

Data-Over-Cable Service Interface Specifications DOCSIS® 3.1

MAC and Upper Layer Protocols Interface Specification

CM-SP-MULPIv3.1-I25-230419

ISSUED

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Annex D CM Configuration Interface Specification (Normative)

D.1 CM Configuration

D.1.1 CM Binary Configuration File Format

The CM-specific configuration data is contained in a file which is downloaded to the CM via TFTP. This is a binary file in the same format defined for DHCP vendor extension data [RFC 2132].

It consists of a number of configuration settings (1 per parameter) each of the form: Type Length Value.

Type is a single-octet identifier which defines the parameter.

Length is a single octet containing the length of the value field in octets (not including type and length fields).

Value is from one to 254 octets containing the specific value for the parameter.

The configuration settings follow each other directly in the file, which is a stream of octets (no record markers).

The CMs MUST support an 8192-byte configuration file at a minimum.

Authentication of the provisioning information is provided by two message integrity check (MIC) configuration settings, CM MIC and, CMTS MIC.

- CM MIC is a digest which ensures that the data sent from the provisioning server were not modified en route. This is NOT an authenticated digest (it does not include any shared secret).
- CMTS MIC is a digest used to authenticate the provisioning server to the CMTS during registration. It is calculated over a number of fields, one of which is a shared secret between the CMTS and the provisioning server.

Use of the CM MIC allows the CMTS to authenticate the provisioning data without needing to receive the entire file.

Thus, the file structure is of the form shown in Figure 253.

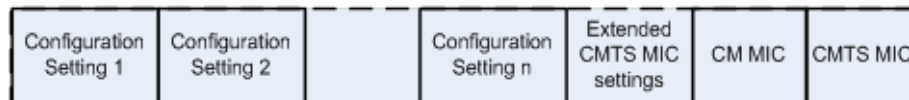


Figure 253 - Binary Configuration File Format

D.1.2 Configuration File Settings

The following configuration settings are included in the configuration file and MUST be supported by all CMs. The CM MUST NOT send a REG-REQ-MP based on a configuration file that lacks these mandatory items.

- Network Access Configuration Setting
- CM MIC Configuration Setting
- CMTS MIC Configuration Setting
- End Configuration Setting
- Upstream Service Flow Configuration Setting
- Downstream Service Flow Configuration Setting

The following configuration settings may be included in the configuration file; and if present, MUST be supported by all CMs:

- Downstream Frequency Configuration Setting
- Upstream Channel ID Configuration Setting
- Baseline Privacy Configuration Setting
- Software Upgrade Filename Configuration Setting
- Upstream Packet Classification Setting
- Downstream Packet Classification Setting
- SNMP Write-Access Control
- SNMP MIB Object
- Software Server IP Address
- CPE Ethernet MAC Address
- Maximum Number of CPEs
- Maximum Number of Classifiers
- Privacy Enable Configuration Setting
- TFTP Server Timestamp
- TFTP Server Provisioned Modem Address (IPv4 or IPv6)
- Pad Configuration Setting
- SNMPv3 Notification Receiver
- Enable Test Modes
- Static Multicast MAC Address

The following configuration settings may be included in the configuration file; and if present, MAY be supported by a CM: DOCSIS Extension Field Configuration Settings

NOTE: There is a limit on the size of Registration Request and Registration Response frames (see the subsection Registration Request Messages in Section 6. The configuration file should not be so large as to require the CM or CMTS to exceed that limit.

If the Extended CMTS MIC Encoding is included in the CM Configuration file, the CM MUST include in its REG-REQ-MP message all instances of top-level TLVs in the CM configuration for which there is a '1' bit in the CMTS MIC Encoding Bitmask.

D.1.3 Configuration File Creation

The sequence of operations required to create the configuration file is as shown in Figure 254 through Figure 258.

1. Create the type/length/value entries for all the parameters required by the CM.

type, length, value for parameter 1
type, length, value for parameter 2
type, length, value for parameter n

Figure 254 - Create TLV Entries for Parameters Required by the CM

2. Insert the Extended CMTS MIC Parameters configuration setting as defined in Annex D.2.1 and add to the file following the last parameter using code and length values defined for this field. A configuration file for a pre-DOCSIS 3.0 modem MAY include the Extended CMTS MIC.

