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Telecommunications and exchange between information technology systems — Requirements for local and metropolitan area networks

Part 1AX: Link aggregation

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Second edition
2021-09

Telecommunications and exchange between information technology systems — Requirements for local and metropolitan area networks —

Part 1AX: Link aggregation

Télécommunications et échange entre systèmes informatiques — Exigences pour les réseaux locaux et métropolitains —

Partie 1AX: Agrégation de lien

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IEEE Std 802.1AX™-2020
(Revision of IEEE Std 802.1AX-2014)

IEEE Standard for Local and Metropolitan Area Networks—

Link Aggregation

Developed by the

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 30 January 2020

IEEE SA Standards Board

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Abstract: Link Aggregation allows parallel point-to-point links to be used as if they were a single link and also supports the use of multiple links as a resilient load-sharing interconnect between multiple nodes in two separately administered networks. This standard defines a MAC-independent Link Aggregation capability and provides general information relevant to specific MAC types.

Keywords: Aggregated Link, Aggregator, Distributed Resilient Network Interconnect, DRNI, interconnect, Link Aggregation, Link Aggregation Group, local area network, management, Network-Network Interface, NNI

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Introduction

(This introduction is not part of IEEE Std 802.1AX-2020, IEEE Standard for Local and Metropolitan Area Networks—Link Aggregation.)

Link Aggregation allows one or more links to be aggregated together to form a Link Aggregation Group (LAG) so that the Link Aggregation Client can treat the LAG as if it were a single link. Link Aggregation was originally published as IEEE Std 802.3ad™-2000 and subsequently incorporated into the IEEE Std 802.3™, 2000 Edition. In 2008 Link Aggregation was removed from IEEE Std 802.3 and published as IEEE Std 802.1AX-2008. These standards specified the aggregation of full-duplex point-to-point links using IEEE Std 802.3 media of the same speed.

An amendment, IEEE Std 802.1AXbk™-2012, specified changes to the addressing used by the link aggregation control and marker protocols to allow a LAG to span Two-Port Media Access Control (MAC) Relays (TPMRs) and to span Provider Bridged Networks and Provider Backbone Bridge Networks.

A revision, IEEE Std 802.1AX-2014, extended Link Aggregation in three areas. First, it explicitly allowed the aggregation of point-to-point links of any speed using any physical media or logical connection capable of supporting the Internal Sublayer Service specified in IEEE Std 802.1AC™. Second, it specified Conversation-Sensitive Collection and Distribution (CSCD) that provides a mechanism to identify the distribution algorithm in use to map data frames to individual links in the LAG and to convey that information to the Link Aggregation Partner via Link Aggregation Control Protocol Data Units (LACPDUs) containing version 2 type/length/values (TLVs). Third, it specified Distributed Resilient Network Interconnect (DRNI) that allows a LAG to terminate at two or three cooperating Systems so that the LAG provides resiliency to System-level failures as well as link level failures. A corrigendum, IEEE Std 802.1AX-2014/Cor 1-2017, provided technical and editorial corrections to CSCD.

This revision, IEEE Std 802.1AX-2020, makes significant refinements and simplifications to the Link Aggregation Control Protocol (LACP) as well as to CSCD and DRNI. In LACP, the Periodic state machine and Transmit state machine are combined to a single machine, and the Mux machine is optimized to reduce the likelihood of excessive Link Aggregation Control Protocol Data Unit (LACPDU) transmissions. CSCD is refined to eliminate the TLVs that led to LACPDUs greater than 128 bytes in length. DRNI is significantly revised and simplified to support a LAG terminating at just two (not three) cooperating Systems.

Every effort has been made to maintain interoperability, without prior configuration, with LACP implementations conforming to IEEE Std 802.3ad-2000, IEEE Std 802.1AX-2008, or IEEE Std 802.1AX-2014 and with CSCD implementations conforming to IEEE Std 802.1AX-2014. The changes to DRNI, and in particular the Distributed Relay Control Protocol (DRCP), are such that an implementation conforming to this standard will not interoperate with a DRCP implementation conforming to IEEE Std 802.1AX-2014. The DRCP version number in this standard has been changed to version 2, and care has been taken so that a DRCP implementation conformant to IEEE Std 802.1AX-2014 will discard version 2 DRCPDUs as invalid and that implementations of this standard will discard version 1 DRCPDUs.

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are anticipated within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Information on the current revision state of this and other IEEE 802 standards may be obtained from

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Contents

1. Overview ... 18

1.1 Scope ... 18
1.2 Purpose ... 18
1.3 State diagram conventions ... 19

2. Normative references ... 20

3. Definitions ... 21

4. Acronyms and abbreviations ... 24

5. Conformance ... 25

5.1 Requirements terminology ... 25
5.2 Protocol implementation conformance statement ... 25
5.3 Link Aggregation ... 25
5.3.2 Link Aggregation options ... 26
5.4 Distributed Resilient Network Interconnect (DRNI) ... 26
5.4.2 DRNI options ... 27

6. Link Aggregation ... 28

6.1 Overview ... 28
6.1.1 Goals and objectives ... 28
6.1.2 Positioning of Link Aggregation within the IEEE 802 architecture ... 29
6.1.3 Protocol Parser/Multiplexer ... 29
6.1.3.1 Protocol Parser state diagram ... 30
6.2 Link Aggregation operation ... 31
6.2.1 Principles of Link Aggregation ... 33
6.2.2 Service interfaces ... 34
6.2.3 Frame Collector ... 34
6.2.3.1 Frame Collector state diagram ... 35
6.2.4 Frame Distributor ... 36
6.2.4.1 Frame Distributor state diagram ... 36
6.2.5 Marker Generator/Receiver (optional) ... 37
6.2.6 Marker Responder ... 38
6.2.7 Aggregator Parser/Multiplexer ... 38
6.2.7.1 Aggregator Parser/Multiplexer state diagrams ... 38
6.2.8 Aggregator ... 42
6.2.9 LACP Parser/Multiplexer ... 43
6.2.10 Addressing ... 43
6.2.10.1 Source address (SA) ... 43
6.2.10.2 Destination address (DA) ... 43
6.3 Link Aggregation Control ... 44
6.3.1 Characteristics of Link Aggregation Control ... 45
6.3.2 System identification ... 46
6.3.3 Aggregator identification ... 46
6.3.4 Port identification ... 46
6.3.5 Capability identification ... 47
6.3.6 Link Aggregation Group identification ... 48

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Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

6.3.6.1 Construction of the Link Aggregation Group Identifier 48
6.3.6.2 Representation of the Link Aggregation Group Identifier 48
6.3.7 Selecting a Link Aggregation Group 49
6.3.8 Agreeing on a Link Aggregation Group 49
6.3.9 Attaching a link to an Aggregator 50
6.3.10 Signaling readiness to transfer user data 50
6.3.11 Enabling the Frame Collector and Frame Distributor 50
6.3.12 MAC_Operational status 51
6.3.13 Monitoring the membership of a Link Aggregation Group 51
6.3.14 Detaching a link from an Aggregator 51
6.3.15 Configuration and administrative control of Link Aggregation 52
6.3.16 Link Aggregation Control state information 52
6.4 Link Aggregation Control Protocol 52
6.4.1 LACP design elements 52
6.4.2 LACPDU structure and encoding 53
6.4.2.1 Transmission and representation of octets 53
6.4.2.2 Encapsulation of LACPDUs in frames 53
6.4.2.3 LACPDU structure 54
6.4.2.4 Version 2 TLVs 57
6.4.3 LACP state machine overview 59
6.4.4 Constants 60
6.4.5 Variables associated with each Aggregator 61
6.4.6 Variables associated with each Aggregation Port 63
6.4.7 Variables used for managing the operation of the state machines 68
6.4.8 Functions 69
6.4.9 Timers 72
6.4.10 Messages 72
6.4.11 LACP Receive machine 72
6.4.12 Selection Logic 74
6.4.12.1 Selection Logic—Requirements 75
6.4.12.2 Selection Logic—Recommended default operation 77
6.4.13 Mux machine 78
6.4.14 LACP Transmit machine 81
6.5 Marker protocol 82
6.5.1 Introduction 82
6.5.2 Sequence of operations 83
6.5.3 Marker and Marker Response PDU structure and encoding 83
6.5.3.1 Transmission and representation of octets 83
6.5.3.2 Encapsulation of Marker and Marker Response PDU in frames 83
6.5.3.3 Marker and Marker Response PDU structure 84
6.5.4 Protocol definition 85
6.5.4.1 Operation of the marker protocol 85
6.5.4.2 Marker Responder state diagram 86
6.6 Conversation-Sensitive Collection and Distribution 87
6.6.1 Port Algorithms and Port Conversation IDs 89
6.6.2 Link numbers and link selection 89
6.6.3 Conversation-sensitive LACP 90
6.6.3.1 Per-Aggregator variables 91
6.6.3.2 Variables associated with each Aggregation Port 94
6.6.3.3 Variables used for managing the operation of the state diagrams 95
6.6.3.4 Functions 96
6.6.3.5 Update Mask machine 100
6.7 Configuration capabilities and restrictions 102
6.7.1 Use of system and port priorities 102

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Documents
Document Sharing Hub
Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

6.7.2 Dynamic allocation of operational Keys 103
6.7.3 Link Aggregation on shared-medium links 103
6.7.4 Selection Logic variants 104
6.7.4.1 Reduced reconfiguration 104
6.7.4.2 Limited Aggregator availability 104
6.7.5 LACP configuration for dual-homed Systems 104

7. Management 106

7.1 Overview 106
7.1.1 Systems management overview 106
7.1.2 Management model 107
7.2 Managed objects 107
7.2.1 Introduction 107
7.2.2 Overview of managed objects 108
7.2.2.1 Text description of managed objects 108
7.2.3 Containment 108
7.2.4 Naming 109
7.2.5 Capabilities 109
7.3 Management for Link Aggregation 114
7.3.1 Aggregator managed object class 114
7.3.1.1 Aggregator attributes 115
7.3.1.2 Aggregator Notifications 125
7.3.2 Aggregation Port managed object class 125
7.3.2.1 Aggregation Port Attributes 125
7.3.2.2 Aggregation Port Extension Attributes 132
7.3.3 Aggregation Port Statistics managed object class 133
7.3.3.1 Aggregation Port Statistics attributes 133
7.3.4 Aggregation Port Debug Information managed object class 134
7.3.4.1 Aggregation Port Debug Information attributes 135
7.4 Management for Distributed Resilient Network Interconnect 137
7.4.1 DRNI Managed Object Class 137
7.4.1.1 DRNI Attributes 137

8. Distribution algorithms 148

8.1 Distribution algorithm identification 148
8.2 Per-Service Frame Distribution 149
8.2.1 Distribution based on C-VLAN Identifier (C-VID) 149
8.2.2 Distribution based on S-VLAN Identifier (S-VID) 150
8.2.3 Distribution based on Backbone Service Instance Identifier (I-SID) 150
8.2.4 Distribution based on Traffic Engineering Service Instance Identifier (TE-SID) 150
8.2.5 Distribution based on Flow Hash 150

