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SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Interactive systems for digital television distribution (DOCSIS third to fifth generations)

Fifth-generation transmission systems for interactive cable television services – IP cable modems

Recommendation ITU-T J.224

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Fifth-generation transmission systems for interactive cable television services – IP cable modems

Summary

Recommendation ITU-T J.224 specifies the fifth generation of high-speed data-over-cable systems. Fifth generation transmission systems introduce a number of new features that build upon what was present in previous ITU-T Recommendations, namely ITU-T J.112, ITU-T J.122, the ITU-T J.222.x-series and the ITU-T J.223.x-series. Recommendation ITU-T J.224 includes key new features for the physical (PHY) layer and establishes a full duplex data-over-cable service interface specification (DOCSIS) mode of operation, including enhancements to media access control (MAC) layer protocols, as well as requirements for those in the upper layer, e.g., the Internet protocol (IP) and dynamic host configuration protocol (DHCP). Fifth generation cable modem specifications fully incorporate those of the fourth generation.

NOTE – The structure and content of Recommendation ITU-T J.224 have been organized for ease of use through direct reference to the original source material, based on the recognition of CableLabs by ITU in accordance with Recommendation ITU-T A.5.[1]

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Data-over-cable service interface specification, DOCSIS.

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[1] Recommendation ITU-T A.5 (2019), *Generic procedures for including references to documents of other organizations in ITU-T Recommendations*. See: https://www.itu.int/en/ITU-T/extcoop/Pages/sdo.aspx

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Fifth-generation transmission systems for interactive cable television services – IP cable modems

1 Scope

This Recommendation specifies the fifth generation of high-speed data-over-cable systems. Fifth generation transmission systems introduce a number of new features that build upon what was present in previous ITU-T Recommendations, namely [b-ITU-T J.112], [b-ITU-T J.122], [b-ITU-T J.222.x] and [b-ITU-T J.223.x] listed in Appendix I. This Recommendation includes key new features for the physical (PHY) layer and establishes a full duplex data-over-cable service interface specification (DOCSIS) mode of operation, including enhancements to the media access control (MAC) layer protocols, as well as requirements for those in the upper layer, e.g., the Internet protocol (IP) and dynamic host configuration protocol (DHCP). Fifth generation cable modem specifications fully incorporate those of the fourth generation. [b-ITU-T J-Sup.10] records the correspondence between DOCSIS specifications and ITU-T Recommendations.

2 References

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

[DOCSIS CCAP-OSSIv4.0] Cable Television Laboratories, Inc., CM-SP-CCAP-OSSIv4.0-I01-190815 (2019), *Data-over-cable service interface specifications, DOCSIS 4.0 – CCAP operations support system interface, specification*. Cable Television Laboratories, Inc.

[DOCSIS CM-OSSIv4.0] Cable Television Laboratories, Inc., CM-SP-CM-OSSIv4.0-I01-190815 (2019), *Data-over-cable service interface specifications, DOCSIS 4.0 – Cable modem operations support system interface, specification*. Cable Television Laboratories, Inc.

[DOCSIS MULPIv4.0] Cable Television Laboratories, Inc., CM-SP-MULPIv4.0-I01-190815 (2019), *Data-over-cable service interface specifications, DOCSIS 4.0 – MAC and upper layer protocols interface, specification*. Cable Television Laboratories, Inc.

[DOCSIS PHYv4.0] Cable Television Laboratories, Inc., CM-SP-PHYv4.0-I01-190815 (2019), *Data-over-cable service interface specifications, DOCSIS 4.0 – Physical layer specification*. Cable Television Laboratories, Inc.

[DOCSIS SECv4.0] Cable Television Laboratories, Inc., CM-SP-SECv4.0-I01-190815 (2017), *Data-over-cable service interface specifications, DOCSIS 4.0 – Security specification*. Cable Television Laboratories, Inc.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 full duplex data-over-cable service interface specification (DOCSIS) mode: An extension of the fourth generation of cable modem specifications that is targeted at significantly increasing upstream capacity by using the spectrum currently used for downstream transmission for simultaneous upstream and downstream communications.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

DHCP	Dynamic Host Configuration Protocol
DOCSIS	Data-Over-Cable Service Interface Specification
IP	Internet Protocol
MAC	Media Access Control
OFDM	Orthogonal Frequency Division Modulation
PHY	Physical
QAM	Quadrature Amplitude Modulation

For other abbreviations, see sections 4 – *Abbreviations and Acronyms* in each of the specifications listed in clause 2.

5 Conventions

None.