NOTE: The Extended CMTS MIC Encoding may include an Explicit Extended CMTS MIC Digest subtype that is calculated over the top-level parameters in the Extended CMTS MIC Bitmap, ordered first by top-level TLV type code and secondly by their position within the CM configuration file (and hence their position in REG-REQ-MP).

NOTE: The Explicit Extended CMTS MIC Digest value, if present, does not include either the CM MIC or CMTS MIC digest value. If the Explicit Extended CMTS MIC Digest value is present, and the Extended CMTS MIC Bitmap indicates that TLV 43 is to be covered by the Extended CMTS MIC, then the Explicit Extended CMTS MIC Digest TLV is initially populated with an all-zeros value (and length appropriate for the HMAC Type selected) for purposes of the Extended CMTS MIC Digest calculation.

type, length, value for parameter 1
type, length, value for parameter 2
type, length, value for parameter n
type, length, value for Ext CMTS MIC Params

Figure 255 - Add Extended CMTS MIC Parameters

3. Calculate the CM message integrity check (MIC) configuration setting as defined in Annex D.1.3.1 and add to the file following the Extended CMTS MIC Params using code and length values defined for this field.

NOTE: The CM MIC code includes the Explicit Extended CMTS MIC digest value, if present in the config file.

type, length, value for parameter 1
type, length, value for parameter 2
type, length, value for parameter n
type, length, value for Ext CMTS MIC Params
type, length, value for CM MIC

Figure 256 - Add CM MIC

4. Calculate the CMTS message integrity check (MIC) configuration setting as defined in Annex D.2.1 and add to the file following the CM MIC using code and length values defined for this field, and parameters defined in the Extended CMTS MIC Params configuration setting.

type, length, value for parameter 1
type, length, value for parameter 2
type, length, value for parameter n
type, length, value for Ext CMTS MIC Params
type, length, value for CM MIC
type, length, value for CMTS MIC

Figure 257 - Add CMTS MIC

5. Add the end of data marker and any needed padding bytes.

type, length, value for parameter 1	
type, length, value for parameter 2	
type, length, value for parameter n	
type, length, value for Ext CMTS MIC Params	
type, length, value for CM MIC	
type, length, value for CMTS MIC	
End of data marker	Pad (if required)

Figure 258 - Add End of Data Marker and Padding

D.1.3.1 CM MIC Calculation

The CM message integrity check configuration setting **MUST** be calculated by performing an MD5 digest over the bytes of the configuration setting fields. It is calculated over the bytes of these settings as they appear in the TFTPed image, without regard to TLV ordering or contents.

There are two TLVs which are not included in the CM MIC calculation:

- The bytes of the CM MIC TLV itself are omitted from the calculation. This includes the type, length, and value fields;
- The bytes of the CMTS MIC TLV are omitted from the calculation. This includes the type, length, and value fields.

These TLVs are the last TLVs in the CM configuration file.

NOTE: The bytes of the Extended CMTS MIC Params TLV are specifically included in the calculation and therefore need to be inserted in the configuration file prior to the CM MIC. This includes the type, length, and value fields.

The CM **MUST** accept configuration files with any number of TLVs following the CM MIC regardless of their length, unless the total file length exceeds the CM's maximum supported configuration file length.

On receipt of a configuration file, the CM **MUST** recompute the digest and compare it to the CM MIC configuration setting in the file. If the digests do not match, then the CM **MUST** discard the configuration file.

D.2 Configuration Verification

It is necessary to verify that the CM's configuration file has come from a trusted source. Thus, the CMTS and the configuration server share an Authentication String that they use to verify portions of the CM's configuration in the Registration Request.

D.2.1 CMTS MIC Calculation

The CMTS MUST calculate a CMTS MIC Digest value on TLVs of the REG-REQ/REG-REQ-MP message and compare it to the CMTS Message Integrity Check configuration setting in TLV7. If the Extended CMTS MIC Encoding is present but does not include an Explicit E-MIC Digest subtype, it indicates that the Extended CMTS MIC digest is implicitly provided in the CMTS MIC Configuration Setting of TLV7. In this case, the CMTS calculates only an Extended CMTS MIC digest using the TLVs indicated in the E-MIC Bitmap and compares it to the CMTS MIC Configuration Setting in TLV7. When the Extended CMTS MIC is implicitly provided in TLV7, the CMTS MUST confirm that the calculated Extended CMTS MIC digest matches the implicit digest in TLV7 in order to authorize the CM for registration.

