

ISO/IEC/IEEE 8802-1AE:2020-08 (E)

Telecommunications and exchange between information technology systems - Requirements for local and metropolitan area networks - Part 1AE: Media access control (MAC) security

Contents

1.	Overview.....	16
1.1	Introduction.....	16
1.2	Scope.....	17
2.	Normative references.....	18
3.	Definitions	19
4.	Abbreviations and acronyms	23
5.	Conformance.....	25
5.1	Requirements terminology.....	25
5.2	Protocol Implementation Conformance Statement (PICS).....	25
5.3	MAC Security Entity requirements	26
5.4	MAC Security Entity options	27
5.5	EDE conformance.....	27
5.6	EDE-M conformance.....	28
5.7	EDE-CS conformance.....	28
5.8	EDE-CC conformance	29
5.9	EDE-SS conformance	29
6.	Secure provision of the MAC Service	30
6.1	MAC Service primitives and parameters.....	30
6.2	MAC Service connectivity.....	32
6.3	Point-to-multipoint LANs.....	32
6.4	MAC status parameters.....	33
6.5	MAC point-to-point parameters.....	33
6.6	Security threats	34
6.7	MACsec connectivity	35
6.8	MACsec guarantees	35
6.9	Security services	36
6.10	Quality of Service maintenance	37
7.	Principles of secure network operation.....	39
7.1	Support of the secure MAC Service by an individual LAN	39
7.2	Multiple instances of the secure MAC Service on a single LAN	44
7.3	Use of the secure MAC Service.....	45
8.	MAC Security protocol (MACsec).....	48
8.1	Protocol design requirements.....	48
8.2	Protocol support requirements	51
8.3	MACsec operation	53
9.	Encoding of MACsec Protocol Data Units.....	55
9.1	Structure, representation, and encoding.....	55
9.2	Major components	55
9.3	MAC Security TAG	56
9.4	MACsec EtherType	56

9.5	TAG Control Information (TCI).....	57
9.6	Association Number (AN).....	58
9.7	Short Length (SL)	58
9.8	Packet Number (PN)	58
9.9	Secure Channel Identifier (SCI)	59
9.10	Secure Data	59
9.11	Integrity check value (ICV)	59
9.12	PDU validation	60
10.	Principles of MAC Security Entity (SecY) operation	61
10.1	SecY overview	61
10.2	SecY functions.....	62
10.3	Model of operation.....	63
10.4	SecY architecture.....	63
10.5	Secure frame generation	65
10.6	Secure frame verification.....	68
10.7	SecY management	72
10.8	Addressing	85
10.9	Priority	85
10.10	SecY performance requirements.....	86
11.	MAC Security in systems	87
11.1	MAC Service interface stacks.....	87
11.2	MACsec in end stations	88
11.3	MACsec in MAC Bridges.....	89
11.4	MACsec in VLAN-aware Bridges.....	90
11.5	MACsec and Link Aggregation	91
11.6	Link Layer Discovery Protocol (LLDP).....	92
11.7	MACsec in Provider Bridged Networks	93
11.8	MACsec and multi-access LANs.....	95
12.	MACsec and EPON	97
13.	MAC Security Entity MIB.....	98
13.1	Introduction.....	98
13.2	The Internet-Standard Management Framework	98
13.3	Relationship to other MIBs.....	98
13.4	Security considerations	100
13.5	Structure of the MIB module	102
13.6	MAC Security Entity (SecY) MIB definitions	107
14.	Cipher Suites	141
14.1	Cipher Suite use	141
14.2	Cipher Suite capabilities	142
14.3	Cipher Suite specification	143
14.4	Cipher Suite conformance	143
14.5	Default Cipher Suite (GCM-AES-128)	145
14.6	GCM-AES-256	146
14.7	GCM-AES-XPN-128.....	147
14.8	GCM-AES-XPN-256.....	148