6 Overview of fifth generation high-speed data-over-cable systems

6.1 Specifications for fifth generation high-speed data-over-cable systems

With fifth generation high-speed data-over-cable systems, global technical specifications have been achieved. As such, it is a general practice of cable operators worldwide to reference the same high quality CableLabs specifications when making purchasing decisions. These specifications have been readily and widely available since late 2019, but certification of cable modem devices has not yet occurred.

The fifth-generation high-speed data-over-cable systems specifications are also known as DOCSIS 4.0 specifications.[2]

The DOCSIS 4.0 specifications introduce a number of features that increase the capability and application of the technology as follows.

1) The use of orthogonal frequency division modulation (OFDM) in both upstream and downstream increasing the transmission efficiency (expressed in bits per hertz) over single

[2] DOCSIS® is a registered trademark of Cable Television Laboratories, Inc. and is used in ITU-T Recommendations with permission.

carrier quadrature amplitude modulation (QAM). OFDM enables higher bandwidth capacity over the same amount of spectrum when compared to previous generations of DOCSIS with the potential for 10 Gbit/s service tiers over coax.

2) The specification of a full duplex mode of operation enabling the concurrent use of spectrum for both upstream and downstream transmission, greatly increasing the upstream capacity. This provides the ability to provide symmetric multi-gigabit services over coax.

3) The specification of multiple modulation profiles enabling cable modems to operate at different modulation orders and to dynamically optimize the transmission capacity for the channel conditions it is experiencing. This improves the operational efficiency by not constraining all cable modems to operate at the lowest modulation order supported by the network.

4) The specification of full-band spectrum capture that enables analysis of the full spectrum as measured from the cable modem enabling sophisticated proactive diagnostics of network issues prior to customer impacting events.

5) The specification of additional security features to enhance the robustness of the DOCSIS network in the face of malicious cyberattacks.

This Recommendation is comprised of the specifications identified in clause 2. Preceding relevant ITU-T Recommendations are listed in Appendix I. Other references for the specifications listed in clause 2 are provided in the bibliography.

6.2 CableLabs DOCSIS certification programme

In addition to developing the specifications for DOCSIS, CableLabs also conducts interoperability and compliance testing to validate products that implement the DOCSIS specifications. Details of the CableLabs certification programme can be found at: https://www.cablelabs.com/specs/certification/.

The DOCSIS specifications are living documents and are updated three to four times per year under a strict engineering change request and document control process. Consequently, it is important that manufacturers of DOCSIS products understand exactly the requirements against which they are being tested for certification. The CableLabs specification and certification process links engineering change requests with certification testing with sufficient time allowed for manufacturers to implement the required changes. In this way, knowing when a product has been certified, it is possible to know exactly which version of the DOCSIS specifications was used.

Appendix I

Preceding relevant ITU-T Recommendations

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

The following list provides preceding relevant ITU-T Recommendations:

[b-ITU-T G.8275.1] Recommendation ITU-T G.8275.1/Y.1369.1 (2016), *Precision time protocol telecom profile for phase/time synchronization with full timing support from the network.*

[b-ITU-T J.83] Recommendation ITU-T J.83 (2007), *Digital multi-programme systems for television, sound and data services for cable distribution*.

[b-ITU-T J.112] Recommendation ITU-T J.112 (1998), *Transmission systems for interactive cable television services*.

[b-ITU-T J.122] Recommendation ITU-T J.122 (2007), *Second-generation transmission systems for interactive cable television services – IP cable modems*.

[b-ITU-T J.126] Recommendation ITU-T J.126 (2007), *Embedded Cable Modem device specification*.

[b-ITU-T J.162] Recommendation ITU-T J.162 (2007), *Network call signalling protocol for the delivery of time-critical services over cable television networks using cable modems.*

[b-ITU-T J.163] Recommendation ITU-T J.163 (2007), *Dynamic quality of service for the provision of real-time services over cable television networks using cable modems.*

[b-ITU-T J.179] Recommendation ITU-T J.179 (2005), *IPCablecom support for multimedia*.

[b-ITU-T J.210] Recommendation ITU-T J.210 (2006), *Downstream RF interface for cable modem termination systems.*

[b-ITU-T J.211] Recommendation ITU-T J.211 (2006), *Timing interface for cable modem termination systems*.

[b-ITU-T J.212] Recommendation ITU-T J.212 (2006), *Downstream external Physical layer interface for modular cable modem termination systems*.

[b-ITU-T J.213] Recommendation ITU-T J.213 (2006), *Layer 2 virtual private networks for IP cable modem systems*.

[b-ITU-T J.222.x] Recommendations ITU-T J.222.x-series (2007), *Third-generation transmission systems for interactive cable television services – IP cable modems*.

[b-ITU-T J.223.x] Recommendation ITU-T J.223.x-series (2016), *Cabinet DOCSIS (C-DOCSIS) functional requirements; system specification*.

