- [R]: recent activity in the EDNA areas of interest.

7 Reference list

1. Anson Wu, Paul Ryan and Terence Smith, "Intelligent Efficiency for Data Centres & Wide Area Networks", May 2019, EDNA report.
2. <https://www.3gpp.org/>
3. <https://aioti.eu/>
4. <https://www.arib.or.jp/english/>
5. <https://www.ashrae.org/about>
6. <https://www.atis.org/standards-and-specifications/>
7. <https://www.bicsi.org/>
8. <https://www.bluetooth.com/specifications/bluetooth-core-specification/>
9. <https://www.cencenelec.eu/>
10. <http://www.ccsa.org.cn/english/>
11. <https://www.cablelabs.com/>
12. <https://www.eebus.org/about-us/>
13. <https://www.thegreengrid.org/>
14. <https://csa-iot.org/>
15. <https://www.csagroup.org/>
16. <https://www.ecma-international.org/>
17. <https://www.etsi.org/>
18. <https://www.iec.ch/homepage>
19. <https://www.ieee.org/>
20. <https://www.ietf.org/>
21. <https://www.itu.int/es/Pages/default.aspx>
22. <https://www.jeita.or.jp/english/>
23. <https://www.knx.org/knx-en/for-professionals/index.php>
24. <https://www.oasis-open.org/org/>
25. <https://omaspecworks.org/>
26. <https://www.openadr.org/>
27. <https://tiaonline.org/>
28. <http://tta.kr/eng/index.do>
29. <https://www.ttc.or.jp/>
30. <https://tsdsi.in/>
31. <https://www.usb.org/>
32. <https://www.w3.org/>
33. <https://z-wavealliance.org/>