9. Distributed Resilient Network Interconnect 151

9.1 Goals 151
9.2 Distributed Relay operation 152
9.3 Intra-Relay Connection 154
9.4 Using DRNI 155
9.4.1 DRNI connectivity 155
9.4.2 DRNI fault recovery 157
9.4.3 DRNI configuration 158

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Documents
Document Sharing Hub

Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

9.5 DRNI Gateway 159
9.5.1 DRCP Parser/Multiplexer 160
9.5.2 DRNI Gateway Relay 160
9.5.2.1 Service interfaces 160
9.5.2.2 variables 161
9.5.2.3 Functions 162
9.5.2.4 Messages 162
9.5.2.5 DR_Gateway Collector/Distributor 162
9.5.2.6 DR_Aggregator Parser/Multiplexer 163
9.5.2.7 DR_IRP Parser/Multiplexer 164
9.5.3 DRNI Gateway Control 165
9.5.3.1 DRNI Gateway and DRNI Identification 165
9.5.3.2 Forming the DRNI 166
9.5.3.3 Partner Selection and Forming a LAG 166
9.5.3.4 Port Algorithm and Aggregator Port Selection 166
9.5.3.5 Gateway Algorithm and DRNI Gateway Port selection 167
9.6 Distributed Relay Control Protocol 168
9.6.1 DRCPDU transmission, addressing, and protocol identification 169
9.6.1.1 Destination MAC Address 169
9.6.1.2 Source MAC Address 170
9.6.1.3 Priority 170
9.6.1.4 Protocol Identification 170
9.6.1.5 Encapsulation of DRCPDUs in frames 170
9.6.2 DRCPDU structure and encoding 170
9.6.2.1 Transmission and representation of octets 170
9.6.2.2 DRCP TLV structure 171
9.6.2.3 DRCPDU structure 172
9.6.2.4 Aggregator State TLV 174
9.6.2.5 Gateway State TLV 176
9.6.2.6 Gateway Preference TLV 176
9.6.2.7 Organization-Specific TLV 177
9.6.3 DRCP state machine overview 178
9.6.4 Constants 179
9.6.5 Variables associated with the DRNI Gateway 179
9.6.6 Variables used for managing the operation of the state machines 185
9.6.7 Functions 187
9.6.8 Timers 194
9.6.9 Messages 194
9.6.10 DRCP Receive machine 195
9.6.11 Distributed Relay machine 197
9.6.12 DRNI Gateway and Aggregator machine 198
9.6.13 DRCP Transmit machine 199

Annex A (normative) Protocol implementation conformance statement (PICS) proforma 200
A.1 Introduction 200
A.1.1 Abbreviations and special symbols 200
A.1.2 Instructions for completing the PICS proforma 201
A.1.3 Additional information 201
A.1.4 Exceptional information 201
A.1.5 Conditional items 202
A.1.6 Identification 202
A.1.6.1 Implementation identification 202
A.1.6.2 Protocol summary 202

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AVA Documents Document Sharing Hub

Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

A.2 PICS proforma for Clause 6 ... 203
A.2.1 Major capabilities/options ... 203
A.2.3 Protocol Parser/Multiplexer support ... 204
A.2.4 Frame Collector ... 204
A.2.5 Frame Distributor ... 204
A.2.2 LLDP Port connectivity ... 204
A.2.7 Aggregator Parser/Multiplexer ... 205
A.2.8 LACP Parser/Multiplexer ... 205
A.2.6 Marker protocol ... 205
A.2.10 Aggregator identification ... 206
A.2.11 Port identification ... 206
A.2.12 Capability identification ... 206
A.2.9 System identification ... 206
A.2.14 Detaching a link from an Aggregator ... 207
A.2.15 LACPDU structure ... 207
A.2.16 Receive machine ... 207
A.2.13 Link Aggregation Group identification ... 207
A.2.18 Mux machine ... 208
A.2.17 Selection Logic ... 208
A.2.20 Marker protocol ... 209
A.2.19 Transmit machine ... 209
A.2.21 Management ... 210
A.2.23 Conversation-sensitive frame collection and distribution ... 211
A.2.22 Per-Service Frame Distribution ... 211
A.2.25 Link Aggregation on shared-medium links ... 212
A.2.24 Configuration capabilities and restrictions ... 212
A.2.27 DRCPDU structure ... 213
A.2.26 Distributed Resilient Network Interconnect ... 213

Annex B (informative) Collection and distribution algorithms ... 214
B.1 Introduction ... 214
B.2 Port selection ... 215
B.3 Dynamic reallocation of conversations to different Aggregation Ports ... 215
B.4 Topology considerations in the choice of distribution algorithm ... 216

Annex C (informative) LACP standby link selection and dynamic Key management ... 218
C.1 Introduction ... 218
C.2 Goals ... 218
C.3 Standby link selection ... 219
C.4 Dynamic Key management ... 219
C.5 A dynamic Key management algorithm ... 219
C.6 Example 1 ... 221
C.7 Example 2 ... 221

Annex D (normative) SMIv2 MIB definitions for Link Aggregation ... 223
D.1 Introduction ... 223
D.2 SNMP Management Framework ... 223
D.3 Security considerations ... 223
D.4 Structure of the MIB module ... 224
D.4.1 Relationship to the managed objects defined in Clause 7 ... 225
D.4.2 MIB Subtrees ... 232
D.4.2.1 The dot3adAgg Subtree ... 232
D.4.2.2 The dot3adAggPort Subtree ... 232

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Documents
Document Sharing Hub
Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

D.4.2.3 The dot3adAggNotifications Subtree 232
D.4.2.4 The dot3adDrni Subtree 232
D.5 Relationship to other MIBs 233
D.5.1 Relationship to the Interfaces MIB 233
D.5.2 Layering model 233
D.5.3 ifStackTable 234
D.5.4 ifRcvAddressTable 234
D.6 Definitions for Link Aggregation MIB 234

Annex E (informative) DRNI on Bridges 325
E.1 DRNI on VLAN Bridges 325
E.2 DRNI on Provider Bridges and Provider Edge Bridges 326
E.3 DRNI on Backbone Edge Bridges 327

Annex F (normative) Link Aggregation and Link Layer Discovery Protocol 328
F.1 Positioning Link Layer Discovery Protocol (LLDP) relative to Link Aggregation 328
F.1.1 LLDP Parser/Multiplexer 328
F.2 Link Aggregation TLV 328
F.2.1 aggregation status 329
F.2.2 aggregated Port ID 329
F.2.3 Link Aggregation TLV usage rules 329
F.2.4 Use of other TLVs on an Aggregator or Aggregation Link 330

Annex G (informative) Bibliography 331

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Documents
Document Sharing Hub
Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

Figures

Figure 6-1 Architectural positioning of Link Aggregation sublayer 29
Figure 6-2 Protocol Parser state diagram 31
Figure 6-3 Link Aggregation sublayer block diagram 32
Figure 6-4 Frame Collector state diagram 36
Figure 6-5 Frame Distributor state diagram 37
Figure 6-6 Aggregator Parser state diagram 41
Figure 6-7 Aggregator Multiplexer state diagram 42
Figure 6-8 LACPDU structure 54
Figure 6-9 Bit encoding of the Actor_State and Partner_State fields 55
Figure 6-10 Port Algorithm TLV 57
Figure 6-11 Port Conversation Link Digest TLV 58
Figure 6-12 Port Conversation Service Digest TLV 58
Figure 6-13 LACP state machine overview 59
Figure 6-14 LACP Receive state diagram 73
Figure 6-15 Selection of Aggregators 78
Figure 6-16 Mux state diagram 79
Figure 6-17 LACP Transmit state diagram 81
Figure 6-18 Marker protocol time sequence diagram 83
Figure 6-19 Marker PDU and Marker Response PDU structure 84
Figure 6-20 Marker Responder state diagram 86
Figure 6-21 Conversation-Sensitive Collection and Distribution overview 88
Figure 6-22 Distribution algorithm information flow 91
Figure 6-23 Update Mask state diagram 101
Figure 6-24 Dual-homed System examples 105
Figure 7-1 Link aggregation entity relationship diagram 109
Figure 8-1 Distribution algorithm identifiers 148
Figure 9-1 A DRNI 153
Figure 9-2 Transmission and reception via the IRC 154
Figure 9-3 DRNI with dedicated IRC Link 155
Figure 9-4 DRNI with dedicated IRC LAG 155
Figure 9-5 DRNI end station attach 156
Figure 9-6 DRNI network attach 156
Figure 9-7 DRNI Gateway block diagram 159
Figure 9-8 DR_Gateway state machine 163
Figure 9-9 DR_Aggregator state machine 164
Figure 9-10 DR_IRP state machine 165
Figure 9-11 Basic TLV format 171
Figure 9-12 DRCPDU structure 172
Figure 9-13 Bit encoding of the Home_IRP_State and Neighbor_IRP_State fields 173
Figure 9-14 Aggregator State TLV 174
Figure 9-15 Bit encoding of the Aggregator_CSCD_State fields 175
Figure 9-16 Gateway State TLV 176
Figure 9-17 Gateway Preference TLV 176
Figure 9-18 Organization-Specific TLV 177
Figure 9-19 DRCP state machine overview 178
Figure 9-20 DRCP Receive machine state diagram 195
Figure 9-21 Distributed Relay machine state diagram 197
Figure 9-22 DRNI Gateway and Aggregator machine state diagram 198
Figure 9-23 DRCP Transmit state diagram 199
Figure B-1 Link aggregation topology examples 217
Figure C-1 Example 1 221

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Documents
Document Sharing Hub
Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

Figure C-2 Example 2a 222
Figure C-3 Example 2b 222
Figure E-1 DRNI on VLAN Bridges 325
Figure E-2 DRNI on Provider Edge Bridges 326
Figure E-3 DRNI on Backbone Edge Bridges 327
Figure F-1 Link Aggregation TLV format 328

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Documents
Document Sharing Hub
Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

Tables

Table 6-1 Link Aggregation protocol destination addresses 44
Table 6-2 Example Partner parameters 49
Table 6-3 Slow Protocols EtherType Assignment 53
Table 6-4 Type field values of Version 2 TLVs 57
Table 7–1 Link Aggregation capabilities 110
Table 8-1 IEEE per-service distribution algorithms 149
Table 9-1 Distributed Relay Control Protocol destination addresses 169
Table 9-2 DRNI EtherType Assignment 170
Table 9-3 DRNI Protocol subtypes 170
Table 9-4 Type field values of DRCP TLVs 171
Table F.1 Link aggregation capability/status 329

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Full document details: BS ISO/IEC/IEEE 8802-1AX:2021

IEEE Standard for Local and Metropolitan Area Networks—

Link Aggregation

1. Overview

1.1 Scope

Link Aggregation provides protocols, procedures, and managed objects that allow the following:

— One or more parallel instances of point-to-point links to be aggregated together to form a Link Aggregation Group (LAG) so that a Link Aggregation Client can treat the LAG as if it were a single link.