[b-ITU-T X.25] Recommendation ITU-T X.25 (1996), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit*.

[b-ITU-T X.509] Recommendation ITU-T X.509 (2012) | ISO/IEC 9594-8:2017, *Information technology – Open Systems Interconnection – The Directory: Public key and attribute certificate frameworks*.

[b-ITU-T X.690] Recommendation ITU-T X.690 (2015) | ISO/IEC 8825-1:2002, *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER).*

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Other references for specifications listed in clause 2

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[b-IEC 61169-24] IEC 61169-24:2001, *Radio-frequency connectors – Part 24: Sectional specification – Radio frequency coaxial connectors with screw coupling, typically for use in 75 ohm cable distribution systems (type F)*.

[b-ISO/IEC 8802-2] ISO/IEC 8802-2:1998, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*.

[b-ISO/IEC 8802-3] ISO/IEC 8802-3:2000, *Information technology, Telecommunications and information exchange between systems, Local and metropolitan area networks, Specific requirements, Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*.

[b-ISO/IEC 8825-1] ISO/IEC 8825-1:2008, *Information technology – ASN.1 encoding rules: Specification of basic encoding rules (BER) – canonical encoding rules (CER) and distinguished encoding rules (DER).*

[b-ISO/IEC 8859-1] ISO/IEC 8859-1:1998, *Information technology – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No.1*.

[b-ISO/IEC 10038] ISO/IEC 10038:1993, *Information technology – Telecommunications and information exchange between systems – Local area networks – Media access control (MAC) bridges*.

[b-ISO/IEC 13818-1] ISO/IEC 13818-1:2007, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

[b-CENELEC EN 50083-2] CENELEC EN 50083-2:2005, *Cable networks for television signals, sound signals and interactive services – Part 2: Electromagnetic compatibility for equipment*.

[b-CENELEC EN 50083-7] CENELEC EN 50083-7:1996, *Cable networks for television signals, sound signals and interactive services –Part 7: System performance.*

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[b-CENELEC EN 61000-6-3] CENELEC EN 61000-6-3:2003, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments.*

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[b-FIPS 46-3] Federal Information Processing Standard Publication (FIPS PUB) 46-3 (1999), *Data encryption standard (DES)*.

[b-FIPS 140-2] Federal Information Processing Standard Publication (FIPS PUB) 140-2 (2001), *Security requirements for cryptographic modules*.

[b-FIPS 180-1] FIPS PUB 180-1, Secure *hash standard* (1993).

[b-FIPS 180-4] Federal Information Processing Standard Publication (FIPS PUB) 180-4 (2014), *Secure hash standard (SHS)*.

[b-FIPS 197] Federal Information Processing Standard Publication (FIPS PUB) 197 (2001), *Advanced encryption standard (AES)*.

[b-GB 8898-2011] GB 8898-2011, *Audio, video and similar electronic apparatus – Safety requirements.*

[b-IEEE 802.1D] IEEE Std 802.1D-2004, *IEEE Standard for local and metropolitan area networks: Media access control (MAC) bridges.*
Incorporates IEEE 802.1t-2001 and IEEE 802.1w.

[b-IEEE 802.1ad] IEEE Std. 802.1ad-2005, *IEEE Standard for local and metropolitan area networks – Virtual bridged local area*

networks amendment 4: Provider bridges. Former amendment to 802.1Q, now part of 802.1Q-2011.

[b-IEEE 802.1Q] IEEE Std. 802.1Q-2011, *IEEE Standard for local and metropolitan area networks – Media access control (MAC) Bridges and virtual bridge local area networks*.

[b-IEEE 802.1ah] IEEE Std. 802.1ah-2008, *IEEE Standard for local and metropolitan area networks – Virtual bridged local area networks – Amendment 7: Provider backbone bridges*. Former amendment to 802.1Q, now part of 802.1Q-2011.

[b-IEEE 802.3as] IEEE Std. 802.3as-2006, *IEEE Standard for information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.*

[b-IEEE 1588] IEEE Std. 1588-2008, *IEEE Standard for a precision clock synchronization protocol for networked measurement and control systems*.

[b-NIST SP 800-38A] NIST SP 800-38A (2001), *Recommendation for block cipher modes of operation, methods and techniques*.

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[b-CANN DHCP-Reg] CL-SP-CANN-DHCP-Reg-I15-180509, *CableLabs' DHCP options registry specification.* Cable Television Laboratories, Inc.

[b-C-DOCSIS] CM-SP-CDOCSIS-I02-150305, *Data-over-cable service interface specifications, C-DOCSIS – C-DOCSIS system specification.* Cable Television Laboratories, Inc.