15.	Ethernet Data Encryption devices.....	149
15.1	EDE characteristics.....	149
15.2	Securing LANs with EDE-Ms	150
15.3	Securing connectivity across PBNs	152
15.4	Securing PBN connectivity with an EDE-M	153
15.5	Securing PBN connectivity with an EDE-CS	154
15.6	Securing PBN connectivity with an EDE-CC	156
15.7	Securing PBN connectivity with an EDE-SS	158
15.8	EDE Interoperability	159
15.9	EDEs, CFM, and UNI Access	160
16.	Using MIB modules to manage EDEs	161
16.1	Security considerations	161
16.2	EDE-M Management.....	161
16.3	EDE-CS Management.....	161
16.4	EDE-CC and EDE-SS Management.....	161
	Annex A (normative) PICS proforma.....	163
A.1	Introduction.....	163
A.2	Abbreviations and special symbols.....	163
A.3	Instructions for completing the PICS proforma.....	164
A.4	PICS proforma for IEEE Std 802.1AE	166
A.5	Major capabilities	167
A.7	MAC status and point-to-point parameters.....	169
A.6	Support and use of Service Access Points	169
A.8	Secure Frame Generation.....	170
A.9	Secure Frame Verification	171
A.10	MACsec PDU encoding and decoding	172
A.11	Key Agreement Entity LMI.....	172
A.12	Management	173
A.13	Additional fully conformant Cipher Suite capabilities	177
A.14	Additional variant Cipher Suite capabilities	177
	Annex B (informative) Bibliography	180
	Annex C (informative) MACsec test vectors	182
C.1	Integrity protection (54-octet frame)	183
C.2	Integrity protection (60-octet frame)	188
C.3	Integrity protection (65-octet frame)	193
C.4	Integrity protection (79-octet frame)	198
C.5	Confidentiality protection (54-octet frame).....	203
C.6	Confidentiality protection (60-octet frame).....	208
C.7	Confidentiality protection (61-octet frame).....	213
C.8	Confidentiality protection (75-octet frame).....	218
	Annex D (normative) PICS proforma for an Ethernet Data Encryption device	223
D.1	Introduction.....	223
D.2	Abbreviations and special symbols.....	223
D.3	Instructions for completing the PICS proforma.....	224
D.4	PICS proforma for IEEE Std 802.1AE EDE	226
D.5	EDE type and common requirements	227

D.6	EDE-M Configuration	228
D.7	EDE-CS Configuration	229
D.8	EDE-CC Configuration.....	229
D.9	EDE-SS Configuration	229
	Annex E (informative) MKA operation for multiple transmit SCs	230
	Annex F (informative) EDE Interoperability and PAE addresses	232
	Annex G (informative) Management and MIB revisions	235
G.1	Counter changes.....	236
G.2	Available Cipher Suites	237

Figures

Figure 6-1	MACsec secured LAN with three stations.....	30
Figure 6-2	MACsec Frame, VLAN TAG, and QoS	32
Figure 7-1	Two stations connected by a point-to-point LAN.....	40
Figure 7-2	Two stations in a CA created by MACsec Key Agreement	40
Figure 7-3	Secure communication between two stations	41
Figure 7-4	Four stations attached to a shared media LAN	41
Figure 7-5	A CA including ports A, B, and C	42
Figure 7-6	Secure communication between three stations	42
Figure 7-7	Secure Channel and Secure Association Identifiers	44
Figure 8-1	MACsec	48
Figure 8-2	MACsec operation	54
Figure 9-1	MPDU components.....	56
Figure 9-2	SecTAG format.....	56
Figure 9-3	MACsec EtherType encoding.....	57
Figure 9-4	MACsec TCI and AN Encoding	57
Figure 10-1	SecY	61
Figure 10-2	SecY architecture and operation	64
Figure 10-3	Management controls and counters for secure frame generation	66
Figure 10-4	Management controls and counters for secure frame verification.....	69
Figure 10-5	SecY managed objects	73
Figure 11-1	Direct support of the MAC Service by a media access method.....	87
Figure 11-2	Provision of MAC Service with media-independent functions	88
Figure 11-3	MACsec in an end station	88
Figure 11-4	MACsec in a VLAN-unaware MAC Bridge.....	89
Figure 11-5	VLAN-unaware MAC Bridge Port with MACsec.....	89
Figure 11-6	Addition of MAC Security to a VLAN-aware MAC Bridge.....	90
Figure 11-7	IEEE 802.1Q VLAN-aware Bridge Port with MACsec	90
Figure 11-8	MACsec and Link Aggregation in an interface stack.....	91
Figure 11-9	IEEE 802.1Q VLAN-aware Bridge Port with MACsec and Link Aggregation	92
Figure 11-10	MACsec with LLDP	92
Figure 11-11	Internal organization of the MAC sublayer in a Provider Bridged Network.....	93
Figure 11-12	Interface stack for MAC Security to and across provider's network.....	93
Figure 11-13	Provider network with priority selection and aggregation.....	94
Figure 11-14	An example multi-access LAN	95
Figure 11-15	Multi-access LAN interface stack.....	96
Figure 12-1	MACsec with EPON, showing SCs and SCB.....	97
Figure 13-1	MACsec Interface Stack	98
Figure 13-2	SecY MIB structure.....	103
Figure 14-1	Cipher Suite Protect and Validate operations	141
Figure 15-1	EDE-Ms connected by a point-to-point LAN.....	150
Figure 15-2	EDE-Ms securing a point-to-point LAN between Provider Bridges	151
Figure 15-3	MACsec protected frame traversing a PBN.....	152
Figure 15-4	EDE-Ms securing point-to-point LAN connectivity across a PBN	153
Figure 15-5	EDE-Ms securing multi-point PBN connectivity	154
Figure 15-6	Example network with an EDE-CS	155
Figure 15-7	EDE-CS connected to a PBN S-tagged interface.....	156
Figure 15-8	Using an EDE-CC with a C-tagged provider service interface	157
Figure 15-9	EDE-CC architecture	158