— Conversation-Sensitive Collection and Distribution (CSCD) that specifies a means to identify the distribution algorithm in use to assign frames to individual links in a LAG and to convey that information to the System at the other end of the LAG.

— Distributed Resilient Network Interface (DRNI) that enables a LAG to terminate at a pair of cooperating Systems in order to provide system-level as well as link-level resiliency.

1.2 Purpose

Link Aggregation allows the establishment of point-to-point links that have a higher aggregate bandwidth than the individual links that form the aggregation and the use of multiple systems at each end of the aggregation. This allows improved utilization of available links in Bridged local area network (LAN) environments, along with improved resilience in the face of failure of individual links or systems. In applications connecting separately administered networks, the networks are isolated from each other's fault recovery events.

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1.3 State diagram conventions

This standard uses the state diagram conventions in Annex E of IEEE Std 802.1Q™-2018.[1]

When implementation of a state diagram is required for conformance, all states and transitions shown with solid lines shall be implemented. States and transitions shown with dashed lines may be implemented.

If a conflict exists between a state diagram and either the corresponding global transition tables or the textual description associated with the state machine, the state diagram takes precedence.

[1] Information on references can be found in Clause 2.

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2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this standard is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 802®, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.[2, 3]

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1Q™, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks.

IEEE Std 802.3™, IEEE Standard for Ethernet.

IETF RFC 1213 (IETF STD 17), Management Information Base for Network Management of TCP/IP-based internets: MIB-II, McCloghrie, K., and M. Rose, editors, Mar. 1991.[4]

IETF RFC 1321, The MD5 Message-Digest Algorithm, R. Rivest, Apr. 1992.

IETF RFC 2578 (STD 58), Structure of Management Information Version 2 (SMIv2), McCloghrie, K., D. Perkins, and J. Schoenwaelder, Apr. 1999.

IETF RFC 2579 (STD 58), Textual Conventions for SMIv2, McCloghrie, K., D. Perkins, J. Schoenwaelder, J. Case, M. Rose, and S. Waldbusser, Apr. 1999.

IETF RFC 2580 (STD 58), Conformance Statements for SMIv2, McCloghrie, K., D. Perkins, J. Schoenwaelder, J. Case, M. Rose, and S. Waldbusser, Apr. 1999.

IETF RFC 2863, The Interfaces Group MIB, McCloghrie, K., and F. Kastenholz, June 2000.

IETF RFC 3410, Introduction and Applicability Statements for Internet-Standard Management Framework, Case, J., R. Mundy, D. Partain, and B. Stewart, Dec. 2002.

IETF RFC 3414 (STD 62), User-based Security Model (USM) for Version 3 of the Simple Network Management Protocol (SNMPv3), Blumenthal, U., and B. Wijnen, Dec. 2002.

IETF RFC 3415 (STD 62), View-based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP), Wijnen, B., R. Presuhn, and K. McCloghrie, Dec. 2002.

ISO/IEC 10165-4:1992, Information technology—Open Systems Interconnection—Structure of management information—Part 4: Guidelines for the definition of managed objects.[5]

[2] IEEE publications are available from The Institute of Electrical and Electronics Engineers (https://standards.ieee.org/).

[3] The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

[4] IETF documents (i.e., RFCs) are available from the Internet Engineering Task Force (https://www.rfc-archive.org/).

[5] ISO/IEC publications are available from the International Organization for Standardization (https://www.iso.org/), the International Electrotechnical Commission (https://www.iec.ch), and the American National Standards Institute (https://www.ansi.org/).

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3. Definitions

For the purposes of this standard, the following terms and definitions apply. The *IEEE Standards Dictionary Online* can be consulted for terms not defined in this clause.[6]

This standard makes use of the following terms defined in IEEE Std 802:

— end station
— logical link
— station

This standard makes use of the following terms defined in IEEE Std 802.1AC:

— client (7.1 of IEEE Std 802.1AC-2016)
— frame (7.2 of IEEE Std 802.1AC-2016)
— Internal Sublayer Service (ISS) (Clause 11 of IEEE Std 802.1AC-2016)
— port (7.4 of IEEE Std 802.1AC-2016)

NOTE 1—It is helpful for the reader of this standard to review IEEE Std 802.1AC's description of the basic architectural concepts and terms used in this standard.[7]

This standard makes use of the following terms defined in IEEE Std 802.1Q:

— Bridge
— service instance

Actor: The local entity in a Link Aggregation Control Protocol exchange.

Aggregateable: A link terminating at an Aggregation Port that is configured to allow that link to form a Link Aggregation Group with other Aggregation Links.

Aggregation Key: A parameter, associated with each Aggregation Port and with each Aggregator of an Aggregation System, that prohibits the participation of multiple Aggregation Ports and Aggregators in the same Link Aggregation Group if their Aggregation Keys differ.

Aggregation Link: A local area network (LAN) that connects two Aggregation Systems.

Aggregation Port: A Service Access Point in an Aggregation System that provides access to a single Aggregation Link.

Aggregation System: A system that includes one or more Aggregators, each capable of using one or more Aggregation Ports to provide service to an Aggregator Client.

Aggregator: A multiplexing/demultiplexing entity that is capable of providing service at an Aggregator Port using the services provided by one or more Aggregation Ports.

Aggregator Client: A protocol entity that makes use of the service provided by a single Aggregator.

Aggregator Port: A port that provides access to the service provided by a single Aggregator.

---

[6] *IEEE Standards Dictionary Online* subscription is available at https://dictionary.ieee.org. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.
[7] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

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conversation: A set of frames transmitted from one end station to another, with the assumption that the communicating end stations require intermediate systems to maintain the ordering of those frames.

Conversation ID: An integer in the range of 0 through 4095, where each value identifies one or more conversations.

Distributed Relay: Transmission and reception of frames by Distributed Resilient Network Interconnect (DRNI) Gateway Ports in a pair of DRNI Systems using Aggregator Ports and Intra-Relay Ports in both DRNI Systems.

Distributed Relay Client: A protocol entity that makes use of the service provided by a DRNI Gateway.

Distributed Resilient Network Interconnect (DRNI): The DRNI Gateways in a pair of Aggregation Systems that are connected by an Intra-Relay Connection and can be used to create a single Link Aggregation Group using Aggregation Ports from either or both of the Aggregation Systems.

Down frame: A frame that has entered a Distributed Relay from the Distributed Relay Client.

DRNI Gateway: A protocol entity in an Distributed Resilient Network Interconnect (DRNI) System that can be paired with a DRNI Gateway in a another DRNI System and that provides Distributed Relay service at a DRNI Gateway Port using the services provided by an Aggregator Port in each system.

DRNI Gateway Port: A port that provides access to the service provided by a single Distributed Resilient Network Interconnect (DRNI) Gateway.

DRNI System: An Aggregation System containing one or more Distributed Resilient Network Interconnect (DRNI) Gateways.

Gateway Conversation ID: A Conversation identifier (ID) associated with a frame for the purpose of selecting a Distributed Resilient Network Interconnect (DRNI) Gateway Port.

Home: The local entity in a Distributed Relay Control Protocol (DRCP) exchange.

Intra-Relay Connection (IRC): A logical link that connects a pair of Distributed Resilient Network Interconnect (DRNI) Gateways comprising a Distributed Relay.

Intra-Relay Port (IRP): The service interface of a Distributed Resilient Network Interconnect (DRNI) Gateway provided by an Intra-Relay Connection.

Key: *See:* **Aggregation Key.**

Link Aggregation Group (LAG): A group of links that appear to an Aggregator Client as a single link.

Link_Number: An Aggregation Link identifier that is unique within a Link Aggregation Group, with an operational value common to both the Actor and Partner Systems.

Neighbor: The remote entity in a Distributed Relay Control Protocol (DRCP) exchange.

Partner: The remote entity in a Link Aggregation Control Protocol (LACP) exchange.

Port Conversation ID: A Conversation identifier (ID) associated with a frame for the purpose of selecting an Aggregation Port.

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Service Identifier (Service ID): A value extracted from the header of a frame (e.g., VID, I-SID) that identifies the service instance with which that frame is associated.

NOTE 2—This standard makes use of service identifiers specified in IEEE Std 802.1Q.

Solitary: An Aggregation Link that cannot be included in a Link Aggregation Group with any other Aggregation Link, due to administrative configuration at either of the attached Aggregation Systems.

System: When used in this standard and not preceded by “Aggregation” or “DRNI”, “System” means an Aggregation System.

Up frame: A frame that has entered a Distributed Relay through an Aggregator Port.

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4. Acronyms and abbreviations

This standard contains the following acronyms and abbreviations:

CID	Company ID[8] (see also OUI)
CSCD	Conversation-Sensitive Collection and Distribution
DA	destination address
DRCP	Distributed Relay Control Protocol
DRCPDU	Distributed Relay Control Protocol Data Unit
DRNI	Distributed Resilient Network Interconnect
DWC	Discard Wrong Conversation
FCS	frame check sequence
IRC	Intra-Relay Connection
IRP	Intra-Relay Port
ISS	Internal Sublayer Service
LACP	Link Aggregation Control Protocol
LACPDU	Link Aggregation Control Protocol Data Unit
LAG	Link Aggregation Group
LAG ID	Link Aggregation Group Identifier
LAN	local area network
LLC	logical link control
LLDP	Link Layer Discovery Protocol
MAC	medium access control
MIB	management information base
MSAP	MAC Service Access Point
NTT	Need To Transmit
OUI	organizationally unique identifier
PDU	Protocol Data Unit
PICS	protocol implementation conformance statement
SA	source address
TLV	type/length/value
TPMR	Two-Port MAC Relay
UCT	unconditional transition

[8] See https://standards.ieee.org/develop/regauth/tut/eui.pdf.

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5. Conformance

This clause specifies the mandatory and optional capabilities provided by conformant implementations of this standard.

5.1 Requirements terminology

For consistency with existing IEEE and IEEE 802.1™ standards, requirements placed upon conformant implementations of this standard are expressed using the following terminology:

a) ***Shall*** is used for mandatory requirements;
b) ***May*** is used to describe implementation or administrative choices ("may" means "is permitted to," and hence, "may" and "may not" mean precisely the same thing);
c) ***Should*** is used for recommended choices (the behaviors described by "should" and "should not" are both permissible but not equally desirable choices).

The protocol implementation conformance statement (PICS) proformas (see Annex A) reflect the occurrences of the words "shall," "may," and "should" within the standard.

The standard avoids needless repetition and apparent duplication of its formal requirements by using ***is***, ***is not***, ***are***, and ***are not*** for definitions and the logical consequences of conformant behavior. Behavior that is permitted but is neither always required nor directly controlled by an implementer or administrator, or whose conformance requirement is detailed elsewhere, is described by ***can***. Behavior that never occurs in a conformant implementation or System of conformant implementations is described by ***cannot***.

This clause lists requirements and options for certain capabilities, e.g., Link Aggregation. If a System claims to support such a capability for one of its ports, then the System is considered *conformant* if it meets that capability's requirements in this clause for that port. For example, a claim that a System supports Link Aggregation on a set of ports requires the System's behavior to meet the requirements specified in 5.3 for the identified ports.