[b-CLABDEF-MIB] CL-SP-MIB-CLABDEF-I12-160325, *CableLabs definition MIB specification*. Cable Television Laboratories, Inc.

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[b-DOCSIS BPI+] CM-SP-BPI+-C01-081104, *Data-over-cable service interface specifications – Baseline privacy interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS DEPI] CM-SP-DEPI-I08-100611, *Data-over-cable service interface specifications, modular headend architecture – Downstream external-PHY interface*. Cable Television Laboratories, Inc.

[b-DOCSIS DRFI] CM-SP-DRFI-I16-170111, *Data-over-cable service interface specifications – Downstream RF interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS DSG] CM-SP-DSG-I25-170906, *Data-over-cable service interface specifications –Set-top gateway (DSG) interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS DTI] CM-SP-DTI-I06-150305, *Data-over-cable service interface specifications, Modular headend architecture – DOCSIS timing interface specification*. Cable Televisions Laboratories, Inc.

[b-DOCSIS eDOCSIS] CM-SP-eDOCSIS-I30-190213, *Data-over-cable service interface specifications, eDOCSIS specification*. Cable Television Laboratories, Inc.

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[b-DOCSIS LLX] CM-SP-LLX-I02-20623, *Data over cable service interface specification, mobile applications – Low latency mobile Xhaul over DOCSIS® technology*, Cable Television Laboratories, Inc.

[b-DOCSIS M-OSSI] CM-SP-M-OSSI-I08-081209, *Data-over-cable service interface specifications, Modular headend architecture – M-CMTS operations support system interface specification.* Cable Television Laboratories, Inc.

[b-DOCSIS MULPIv3.0] CM-SP-MULPIv3.0-C01-171207, *Data-over-cable service interface specifications, DOCSIS 3.0 – MAC and upper layer protocols interface specification.* Cable Television Laboratories, Inc.

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[b-DOCSIS OSSIv2.0] CM-SP-OSSIv2.0-C01-081104, *Data-over-cable service interface specifications, DOCSIS 2.0 – Operations support system interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS OSSIv3.0] CM-SP-OSSIv3.0-C01-171207, *Data-over-cable service interface specifications, DOCSIS 3.0 – Operations support system interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS PHYv3.0] CM-SP-PHYv3.0-C01-171207, *Data-over-cable service interface specifications, DOCSIS 3.0 – Physical layer specification*. Cable Television Laboratories, Inc.

[b-DOCSIS R-DEPI] CM-SP-R-DEPI-I12-190307, *Data-over-cable service interface specifications, DCA - MHAv2 – Remote downstream external PHY interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS-R-PHY] CM-SP-R-PHY-I12-190307, *Data-over-cable service interface specifications, DCA - MHAv2 – Remote PHY specification.* Cable Television Laboratories, Inc.

[b-DOCSIS RFIv1.1] CM-SP-RFIv1.1-C01-050907, *Data-over-cable service interface specifications, DOCSIS 1.1 – Radio frequency interface specification*. Cable Television Laboratories, Inc.

[b-DOCSIS RFIv2.0] CM-SP-RFIv2.0-C02-090422, *Data-over-cable service interface specifications, DOCSIS 2.0 – Radio frequency interface specification.* Cable Television Laboratories, Inc.

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[b-DOCSIS SECv3.0] CM-SP-SECv3.0-C01-171207, *Data-over-cable service interface specifications, DOCSIS 3.0 – Security specification*. Cable Television Laboratories, Inc.

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[b-CCAP-EVENTS-YANG] CCAP YANG, Module for Event Messaging, CCAPevents.yang, http://mibs.cablelabs.com/YANG/DOCSIS/

[b-CCAP-MIB] Converged Cable Access Platform MIB, CCAP-MIB, http://mibs.cablelabs.com/MIBs/DOCSIS

[b-CLAB-TOPO-MIB] CableLabs Topology MIB, CLAB-TOPO-MIB, http://mibs.cablelabs.com/MIBs/common/

[b-DOCS-BPI2EXT-MIB] CableLabs DOCSIS DOCS-BPI2EXT-MIB SNMP MIB Module, DOCS-BPI2EXT-MIB, http://mibs.cablelabs.com/MIBs/DOCSIS

[b-DOCS-DIAG-MIB] DOCSIS Diagnostic Log MIB, DOCS-DIAG-MIB, http://mibs.cablelabs.com/MIBs/DOCSIS/

[b-DOCS-IF3-MIB] DOCSIS Interface 3 MIB Module, DOCS-IF3-MIB, http://mibs.cablelabs.com/MIBs/DOCSIS/

[b-DOCS-IF31-MIB] DOCSIS Interface 3.1 MIB Module, DOCS-IF31-MIB, http://mibs.cablelabs.com/MIBs/DOCSIS/

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