Tables

Table 9-1	MACsec EtherType allocation.....	56
Table 10-1	Management controls and SecTAG encoding	67
Table 10-2	Extended packet number recovery (examples).....	70
Table 10-3	SecY performance requirements.....	86
Table 13-1	Use of ifGeneralInformationGroup Objects	99
Table 13-2	Use of ifCounterDiscontinuityGroup Object	100
Table 13-3	Use of ifStackTable	100
Table 13-4	Use of ifStackGroup2 Objects	100
Table 13-5	Controlled Port service management.....	104
Table 13-6	Transmit and receive SC management	105
Table 13-7	Transmit and receive statistics	106
Table 13-8	Cipher Suite information	107
Table 14-1	MACsec Cipher Suites.....	144
Table 15-1	PAE Group Addresses	159
Table 15-2	PAE Group Address use	160
Table C-1	Unprotected frame (example)	183
Table C-2	Integrity protected frame (example)	183
Table C-3	GCM-AES-128 Key and calculated ICV (example)	184
Table C-4	GCM-AES-256 Key and calculated ICV (example)	185
Table C-5	GCM-AES-XPN-128 Key and calculated ICV (example).....	186
Table C-6	GCM-AES-XPN-256 Key and calculated ICV (example).....	187
Table C-7	Unprotected frame (example)	188
Table C-8	Integrity protected frame (example)	188
Table C-9	GCM-AES-128 Key and calculated ICV (example)	189
Table C-10	GCM-AES-256 Key and calculated ICV (example)	190
Table C-11	GCM-AES-XPN-128 Key and calculated ICV (example).....	191
Table C-12	GCM-AES-XPN-256 Key and calculated ICV (example).....	192
Table C-13	Unprotected frame (example)	193
Table C-14	Integrity protected frame (example)	193
Table C-15	GCM-AES-128 Key and calculated ICV (example)	194
Table C-16	GCM-AES-256 Key and calculated ICV (example)	195
Table C-17	GCM-AES-XPN-128 Key and calculated ICV (example).....	196
Table C-18	GCM-AES-XPN-256 Key and calculated ICV (example).....	197
Table C-19	Unprotected frame (example)	198
Table C-20	Integrity protected frame (example)	198
Table C-21	GCM-AES-128 Key and calculated ICV (example)	199
Table C-22	GCM-AES-256 Key and calculated ICV (example)	200
Table C-23	GCM-AES-XPN-128 Key and calculated ICV (example).....	201
Table C-24	GCM-AES-XPN-256 Key and calculated ICV (example).....	202
Table C-25	Unprotected frame (example)	203
Table C-26	Confidentiality protected frame (example).....	203
Table C-27	GCM-AES-128 Key, Secure Data, and ICV (example)	204
Table C-28	GCM-AES-256 Key, Secure Data, and ICV (example)	205
Table C-29	GCM-AES-XPN-128 Key, Secure Data, and ICV (example).....	206
Table C-30	GCM-AES-XPN-256 Key, Secure Data, and ICV (example).....	207
Table C-31	Unprotected frame (example)	208
Table C-32	Confidentiality protected frame (example).....	208
Table C-33	GCM-AES-128 Key, Secure Data, and ICV (example)	209
Table C-34	GCM-AES-256 Key, Secure Data, and ICV (example)	210
Table C-35	GCM-AES-XPN-128 Key, Secure Data, and ICV (example).....	211
Table C-36	GCM-AES-XPN-256 Key, Secure Data, and ICV (example).....	212
Table C-37	Unprotected frame (example)	213

Table C-38	Confidentiality protected frame (example).....	213
Table C-39	GCM-AES-128 Key, Secure Data, and ICV (example)	214
Table C-40	GCM-AES-256 Key, Secure Data, and ICV (example)	215
Table C-41	GCM-AES-XPN-128 Key, Secure Data, and ICV (example).....	216
Table C-42	GCM-AES-XPN-256 Key, Secure Data, and ICV (example).....	217
Table C-43	Unprotected frame (example)	218
Table C-44	Confidentiality protected frame (example).....	218
Table C-45	GCM-AES-128 Key, Secure Data, and ICV (example)	219
Table C-46	GCM-AES-256 Key, Secure Data, and ICV (example)	220
Table C-47	GCM-AES-XPN-128 Key, Secure Data, and ICV (example).....	221
Table C-48	GCM-AES-XPN-256 Key, Secure Data, and ICV (example).....	222
Table F-1	Interoperability scenarios and PAE Addresses.....	234