5.2 Protocol implementation conformance statement

The supplier of an implementation that is claimed to conform to this standard shall provide the information necessary to identify both the supplier and the implementation, and shall complete a copy of the PICS proforma provided in Annex A.

5.3 Link Aggregation

5.3.1 Link Aggregation requirements

A conformant Link Aggregation System shall

a) Support the Link Aggregation Sublayer and conform to the state machines and procedures in 6.2.
b) Support the Link Aggregation Control Protocol (LACP) and conform to the state machines and procedures in 6.3 and 6.4.
c) Transmit and receive Link Aggregation Control Protocol Data Unit (LACPDUs) in the formats specified in 6.4.2.
d) Implement the Marker Responder as specified in 6.5.4.2 and respond to received Marker PDUs as specified in 6.5.1.
e) Support the LACP configuration for dual-homed Systems described in 6.7.5.

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5.3.2 Link Aggregation options

A conformant Link Aggregation System may

a) Support the Marker Protocol and conform to the state machines and procedures in 6.5 and transmit and receive required Marker and Marker Response PDUs in the formats specified in 6.5.3.
b) Support the management functionality for Link Aggregation as specified in Clause 7.
c) Support SMIv2 management information base (MIB) modules for the management of Link Aggregation capabilities (Annex D).
d) Support Aggregation Port Debug Information package support as specified in 7.2.5.
e) Conform to the required specifications of the Link Layer Discovery Protocol (LLDP) of IEEE Std 802.1AB™ [B1].[9] A conformant System that supports LLDP shall provide an LLDP Parser/Multiplexer to attach zero or more instances of LLDP to each Aggregation Port as specified in F.1.
f) Implement a Protocol Parser/Multiplexer (6.1.3) for a protocol not explicitly specified in this standard.
g) Implement the techniques specified in 6.7.1 and 6.7.2 to form Link Aggregation Groups on an Aggregation System with the constraints described.
h) Support Conversation-Sensitive Collection and Distribution as specified in 6.2.7 and 6.6. An implementation that supports Conversation-Sensitive Collection and Distribution shall support a value of FORCE_FALSE for Admin_Discard_Wrong_Conversation and may support values of FORCE_TRUE and AUTO.
i) Support Per-Service Frame Distribution as specified in 8.2 and shall
    1) Support Conversation-Sensitive Collection and Distribution as specified in 6.2.7 and 6.6, and
    2) Transmit and receive version 2 LACPDUs as specified in 6.4.2.4, and
    3) Support classification by Customer VLAN Tag for C-tagged interfaces and classification by Service VLAN tag for S-tagged and B-tagged interfaces,

    and may
    4) Support classification by Backbone Service Instance Tag as specified in 8.2.3.

5.4 Distributed Resilient Network Interconnect (DRNI)

5.4.1 DRNI requirements

A conformant DRNI System shall

a) Conform to the requirements specified for Link Aggregation as specified in 5.3.
b) Support a DRNI consisting of two DRNI Systems as specified in Clause 9 and shall
    1) Support a DRNI Gateway having a single Intra-Relay Port (IRP) and conform to the state machines and procedures in 9.5,
    2) Support the Distributed Relay Control Protocol (DRCP) and conform to the state machines and procedures specified in 9.6, and
    3) Transmit and receive required Distributed Relay Control Protocol Data Units (DRCPDUs) in the formats specified in 9.6.2.
c) Support using a dedicated link for the Intra-Relay Connection (IRC) as specified in 9.3.

[9] The numbers in brackets correspond to the numbers in the bibliography in Annex G.

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5.4.2 DRNI options

A conformant DRNI System may

a) Implement any of the options specified for Link Aggregation (5.3.2).
b) Support using a LAG for the IRC by supporting the IRP with a dedicated Aggregator as specified in 9.3.
c) Support using a method other than a dedicated link or LAG for the IRC as specified in 9.3.
d) Support Organization-Specific TLVs in DRCPDUs as specified in 9.6.2.7.

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6. Link Aggregation

6.1 Overview

This clause defines an optional Link Aggregation sublayer for use with links offering the IEEE 802.1AC Internal Sublayer Service (ISS). Link Aggregation allows one or more point-to-point links to be aggregated together to form a Link Aggregation Group (LAG) so that an Aggregator Client can treat the LAG as if it were a single link.

The models of operation in this clause provide a basis for specifying the externally observable behavior of the operation and are not intended to place additional constraints on implementations; these can adopt any internal model of operation compatible with the externally observable behavior specified. Conformance of equipment to this standard is purely with respect to observable protocol.

6.1.1 Goals and objectives

Link Aggregation, as specified in this clause, provides the following:

a) **Increased bandwidth**—The capacity of multiple links is combined into one logical link.
b) **Increased availability**—The failure or replacement of a single link within a LAG need not cause failure from the perspective of an Aggregator Client.
c) **Load sharing**—Aggregator Client traffic can be distributed across multiple links.
d) **Automatic configuration**—In the absence of manual overrides, an appropriate set of LAGs is automatically configured, and individual links are allocated to those groups. If a set of links can aggregate, they will aggregate.
e) **Rapid configuration and reconfiguration**—In the event of changes in physical connectivity, Link Aggregation will quickly converge to a new configuration, typically on the order of milliseconds for link down events and 1 s or less for link up events.

NOTE 1—Timing out LACPDU exchanges is the method of last resort for detecting link failures and shifting data flows to other physical links. The MAC_Operational status generated by link hardware is the first choice for link failure detection. Connectivity Fault Management (CFM) (Clause 18 of IEEE Std 802.1Q-2018) provides a method for detecting link failures (also indicated via the MAC_Operational status) when hardware means are not applicable.

f) **Deterministic behavior**—The link aggregation configuration can be made independent of past events and completely determined by the connectivity provided by the individual links and the administrative configuration of the connected systems.
g) **Low risk of duplication or misordering**—During both steady-state operation and link (re)configuration, there is a low probability that frames are duplicated or misordered.
h) **Support of existing medium access control (MAC) Clients**—No change is required to existing higher-layer protocols or applications to use Link Aggregation.
i) **Backwards compatibility with aggregation-unaware devices**—Links that cannot take part in Link Aggregation because of their inherent capabilities, management configuration, or the capabilities of the devices to which they attach operate as normal, individual links.
j) **Accommodation of differing capabilities and constraints**—Devices with differing hardware and software constraints on Link Aggregation are, to the extent possible, accommodated.
k) **No change to frame formats**—Link Aggregation neither adds to, nor changes the contents of, frames exchanged between Aggregator Clients.
l) **Network management support**—The standard specifies appropriate management objects for configuration, monitoring, and control of Link Aggregation.
m) **Point-to-point aggregations**—The mechanisms specified in this clause form a Link Aggregation Group providing a point-to-point connectivity service.

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n) **Dissimilar MACs**—Link Aggregation can be used over any physical or logical medium supporting the ISS with a service providing point-to-point connectivity (i.e., the ISS operPointToPoint variable is TRUE).

Aggregating different data rates is not prohibited nor required by this standard. Determining how to distribute traffic across links of different data rates is beyond the scope of this standard.

NOTE 2—Previous versions of this standard restricted the data rate of the aggregated links. However, the mechanisms specified did not depend on whether the links operated at the same rate.

6.1.2 Positioning of Link Aggregation within the IEEE 802 architecture

Link Aggregation comprises an optional sublayer that (at its upper boundary) has an ISS to Aggregator Clients attached to Aggregator Ports and (at its lower boundary) has an ISS for each of its Aggregation Ports. Figure 6-1 depicts a common case where Aggregation Ports in a system are supported directly by a MAC.

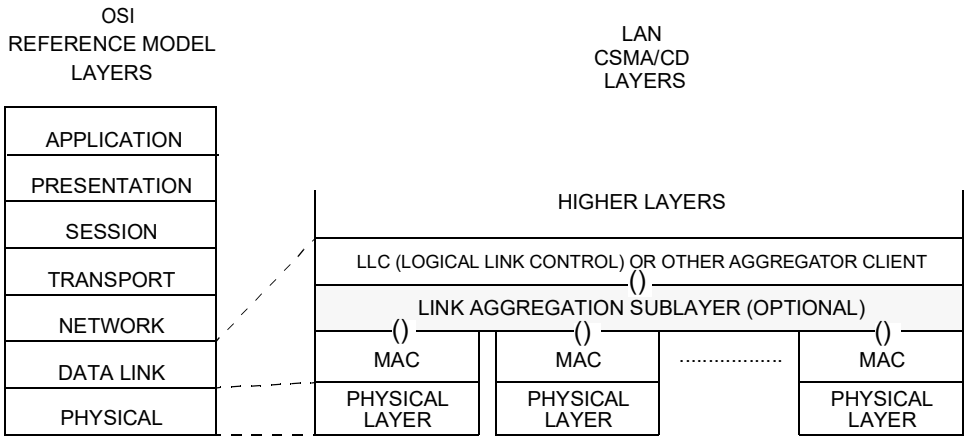

Figure 6-1—Architectural positioning of Link Aggregation sublayer

It is possible to implement the optional Link Aggregation sublayer for some ports within a System while not implementing it for other ports; i.e., it is not necessary for all ports in a System to be subject to Link Aggregation. A conformant implementation is not required to be able to apply the Link Aggregation sublayer to every port.

NOTE—IEEE Std 802.1AX-2008 and Clause 43 in earlier editions of IEEE Std 802.3 used the term “MAC Client” instead of the term “Aggregator Client” and placed Link Aggregation between the IEEE 802.3 MAC sublayer and the IEEE 802.3 MAC Control sublayer. IEEE Std 802.1AX-2014 repositioned Link Aggregation as a sublayer above the MAC sublayer. This rearrangement aligned the standard with common industry practice. It did not cause implementations conformant to earlier editions of the standard to become non-interoperable with those conformant to IEEE Std 802.1AX-2014 and subsequent editions.

6.1.3 Protocol Parser/Multiplexer

A Protocol Parser/Multiplexer is a functional element that separates specific control protocol frames from a sequence of M_UNITDATA.indications received at an ISS interface and combines frames generated for that control protocol with a sequence of M_UNITDATA.requests at an ISS interface. The general purpose Protocol Parser/Multiplexer described here can be customized to a specific control protocol, of which there are three examples in this standard:

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a) The LLDP Parser/Multiplexer (F.1.1)
b) The LACP Parser/Multiplexer (6.2.9)
c) The DRCP Parser/Multiplexer (9.5.1)

NOTE—The Aggregator Parser/Multiplexer (6.2.7) and DR_Aggregator Parser/Multiplexer (9.5.2.6) are not instances of a Protocol Parser/Multiplexer. These perform additional parsing functions not included in the general purpose Protocol Parser/Multiplexer and are described by their own state diagrams.

A Protocol Parser/Multiplexer has three service interfaces, each an instance of the ISS, as follows:

d) One DownPort makes use of an instance of the ISS to pass data and control frames to and from lower layers in the interface stack.
e) One DataPort offers an instance of the ISS to higher layers in the interface stack.
f) One ControlPort offers an instance of the ISS to the functional element for the control protocol.