If the Extended CMTS MIC Encoding is present and provides an Explicit E-MIC Digest subtype, the CMTS calculates both an Extended MIC Digest value and a "pre-3.0 DOCSIS" CMTS MIC digest value using the TLVs reported in REG-REQ or REG-REQ-MP. When both the Extended MIC digest and the pre-3.0 DOCSIS CMTS Digest are checked, the CMTS MUST consider a CM to be authorized when only the pre-3.0 DOCSIS CMTS Digest matches. If the pre-3.0 DOCSIS CMTS MIC digest matches but the explicit Extended CMTS MIC does not, the CMTS MUST silently ignore TLVs in REG-REQ and REG-REQ-MP which were marked as protected by the Extended CMTS MIC Bitmap and are not one of the pre-3.0 DOCSIS CMTS MIC TLVs provided in the Pre-3.0 DOCSIS CMTS MIC TLV List.

If the Extended CMTS MIC Encoding TLV is not present, or if the Extended CMTS MIC Encoding TLV is present and includes an Explicit E-MIC Digest Subtype, then the CMTS MUST calculate the message integrity check configuration setting by performing an MD5 digest over the following configuration setting fields when present in the REG-REQ or REG-REQ-MP messages, in the order shown:

- Downstream Frequency Configuration Setting
- Upstream Channel ID Configuration Setting
- Network Access Configuration Setting
- Baseline Privacy Configuration Setting
- DOCSIS Extension Field Configuration Settings (including Extended CMTS MIC Params)
- CM MIC Configuration Setting
- Maximum Number of CPEs
- TFTP Server Timestamp
- TFTP Server Provisioned Modem Address (IPv4 or IPv6)
- Upstream Packet Classification Setting
- Downstream Packet Classification Setting
- Upstream Service Flow Configuration Setting
- Downstream Service Flow Configuration Setting
- Maximum Number of Classifiers
- Privacy Enable Configuration Setting
- Subscriber Management Control
- Subscriber Management CPE IP Table

- Subscriber Management Filter Groups
- Enable Test Modes

The authentication string is a shared secret between the provisioning server (which creates the configuration files) and the CMTS. It allows the CMTS to authenticate the CM provisioning. The authentication string is to be used as the key for calculating the keyed extended CMTS MIC digest as stated in the Annex D.2.1.1.

The mechanism by which the shared secret is managed is up to the system operator.

On receipt of a configuration file, the CM MUST forward the CMTS MIC as part of the Registration Request (REG-REQ-MP), regardless of its length.

On receipt of a configuration file containing an Extended CMTS MIC Encoding TLV, the CM MUST forward in the Registration Request message all TLVs selected by the E-MIC Bitmap regardless of whether the CM understands the functionality related to those TLVs. The CM MUST send the TLVs that are selected for inclusion in the CMTS MIC or Extended CMTS MIC calculation in the order in which they appear in the config file.

It is important for the CM to preserve the ordering of TLVs from the config file, since this is the order in which they were used when calculating the Extended CMTS MIC Digest.

On receipt of a REG-REQ or REG-REQ-MP, the CMTS MUST attempt to validate the CMTS MIC. If the CMTS is unable to validate the REG-REQ or REG-REQ-MP according to the configuration setting (either because the REG-REQ or REG-REQ-MP does not contain the appropriate MIC TLV or because the HMAC type indicates a hash algorithm unsupported by the CMTS) the CMTS MUST reject the Registration Request by setting the authentication failure result in the Registration Response status field.

To validate the CMTS MIC, the CMTS MUST recompute the digest over the included fields and the authentication string and compare it to the CMTS MIC configuration setting in the file. If the digests do not match, the Registration Request MUST be rejected by setting the authentication failure result in the Registration Response status field.

The CMTS MUST silently ignore any configuration file TLV in the Registration Request that is neither MIC protected (via the Pre-3.0 DOCSIS CMTS MIC or Extended CMTS MIC) nor one of the allowed unprotected TLVs explicitly mentioned in the list of "Configuration File Settings" provided in the subsection Registration Request Messages in Section 6. As a result of this requirement, the configuration file generator needs to ensure that any configuration file TLV (other than those explicitly listed in the subsection Registration Request Messages in Section 6.) that is intended to be transmitted to the CMTS in Registration is protected by either the Pre-3.0 DOCSIS CMTS MIC or the Extended CMTS MIC or both.