A specific instance of the Protocol Parser/Multiplexer, e.g., the LACP Parser/Multiplexer (6.2.9), ties these three notional service interfaces to specific service interfaces, e.g., those in 6.2.2, and provides a definition of the IsControlFrame function (6.1.3.1.2).

On transmission, the Protocol Multiplexer provides transparent pass-through of frames from the ControlPort or the DataPort to the DownPort.

On receipt of a frame from its DownPort, the Protocol Parser uses the IsControlFrame function to determine whether the frame is a control frame. It passes control frames up through the ControlPort and passes all other frames up through the DataPort. The Protocol Parser implements the function specified by the state diagram shown in Figure 6-2 and the associated definitions contained in 6.1.3.1.

6.1.3.1 Protocol Parser state diagram

6.1.3.1.1 Variables

DA
SA
mac_service_data_unit
priority
: The parameters of the M_UNITDATA.indication primitive.

msdu_type
: The type value of the mac_service_data_unit that is either an EtherType or an LLC Address, determined as described in Clause 9 of IEEE Std 802-2014.

BEGIN
: A Boolean variable that is set to TRUE when the System is initialized or reinitialized and is set to FALSE when (re)initialization has completed.
Data Type: Boolean

6.1.3.1.2 Functions

IsControlFrame
: Given an input frame (DA, SA, mac_service_data_unit, priority), returns TRUE if the frame is a control frame for the ControlPort or FALSE if it is a data frame for the DataPort.
Value returned: Boolean

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6.1.3.1.3 Messages

ControlPort:M_UNITDATA.indication
DataPort:M_UNITDATA.indication
DownPort:M_UNITDATA.indication

The service primitives used to pass a received frame to a client with the specified parameters.

6.1.3.1.4 State diagram

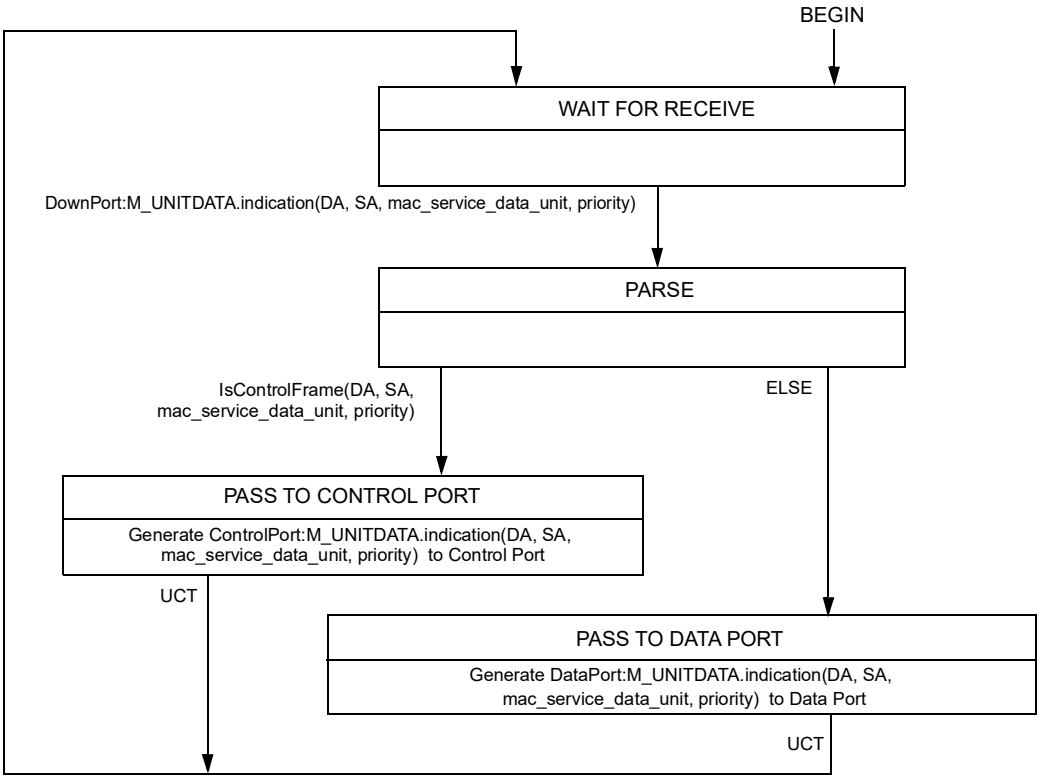

Figure 6-2—Protocol Parser state diagram

6.2 Link Aggregation operation

Figure 6-3 depicts the major blocks that form the Link Aggregation sublayer and their interrelationships. The Link Aggregation sublayer comprises the following functions:

a) **Frame Distribution.** This block is responsible for taking frames submitted by the Aggregator Client and submitting them for transmission on the appropriate Aggregation Port, based on a frame distribution algorithm employed by the Frame Distributor. Frame Distribution includes a Frame Distributor and an optional Marker Generator/Receiver used for the Marker protocol. (See 6.2.4, 6.2.5, and 6.5.)

b) **Frame Collection**. This block is responsible for passing frames received from the various Aggregation Ports to the Aggregator Client. Frame Collection includes a Frame Collector and a Marker Responder, used for the Marker protocol. (See 6.2.3, 6.2.6, and 6.5.)

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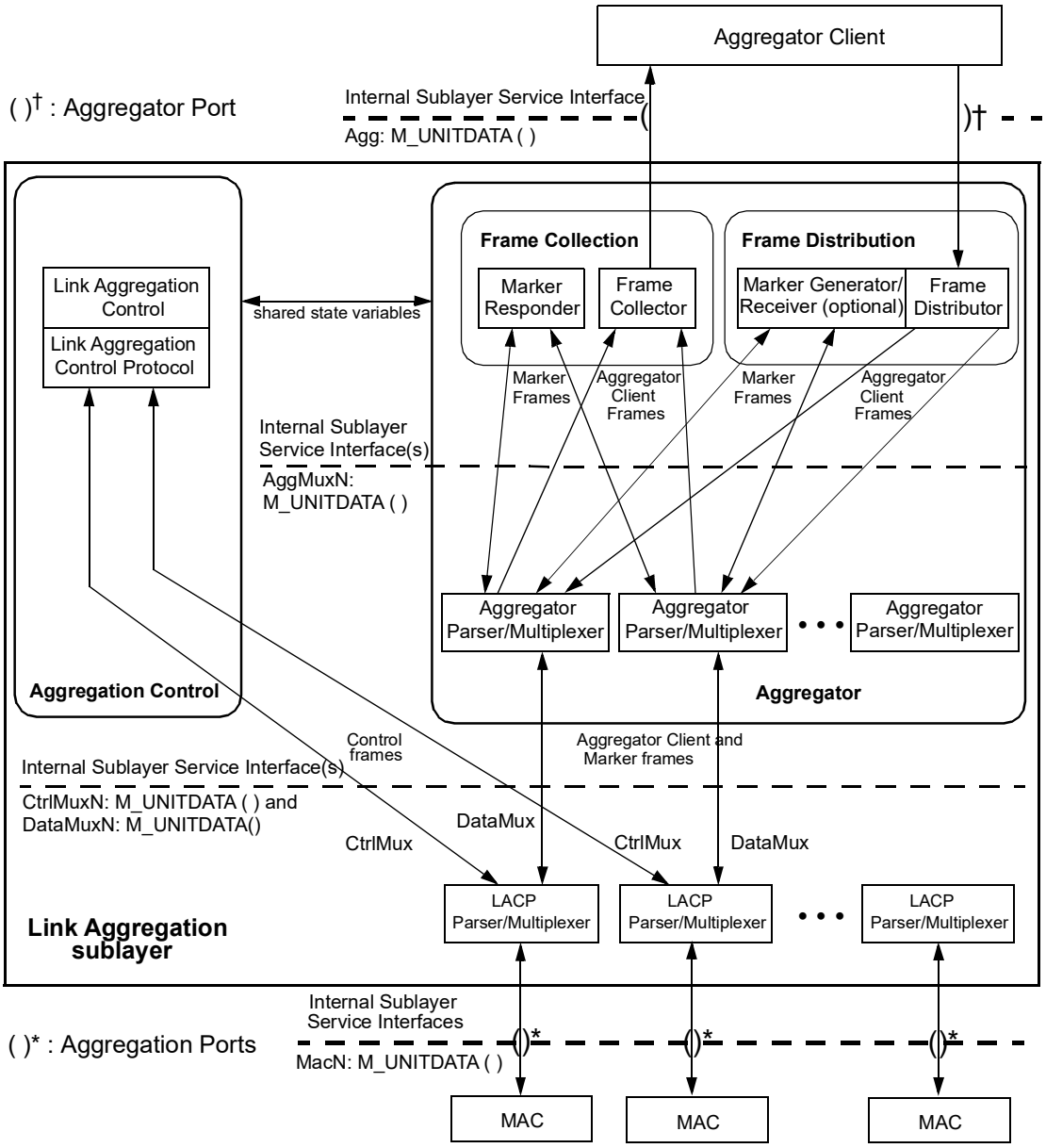

Figure 6-3—Link Aggregation sublayer block diagram

c) **Aggregator Parser/Multiplexers.** On transmit, these entities simply pass frame transmission requests from the Frame Distributor, Marker Generator, and/or Marker Responder to the appropriate Aggregation Port. On receive, these entities distinguish among Marker Request, Marker Response, and MAC Protocol Data Units and pass each to the appropriate entity (Marker Responder, Marker Receiver, and Frame Collector, respectively).

d) **Aggregator**. The combination of Frame Distribution and Frame Collection, along with the Aggregator Parser/Multiplexers, is referred to as the Aggregator.

e) **Aggregation Control**. This block is responsible for the configuration and control of Link Aggregation. It incorporates a Link Aggregation Control Protocol (LACP) that can be used for automatic communication of aggregation capabilities between Systems and automatic configuration of Link Aggregation.

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f) **LACP Parser/Multiplexers**. On transmit, these entities simply pass frame transmission requests from the Aggregator and Control entities to the appropriate Aggregation Port. On receipt, these entities distinguish Link Aggregation Control PDUs from other frames, passing the LACPDUs to the appropriate sublayer entity, and all other frames to the Aggregator.