D.2.1.1 Pre-3.0 DOCSIS CMTS MIC Digest Calculation

If the Extended CMTS MIC Configuration Setting TLV is not present, or the Extended CMTS MIC Encoding is present and contains an Explicit Extended CMTS MIC Subtype, then the CMTS calculates a pre-3.0 DOCSIS CMTS MIC digest field using HMAC-MD5 as defined in [RFC 2104] and only the set of pre-3.0 DOCSIS CMTS MIC TLVs in the order specified in Annex D.2.1 above. When the CMTS calculates a pre-3.0 DOCSIS CMTS MIC digest, the CMTS MUST consider a CM to be unauthorized to register when its calculated pre-3.0 DOCSIS CMTS MIC Digest value differs from the CMTS MIC Configuration Setting in TLV 7 of a REG-REQ or REG-REQ-MP message.

D.2.1.2 Extended CMTS MIC Digest Calculation

When the Extended CMTS MIC Encoding is present, the CMTS MUST calculate the Extended CMTS MIC over the set of TLVs in REG-REQ or REG-REQ-MP as indicated by the Extended CMTS MIC Bitmap subtype. The CMTS MUST calculate the Extended CMTS MIC digest over the selected TLVs in the order that they were received in the Registration Request. Within Type fields, the CMTS MUST calculate the extended CMTS MIC digest over the Subtypes in the order they were received. To allow for correct CMTS MIC calculation by the CMTS, the CM MUST NOT reorder configuration file TLVs of the same Type or Subtypes within any given Type in its Registration-Request message.

If the Extended CMTS MIC Encoding is present in the REG-REQ/REG-REQ-MP message and no Explicit EMIC Digest subtype is provided, the CMTS MIC Configuration Setting in TLV7 is considered to "implicitly" provide an

Extended CMTS MIC digest value. With an implicitly provided Extended CMTS MIC digest, the CMTS MUST compare the TLV7 CMTS MIC digest value to the calculated Extended CMTS MIC digest value. With implicit Extended CMTS MIC comparison, the CMTS MUST consider the CM to be unauthorized if the Extended CMTS MIC digest comparison fails.

The CMTS MUST support a configuration for the shared secret for Extended CMTS MIC calculation to differ from the shared secret for pre-3.0 DOCSIS CMTS MIC calculation, which uses the relatively insecure MD5 algorithm. In the absence of such configuration, the CMTS MUST use the same shared secret for Extended CMTS MIC Digest calculation as for pre-3.0 DOCSIS CMTS MIC digest calculation. The CMTS MUST calculate the Extended CMTS MIC using the algorithm specified in the Extended CMTS MIC Algorithm subtype. The CMTS MUST support the use of both the HMAC- MMH16- σ -n and the HMAC-MD5 hashing algorithms (see [DOCSIS SECv3.0] for details of the MMH hash). The CMTS MAY support other hashing algorithms.

MMH is the preferred algorithm for DOCSISv3.1 (see [DOCSIS SECv3.0]).

If the Explicit Extended CMTS MIC Digest Subtype is present, the CMTS compares its calculated E-MIC value to the Explicit E-MIC Digest value. If the Explicit Extended CMTS MIC Digest Subtype is present, and the Extended CMTS MIC Bitmap indicates that TLV 43 is covered by the Extended CMTS MIC, the CMTS MUST copy the Extended CMTS MIC Digest value out of the Explicit Extended CMTS MIC Digest Subtype (TLV 43.6.3) and replace its value with zeros (0) prior to calculating the E-MIC value.

If the CMTS is unable to verify the Extended CMTS MIC digest, it MUST ignore TLVs in REG-REQ and REG-REQ-MP that are protected only by the Extended CMTS MIC.

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I12-170906.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-17.1729-2	5/11/2017	Max Traffic Burst rate default value changes to accommodate higher US data rates	Mudugere
MULPIv3.1-N-17.1736-2	5/25/2017	Two primary channels are indicated in CM RCP for D-3.1 CMTS only	Mudugere
MULPIv3.1-N-17.1742-4	8/3/2017	Editorial corrections	Dolas
MULPIv3.1-N-17.1743-1	6/15/2017	Correction on RNG-REQ Error Reporting	Dolas
MULPIv3.1-N-17.1789-1	8/10/2017	Correction to MULPIv3.1-N-16.1685-2	Mudugere

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I13-171220.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-17.1798-1	9/21/2017	DBC changing primary downstream channel	Dolas
MULPIv3.1-N-17.1803-2	9/21/2017	CM is not allowed to send the traffic during registration state	Mudugere
MULPIv3.1-N-17.1810-1	10/26/2017	Clarification in CM capability TLV-5.36 for counting UGS US SF	Mudugere

The following Engineering Change was incorporated into CM-SP-MULPIv3.1-I14-180130.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-17.1764-9	12/14/2017	Addition of FDX Capability	Sundaresan

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I15-180509.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-17.1854-2	2/1/2018	Clarification in switchable diplexer feature	Mudugere
MULPIv3.1-N-18.1889-5	4/12/2018	Updates to FDX functionality	Sundaresan

The following Engineering Change was incorporated into CM-SP-MULPIv3.1-I16-180926.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-18.1942-6	8/30/2018	FDX Refinements	Sundaresan

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I17-190121.

ECN Identifier	Accepted Date	Title of EC	Author
Correction per MULPIv3.1-N-15.1294-2	11/5/2018	Correction of the spelling of 'Pload' in Section 8.3.3.2.4, change #6 requirement	Sundaresan
MULPIv3.1-N-18.1939-14	12/20/2018	Low Latency Support	White
MULPIv3.1-N-18.1957-1	10/11/2018	Clarification of ToD State Machine Operation During Registration	Fish
MULPIv3.1-N-18.1974-1	12/6/2018	Update RBA Advance time, and Notes on Initialization	Sundaresan
MULPIv3.1-N-18.1975-1	12/6/2018	Updates to OPT process for FDX	Sundaresan
MULPIv3.1-N-18.1976-1	12/6/2018	EC RBA Sub-band direction set capabilities	Rudek

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I18-190422.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-18.1991-4	2/28/2019	ECT Probe Marking, RBA Clarification, US Tx Pwr Storage, DHCP RFC update	Rudek
MULPIv3.1-N-19.2004-3	4/4/2019	Changes to DHCP behavior for CM	Bloom

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-19.2006-1	3/14/2019	New Encodings to Support QoS Framework for DOCSIS	Andreoli-Fang
MULPIv3.1-N-19.2011-5	4/4/2019	Clarifications and refinements to LLD technology	Sundaresan

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I19-191016.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-19.2037-4	8/15/2019	Removing FDX functionality out of DOCSIS 3.1	Sundaresan
MULPIv3.1-N-19.2050-4	9/26/2019	Refining Low Latency functionality	White

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I20-200407.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-19.2069-3	3/12/2020	LLD refinements and other miscellaneous changes	Sundaresan
MULPIv3.1-N-19.2084-1	3/5/2020	Enhanced Hierarchical QoS (EHQoS)	Liu
MULPIv3.1-N-20.2088-1	4/2/2020	Fix DTP Typos	Chavarria Reyes

The following Engineering Change was incorporated into CM-SP-MULPIv3.1-I21-201020.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-20.2116-3	10/8/2020	LLD miscellaneous refinements	White

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I22-211110.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-20.2121-1	10/29/2020	Aligning MULPI to SYNC spec	Chavarria Reyes
MULPIv3.1-N-21.2153-1	3/18/2021	New TLVs for SYNC and MULPI DTP section error correction	Andreoli-Fang
MULPIv3.1-N-21.2164-1	5/20/2021	One minor change, one corner case fix, plus editorial clean up in LLD spec text	White
MULPIv3.1-N-21.2165-2	5/27/2021	Update to Upstream Data Profile Testing Bursts	

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I23-220328.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-21.2210-2	1/6/2022	Support for Overlapping OFDMA Channels (OOC)	Coldren
MULPIv3.1-N-21.2211-1	12/16/2021	Deprecation of references to IEEE 802.1D	Webster
MULPIv3.1-N-22.2234-1	3/10/2022	Add eTR to Ranging Hold-Off Support	Jones

The following Engineering Change was incorporated into CM-SP-MULPIv3.1-I24-221019.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-22.2281-3	9/22/2022	OPT-ACK, TLV 98/99, CM-STATUS, Annex G, miscellaneous language cleanup	Sundaresan

The following Engineering Changes were incorporated into CM-SP-MULPIv3.1-I25-230419.

ECN Identifier	Accepted Date	Title of EC	Author
MULPIv3.1-N-22.2295-2	3/23/2023	Virtual Queue Delay Estimation for CMs, Relative Ordering of QP and IAQM	White
MULPIv3.1-N-23.2299-4	3/30/23	Service Flow handling, SID, MDD and other miscellaneous	Sundaresan

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