6.2.1 Principles of Link Aggregation

Link Aggregation allows an Aggregator Client to treat a set of one or more Aggregation Ports as if it were a single port. In doing so, it employs the following principles and concepts:

a) An Aggregator Client communicates with a set of Aggregation Ports through an Aggregator, which presents a standard ISS interface to the Aggregator Client. One or more Aggregation Ports attach to an Aggregator within a System.

b) It is the responsibility of the Aggregator to distribute frame transmissions from the Aggregator Client to the various Aggregation Ports, and to collect received frames from the Aggregation Ports and pass them to the Aggregator Client transparently.

c) A System can contain multiple Aggregators, serving multiple Aggregator Clients. A given Aggregation Port will attach to (at most) a single Aggregator at any time. An Aggregator Client is served by a single Aggregator at a time.

d) The attachment of Aggregation Ports to Aggregators within a System is managed by the Link Aggregation Control function for that System, which is responsible for determining which links can be aggregated, aggregating them, attaching the Aggregation Ports within the System to an appropriate Aggregator, and monitoring conditions to determine when a change in aggregation is needed.

e) Such determination and attachment might be under manual control through direct manipulation of the state variables of Link Aggregation (e.g., Keys) by a network manager. In addition, automatic determination, configuration, attachment, and monitoring can occur through the use of a Link Aggregation Control Protocol (LACP). LACP uses peer exchanges across the links to determine, on an ongoing basis, the aggregation capability of the various links and continuously provides the maximum level of aggregation capability achievable between a given pair of Systems.

f) Frame ordering has to be maintained for certain sequences of frame exchanges between Aggregator Clients (known as conversations, see Clause 3). The Frame Distributor ensures that all frames of a given conversation are passed to a single Aggregation Port. For any given Aggregation Port, the Frame Collector is required to pass frames to the Aggregator Client in the order that they are received from that Aggregation Port. The Frame Collector is otherwise free to select frames received from the Aggregation Ports in any order. Since there are no means for frames to be misordered on a single link, this guarantees that frame ordering is maintained for any conversation.

g) Conversations can be moved among Aggregation Ports within an aggregation, both for load balancing and to maintain availability in the event of link failures. Frame ordering can be maintained (6.5 and 6.6) when conversations are moved.

h) This standard does not require the use of a particular distribution algorithm.

i) Each Aggregation Port is assigned a MAC address, unique over the LAG and the IEEE 802.1Q Bridged LAN (if any) to which the LAG is connected. This MAC address is used as the source address (SA) for frame exchanges that are initiated by entities within the Link Aggregation sublayer itself (i.e., LACP and Marker protocol exchanges).

NOTE—LACP and Marker Protocol use a multicast DA for all exchanges and do not require an Aggregation Port to recognize more than one unicast address on received frames.

j) Each Aggregator is assigned a MAC address, unique over the LAG and the IEEE 802.1Q Bridged LAN (if any) to which the LAG is connected; this address is used as the MAC address of the aggregation from the perspective of the Aggregator Client, both as a SA for transmitted frames and as the destination address (DA) for received frames. The MAC address of the Aggregator can be one of the MAC addresses of an Aggregation Port in the associated LAG (see 6.2.10).

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6.2.2 Service interfaces

The Aggregator Client communicates with the Aggregator using the ISS specified in IEEE Std 802.1AC. Similarly, Link Aggregation communicates internally (between Frame Collection/Distribution, the Aggregator Parser/Multiplexers, the LACP Parser/Multiplexers, and Link Aggregation Control) and with its attached Aggregation Ports using the same service interface. No new interlayer service interfaces are defined for Link Aggregation.

Since Link Aggregation uses several instances of the ISS, it is necessary to introduce a notation convention so that the reader can be clear about which interface is being referenced at any given time. A prefix is therefore assigned to each service primitive to indicate which of the interfaces is being invoked, as depicted in Figure 6-3. The prefixes are as follows:

a) Agg:, for primitives issued on the interface between the Aggregator Client and the Link Aggregation sublayer.
b) AggMuxN:, for primitives issued on the interface between Aggregator Parser/Multiplexer N and its internal clients (where N is the Port Number associated with the Aggregator Parser/Multiplexer).
c) CtrlMuxN:, for primitives issued on the interface between LACP Parser/Multiplexer N and Link Aggregation Control (where N is the Port Number associated with the LACP Parser/Multiplexer).
d) DataMuxN:, for primitives issued on the interface between LACP Parser/Multiplexer N and Aggregator Parser/Multiplexer N (where N is the Port Number associated with the LACP Parser/Multiplexer).
e) MacN:, for primitives issued on the interface between underlying MAC N and its LACP Parser/Multiplexer (where N is the Port Number associated with the underlying MAC).

Aggregator Clients can generate Agg:M_UNITDATA.request primitives for transmission on an aggregated link. These are passed by the Frame Distributor to an Aggregation Port selected by the distribution algorithm. MacN:M_UNITDATA.indication primitives signifying received frames are passed unchanged from an Aggregation Port to the Aggregator Client by the Frame Collector.

In order to satisfy the needs of higher layers to access physical ports directly, the Aggregator Parser/Multiplexer (6.2.7) is provided. In particular, if IEEE Std 802.1AB [B1] is implemented in a System supporting Link Aggregation, the Link Aggregation operation (6.2) can attach zero or more instances of LLDP to each Aggregation Port.

6.2.3 Frame Collector

A Frame Collector is responsible for receiving incoming frames (i.e., AggMuxN:M_UNITDATA.indications) from the set of individual links that form the LAG (through each link's associated Aggregator Parser/Multiplexer) and delivering them to the Aggregator Client. Frames received from a given Aggregation Port are delivered to the Aggregator Client in the order that they are received by the Frame Collector. Since the Frame Distributor is responsible for maintaining any frame ordering constraints, there is no requirement for the Frame Collector to perform any reordering of frames received from multiple links.

The Frame Collector shall implement the function specified in the state diagram shown in Figure 6-4 and the associated definitions contained in 6.2.3.1.

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6.2.3.1 Frame Collector state diagram

6.2.3.1.1 Constants

CollectorMaxDelay
: In tens of microseconds, the maximum time that the Frame Collector can delay the delivery of a frame received from an Aggregator Parser to its Aggregator Client. Value is assigned by management or administration policy.
Data Type: Integer
Alias of aAggCollectorMaxDelay (7.3.1.1.32)

6.2.3.1.2 Variables

DA
SA
mac_service_data_unit
priority
: The parameters of the M_UNITDATA.indication primitive.

BEGIN
: A Boolean variable that is set to TRUE when the System is initialized or reinitialized and is set to FALSE when (re)initialization has completed.
Data Type: Boolean

6.2.3.1.3 Messages

Agg:M_UNITDATA.indication
AggMuxN:M_UNITDATA.indication
: The service primitives used to pass a received frame to a client with the specified parameters.

6.2.3.1.4 State diagram

The architectural models of ISS and Link Aggregation do not make any provision for queuing of frames between the link and the Aggregator Client. However, practical implementations of Link Aggregation will typically incur both queuing and delay in the Frame Collector. In order to ensure that frame delivery is not delayed indefinitely (which could cause a frame ordering problem when moving conversations from one link to another), the Frame Collector shall, upon receiving a frame from an Aggregator Parser, either deliver the frame to its Aggregator Client, or discard the frame within a CollectorMaxDelay time. The Frame Distributor (within the Partner System at the other end of the link) can assume that all frames transmitted on a given link have been either received by its Partner's Aggregator Client or discarded after a CollectorMaxDelay plus the propagation delay of the link. The use of CollectorMaxDelay is further discussed in B.3.

NOTE—Because frame discard due to CollectorMaxDelay is a function of queuing and other entities not specified in this standard, the discard action is a requirement of the system, not just of the Frame Collector, and is therefore not shown in Figure 6-4.

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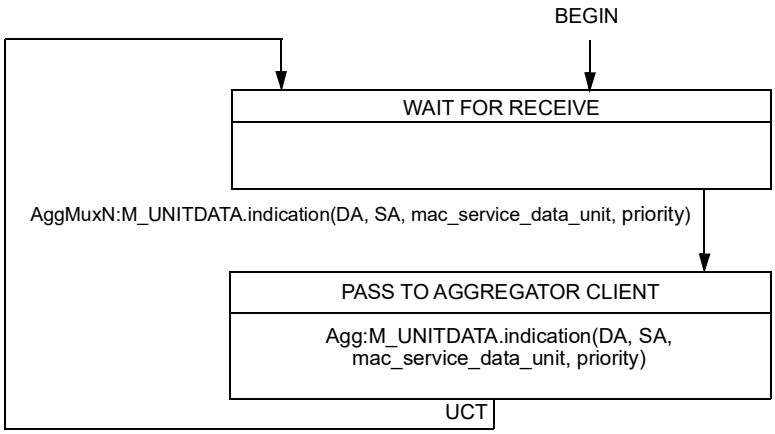

Figure 6-4—Frame Collector state diagram

6.2.4 Frame Distributor

The Frame Distributor is responsible for taking outgoing frames from the Aggregator Client and transmitting them through the set of links that form the LAG. The Frame Distributor implements a distribution function (algorithm) responsible for choosing the link to be used for the transmission of any given frame or set of frames.

This standard allows a wide variety of distribution algorithms. However, practical frame distribution algorithms do not misorder frames that are part of any given conversation, nor do they duplicate frames.

Rather, frame order is maintained by ensuring that all frames that compose a given conversation are transmitted on a single link in the order that they are generated by the Aggregator Client. No addition (or modification) of any information to the MAC frame is necessary, nor is any buffering or processing on the part of the corresponding Frame Collector in order to reorder frames. This approach permits a wide variety of distribution and load balancing algorithms to be used, while also ensuring interoperability between devices that adopt differing algorithms.

NOTE—Distribution algorithms and maintenance of frame ordering are discussed in Annex B.

Conversation-Sensitive Collection and Distribution (6.6) provides a structure for identifying various distribution algorithms, configuring the distribution algorithm to be used, and conveying that information to the LACP partner in LACP Version 2 TLVs (6.4.2.4). Per-Service Frame Distribution (Clause 8) specifies a set of distribution algorithms that can be used by a Link Aggregation implementation.

The Frame Distributor shall implement the function specified in the state diagram shown in Figure 6-5 and the associated definitions contained in 6.2.4.1.

6.2.4.1 Frame Distributor state diagram

6.2.4.1.1 Variables

DA
SA
mac_service_data_unit
priority
: The parameters of the M_UNITDATA.request primitive.

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BEGIN
A Boolean variable that is set to TRUE when the System is initialized or reinitialized and is set to FALSE when (re)initialization has completed.
Data Type: Boolean

6.2.4.1.2 Messages

Agg:M_UNITDATA.request
AggMuxN:M_UNITDATA.request
The service primitives used to transmit a frame with the specified parameters at the Aggregation Port, N, determined by the distribution algorithm. When Conversation-Sensitive Collection and Distribution is not supported, the algorithm used to determine the value of N is unspecified. When Conversation-Sensitive Collection and Distribution is supported, the algorithm used to determine the value of N is specified by the Actor_Port_Algorithm variable. It is possible that the value of N will be zero, indicating that the service primitive is to be discarded.

6.2.4.1.3 State diagram

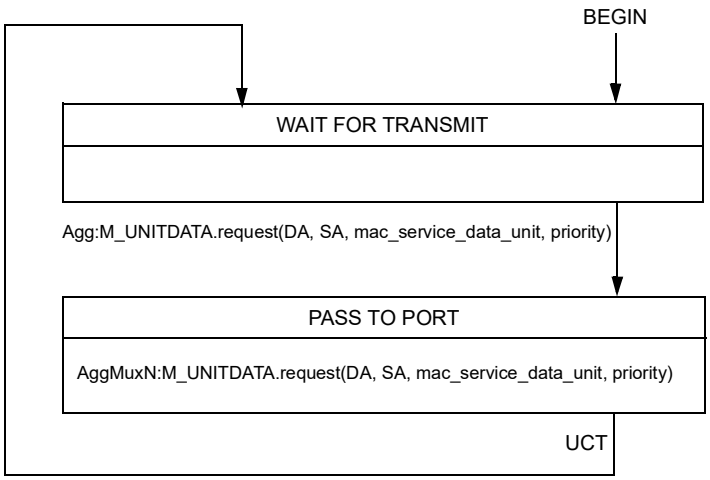

Figure 6-5—Frame Distributor state diagram

6.2.5 Marker Generator/Receiver (optional)

The optional Marker Generator is used by the Marker protocol, as specified in 6.5. When implemented and so requested by the distribution algorithm, the Marker Generator shall issue an AggMuxN:M_UNITDATA.request primitive, with a mac_service_data_unit containing a Marker PDU as defined in 6.5.3, to the Aggregation Port associated with the conversation being marked, subject to the timing restrictions for Slow Protocols specified in IEEE Std 802.3-2018, Annex 57A.

The optional Marker Receiver is used by the Marker protocol, as specified in 6.5. It receives Marker Response PDUs from the Aggregator Parser.

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6.2.6 Marker Responder

The Marker Responder is used by the Marker protocol, as specified in 6.5. The Marker Responder receives Marker PDUs (generated by a Partner System's Marker Generator), and transmits a Marker Response PDU through the same Aggregation Port from which the Marker PDU was received. While implementation of the Marker Generator/Receiver is optional, the ability to respond to a Marker PDU (the Marker Responder) is mandatory. An implementation conformant to this clause that is not under a Distributed Relay component (DRNI Gateway, see 9.2, 9.5) shall implement the Marker Responder as specified in 6.5.4.2, thus ensuring that implementations that need to make use of the protocol can do so.

A Marker Responder that is under a DRNI Gateway is not required to respond to a Marker PDU.

NOTE—Since this standard lacks any means for coordinating Marker PDU responses among the DRNI Systems comprising a DRNI, it is safer to ignore a Marker PDU and allow the sender to time out, rather than to return a Marker PDU and run the risk of delivering frames out of order.

6.2.7 Aggregator Parser/Multiplexer

On transmission, the Aggregator Multiplexer shall provide transparent pass-through of frames submitted by the Marker Responder and optional Marker Generator to the Aggregation Port specified in the transmission request. The Aggregator Multiplexer shall provide transparent pass-through of frames submitted by the Frame Distributor to the Aggregation Port specified in the transmission request only when the Aggregation Port state is Distributing (see 6.4.13). Furthermore, if Conversation-Sensitive Collection and Distribution is supported, the value of the Distribution_Conversation_Mask for the Port_Conversation_ID associated with the frame is TRUE. Otherwise, such frames shall be discarded.

On receipt, the Aggregator Parser decodes frames received from the LACP Parser, passes those frames destined for the Marker Responder or Marker Receiver to the selected entity, and discards frames with invalid Slow Protocol subtype values (see IEEE Std 802.3-2018, Table 57A–2). The Aggregator Parser shall pass all other frames to the Frame Collector for passage to the Aggregator Client only when the Aggregation Port state is Collecting (see 6.4.13). Furthermore, if Conversation-Sensitive Collection and Distribution is supported, the value of the Collection_Conversation_Mask for the Port_Conversation_ID associated with the frame is TRUE. Otherwise, such frames shall be discarded. The Aggregator Parser shall implement the function specified in the state diagram shown in Figure 6-6 and the associated definitions contained in 6.2.7.1.

6.2.7.1 Aggregator Parser/Multiplexer state diagrams

6.2.7.1.1 Constants

Slow_Protocols_Type
: The value of the Slow Protocols EtherType (Table 6-3).

Marker_subtype
: The value of the Subtype field for the Marker protocol. (See 6.5.3.)
: Data Type: Integer
: Value: 2

Marker_Information
: The encoding of the Marker Information TLV_Type field. (See 6.5.3.)
: Data Type: Integer
: Value: 1

Marker_Response_Information
: The encoding of the Marker Response Information TLV_Type field. (See 6.5.3.)
: Data Type: Integer
: Value: 2

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6.2.7.1.2 Variables

DA
SA
mac_service_data_unit
priority
: The parameters of the M_UNITDATA.indication primitive.

Protocol_DA
: The address determined by the setting of the aAggPortProtocolDA managed object (7.3.2.2.1). A particular instance of link aggregation shall use the same DA for LACP as it does for the Marker protocol.
Data Type: 6 octets.

Length/Type
: The value of the Length/Type field in a received frame.
Data Type: Integer

Subtype
: The value of the octet following the Length/Type field in a Slow Protocol frame. (See IEEE Std 802.3-2018, Annex 57A.)
Data Type: Integer

TLV_Type
: The value contained in the octet following the Version Number in a received Marker or Marker Response frame. This identifies the “type” for the type/length/value (TLV) tuple. (See 6.5.3.)
Data Type: Integer

Collecting
: An alias of Actor_Oper_Port_State.Collecting. When TRUE, the Aggregator Parser can pass frames to the Collector.
Data Type: Boolean.

Collection_Conversation_Mask
: A Boolean vector, indexed by Port_Conversation_ID, that indicates whether the frame is allowed to reach the Aggregator when received through this Aggregation Port (TRUE = passes). When Conversation-Sensitive Collection and Distribution is not supported, this variable is not used (implicitly contains the value TRUE for all Port_Conversation_IDs). When Conversation-Sensitive Collection and Distribution is supported, the value is determined by the Update Mask machine (6.6.3.5).
Data Type: sequence of Boolean values, indexed by Port_Conversation_ID.
Alias of aAggPortOperConversationCollected (7.3.2.1.26).

Distributing
: An alias of Actor_Oper_Port_State.Distributing. When TRUE, the Aggregator Multiplexer can pass frames to the Aggregation Port.
Data Type: Boolean.

Distribution_Conversation_Mask
: A Boolean vector, indexed by Port_Conversation_ID, that indicates whether the M_UNITDATA.request is allowed to be passed to the Aggregation Port (TRUE = passes). When Conversation-Sensitive Collection and Distribution is not supported, this variable is not used (implicitly contains the value TRUE for all Port_Conversation_IDs). When Conversation-Sensitive Collection and Distribution is supported, the value is determined by the Update Mask machine (6.6.3.5).
Data Type: sequence of Boolean values, indexed by Port_Conversation_ID.
Alias of aAggPortOperConversationPasses (7.3.2.1.25).

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Port_Conversation_ID
: A Conversation Identifier (6.6.1) derived from the parameters of the service primitive. When Conversation-Sensitive Collection and Distribution is supported, the mechanism to derive the Conversation Identifier is specified by the Actor_Port_Algorithm (6.6.3.1).
Data Type: Integer
Value: 0 to 4095

BEGIN
: A Boolean variable that is set to TRUE when the System is initialized or reinitialized and is set to FALSE when (re)initialization has completed.
Data Type: Boolean

6.2.7.1.3 Functions

DeterminePortConversationID
: When Conversation-Sensitive Collection and Distribution is supported, this function determines a Port_Conversation_ID for the frame as specified by the Actor_Port_Algorithm variable using the mechanisms described in 6.6 and Clause 8.

6.2.7.1.4 Messages

DataMuxN:M_UNITDATA.indication
AggMuxN:M_UNITDATA.indication
: The service primitives used to pass a received frame to a client with the specified parameters.

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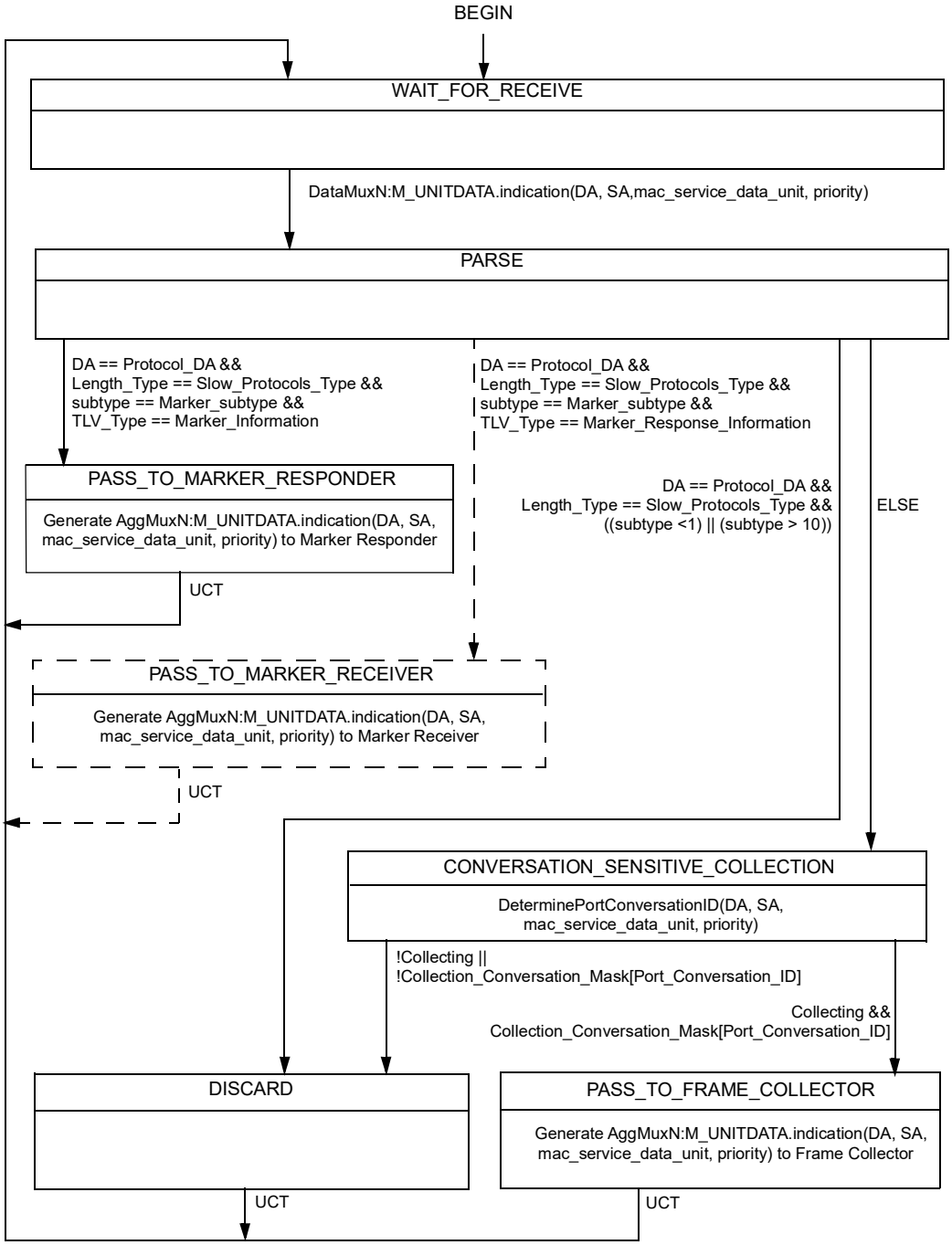
6.2.7.1.5 State diagrams



If the optional Marker Receiver is not implemented, Marker Responses go from the PARSE state to the CONVERSATION_SENSITIVE_COLLECTION state.
If Conversation-Sensitive Collection and Distribution is not implemented, transitions from the CONVERSATION_SENSITIVE_COLLECTION state are based solely on the value of the Collecting variable.

Figure 6-6—Aggregator Parser state diagram

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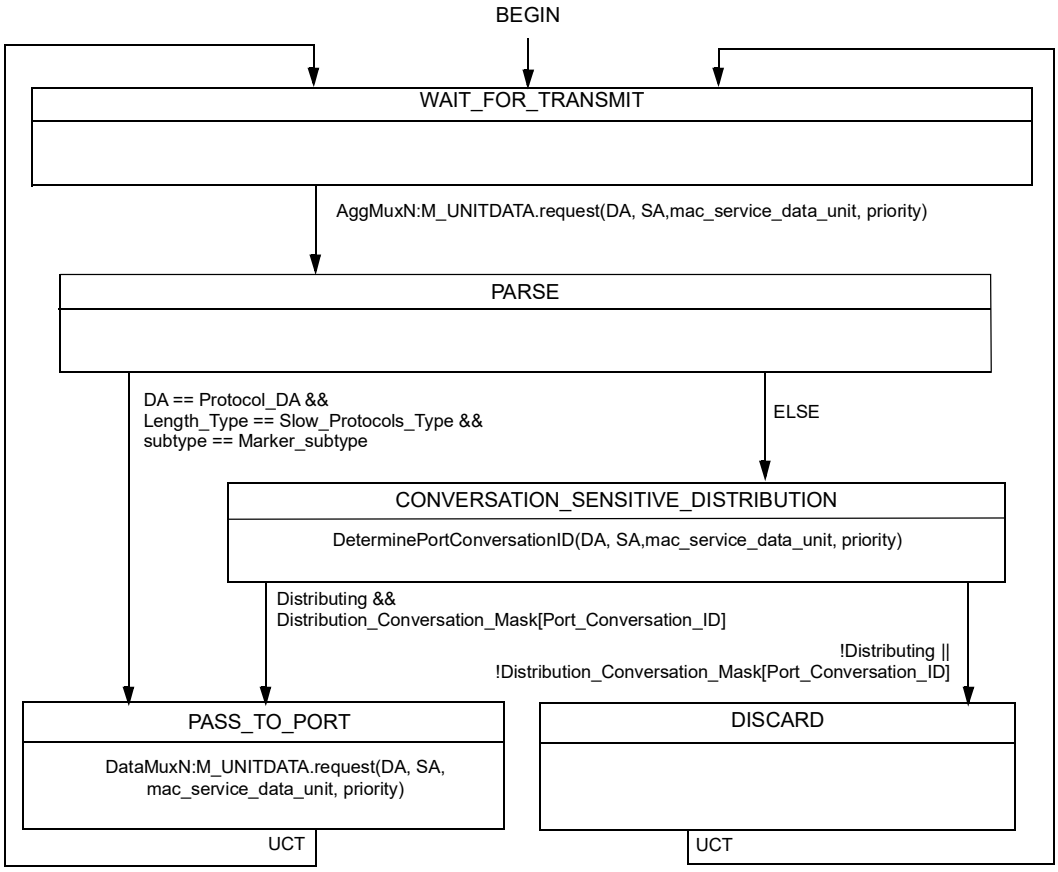

If Conversation-Sensitive Collection and Distribution is not implemented, transitions from the CONVERSATION_SENSITIVE_DISTRIBUTION state are based solely on the value of the Distributing variable.

Figure 6-7—Aggregator Multiplexer state diagram

6.2.8 Aggregator

An Aggregator comprises an instance of a Frame Collection function, an instance of a Frame Distribution function, and one or more instances of the Aggregator Parser/Multiplexer function for a LAG. A single Aggregator is associated with each LAG. An Aggregator offers an ISS interface to its associated Aggregator Client; access to the physical media by an Aggregator Client is always achieved via an Aggregator.

A single individual MAC address is associated with each Aggregator (see 6.2.10).

If the following are all true, an Aggregator is available for use by the Aggregator Client, and MAC_Operational at the Aggregator ISS is TRUE (6.3.12):

a) The Aggregator has one or more attached Aggregation Ports.
b) The Aggregator has not been set to a disabled state by administrative action (see 7.3.1.1.13).
c) One or more of the attached Aggregation Ports is Collecting and Distributing (see 7.3.1.1.14).

NOTE—To simplify the modeling and description of the operation of Link Aggregation, it is assumed that there are as many Aggregators as there are Aggregation Ports in a given System; however, this is not a requirement of this standard. Aggregation of two or more Aggregation Ports consists of changing the attachments between Aggregation Ports and Aggregators so that more than one Aggregation Port is attached to a single Aggregator. The creation of any

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aggregations of two or more links therefore results in one or more Aggregators that are attached to more than one Aggregation Port and one or more Aggregators that are not attached to any Aggregation Port. An Aggregator that is not attached to any Aggregation Port appears to an Aggregator Client as a MAC interface to an inactive Aggregation Port. During times when the attachments between Aggregation Ports and Aggregators are changing, or as a consequence of particular configuration choices, there might be occasions when one or more Aggregation Ports are not attached to any Aggregator.

6.2.9 LACP Parser/Multiplexer

There is an LACP Parser/Multiplexer for each Aggregation Port. Each LACP Parser/Multiplexer is an instance of the Protocol Parser/Multiplexer described in 6.1.3. Specifically:

a) The DownPort of the LACP Parser/Multiplexer is MacN (6.2.2) for LACP Parser/Multiplexer N.
b) The ControlPort of the LACP Parser/Multiplexer is CtrlMuxN (6.2.2) for LACP Parser/Multiplexer N.
c) The DataPort of the LACP Parser/Multiplexer is DataMuxN (6.2.2) for LACP Parser/Multiplexer N.
d) The IsControlFrame function returns a value of TRUE if the DA of the service primitive is equal to the aAggPortProtocolDA (7.3.2.2.1) value, the msdu_type is the Slow Protocols EtherType (Table 6-3), the subtype is the LACP_subtype (IEEE Std 802.3-2018, Table 57A–3), and the length of the mac_service_data_unit is greater than or equal to 60 octets.

6.2.10 Addressing

Each IEEE 802 MAC has an associated individual MAC address regardless of whether that MAC is used for Link Aggregation.

Each Aggregator to which one or more Aggregation Ports are attached has an associated individual MAC address (see 6.3.3). The MAC address of the Aggregator can be the individual MAC address of one of the MACs in the associated LAG, or it can be a distinct MAC address. The manner in which such addresses are chosen is not otherwise constrained by this standard.

6.2.10.1 Source address (SA)

The source MAC address of LACPDUs and Marker protocol frames originating within the Link Aggregation sublayer is that of the Aggregation Port used for their transmission. The source MAC address of frames transmitted by the Aggregator Client is that of the Aggregator (for frames originating from the Aggregator Client) or that assigned by the originator of the frame (for frames bridged by the Aggregator Client).

NOTE—This behavior causes both the Aggregation Port and the Aggregator to behave the same way as a standard MAC with regard to frames submitted by their clients.

6.2.10.2 Destination address (DA)

The destination MAC address of LACPDUs and Marker protocol frames originating within the Link Aggregation sublayer is a group address chosen to limit the propagation of those frames to the desired peer. Appropriate addresses include the C-VLAN component reserved addresses (see Table 8-1 in IEEE Std 802.1Q-2018) and the S-VLAN component reserved addresses (see Table 8-2 in IEEE Std 802.1Q-2018). The choice of address used determines the scope of propagation of Link Aggregation control and marker PDUs within a Bridged LAN, as follows:

a) The Nearest Customer Bridge group address is an address that no conformant C-VLAN component or MAC Bridge forwards. However, this address is relayed by Two-Port MAC Relay (TPMR) components and S-VLAN components. Therefore, Link Aggregation control, Distributed Relay

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control, and marker PDUs received on this address represent information about stations that are not separated from the recipient station by any intervening C-VLAN components or MAC Bridges. There can, however, be TPMR components and/or S-VLAN components in the path between the originating and receiving stations.

NOTE 1—This address makes it possible to communicate information between end stations and/or Customer Bridges and for that communication to be transparent to the presence or absence of TPMRs or S-VLAN components in the communication path. The scope of this address is the same as that of a Customer-Bridge-to-Customer-Bridge MACsec connection.

b) The Slow_Protocols_Multicast group address is an address that no conformant TPMR component, S-VLAN component, C-VLAN component, or MAC Bridge can forward. Link Aggregation control, Distributed Relay control, and marker PDUs transmitted using this DA can therefore travel no further than the stations that can be reached via a single individual LAN from the originating station. Link Aggregation control, Distributed Relay control, and marker PDUs received on this address therefore represent information about stations that are attached to the same individual LAN segment as the recipient station.

NOTE 2—This address makes it possible to transmit a Link Aggregation Control, DRCP, or Marker frame containing information specific to a single individual LAN, and for that information not to be propagated further than the extent of that individual LAN.

c) The Nearest non-TPMR Bridge group MAC address is an address that no conformant C-VLAN component, S-VLAN component, or MAC Bridge can forward. However, this address is relayed by TPMR components. Therefore, Link Aggregation control, Distributed Relay control, and marker PDUs received on this address represent information about stations that are not separated from the recipient station by any intervening C-VLAN component, S-VLAN component, or MAC Bridge. There can, however, be one or more TPMR components in the path between the originating and receiving stations.

NOTE 3—This address makes it possible to communicate information between end stations and/or Bridges and for that communication to be transparent to the presence or absence of TPMRs in the transmission path. This address is primarily intended for use within Provider Bridged Networks.

The Slow_Protocols_Multicast group address is the default for LACP and Marker Protocol destination address. The use and encoding of the Slow_Protocols_Multicast group address is specified in Annex 57A of IEEE Std 802.3-2018.

NOTE 4—IEEE Std 802.1AX-2014 and IEEE Std 802.1AXbk-2012 restricted the LACP and Marker protocol destination addresses to those in Table 6-1. This restriction has been removed, thus permitting the use of other suitable address scopes without further revision of this standard.

Table 6-1—Link Aggregation protocol destination addresses

Assignment	Value
Nearest Customer Bridge group address	01-80-C2-00-00-00
IEEE 802.3 Slow_Protocols_Multicast group address	01-80-C2-00-00-02
Nearest non-TPMR Bridge group address	01-80-C2-00-00-03

6.3 Link Aggregation Control

Link Aggregation Control uses locally configured information and information exchanged by the Link Aggregation Control Protocol.

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