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TELECOMMUNICATION
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G.8010/Y.1306

Amendment 3
(05/2021)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Ethernet over Transport
aspects

SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS,
NEXT-GENERATION NETWORKS, INTERNET OF
THINGS AND SMART CITIES

Internet protocol aspects – Transport

Architecture of Ethernet layer networks

Amendment 3

Recommendation ITU-T G.8010/Y.1306 (2004) –
Amendment 3



ITU-T G-SERIES RECOMMENDATIONS
TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

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Recommendation ITU-T G.8010/Y.1306

Architecture of Ethernet layer networks

Amendment 3

Summary

This Recommendation describes the functional architecture of Ethernet networks using the modelling methodology described in Recommendations ITU-T G.805, ITU-T G.809 and ITU-T G.800. The Ethernet network functionality is described from a network level viewpoint, taking into account an Ethernet network layered structure, client characteristic information, client/server layer associations, networking topology, and layer network functionality providing Ethernet signal transmission, multiplexing, routing, supervision, performance assessment, and network survivability. The functional architecture of the server layer networks used by the Ethernet network is not within the scope of this Recommendation. Such architectures are described in other ITU-T Recommendations or IETF RFCs.

This Recommendation is based on the Ethernet specifications in IEEE Standards 802.1Q-2018 and 802.3-2018, and developments of provider bridged networks.

This Recommendation defines the Ethernet maintenance entities, but the specific impact on the transport functions of connection monitoring in a connectionless layer network is not addressed. Ethernet network survivability is intended for inclusion in a future version.

This Recommendation is the first of a series of Ethernet and Ethernet over Transport-related Recommendations. Other Recommendations in this series will address e.g., equipment, OAM, service, performance aspects.

Amendment 3 updates references and incorporates terms formerly defined in Recommendation ITU-T G.8001/Y.1354 (2016).

History

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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

NOTE

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

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

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Recommendation ITU-T G.8010/Y.1306

Architecture of Ethernet layer networks

Amendment 3

Editorial note: This is a complete-text publication. Modifications introduced by this amendment are shown in revision marks relative to Recommendation ITU-T G.8010/Y.1306 (2004) plus its Amendments 1 and 2.

1 Scope

This Recommendation describes the functional architecture of Ethernet networks using the modelling methodology described in ~~ITU-T Recs G.805~~[\[ITU-T G.805\]](#), [\[ITU-T G.809\]](#) and [\[ITU-T G.800\]](#)~~G.809~~. The Ethernet network functionality is described from a network level viewpoint, taking into account an Ethernet network layered structure, client characteristic information, client/server layer associations, networking topology, and layer network functionality providing Ethernet signal transmission, multiplexing, routing, supervision, performance assessment, and network survivability. The functional architecture of the server layer networks used by the Ethernet network is not within the scope of this Recommendation. Such architectures are described in other ITU-T Recommendations or IETF RFCs.

The bases for this Recommendation are the Ethernet specifications in [\[IEEE 802.1Q\]](#) and [\[IEEE 802.3\]](#). ~~IEEE 802.1D, 802.1Q and 802.3, and developments of provider bridged networks. Furthermore, the architectural aspects of provider bridges currently being defined in IEEE P802.1ad task force are taken into account.~~

2 References

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

- ~~ITU-T Recommendation G.707/Y.1322 (2003), Network node interface for the synchronous digital hierarchy (SDH).~~
- ~~ITU-T Recommendation G.709/Y.1331 (2003), Interfaces for the Optical Transport Network (OTN).~~
- ~~Recommendation ITU-T G.800 (2007), Unified functional architecture of transport networks.~~
- ~~ITU-T Recommendation G.805 (2000), Generic functional architecture of transport networks.~~
- ~~ITU-T Recommendation G.809 (2003), Functional architecture of connectionless layer networks.~~
- ~~ITU-T Recommendation G.7041/Y.1303 (2003), Generic framing procedure (GFP).~~
- ~~ITU-T Recommendation G.7710/Y.1701 (2001), Common equipment management function requirements.~~

- ~~ITU-T Recommendation G.8001/Y.1354 (2006), Terms and definitions for Ethernet frames over Transport(EoT).~~
- ~~ITU-T Recommendation G.8011/Y.1307 (2004), Ethernet over Transport— Ethernet services framework.~~
- ~~ITU-T Recommendation G.8021/Y.1341 (2004), Characteristics of Ethernet transport network equipment functional blocks.~~
- ~~ITU-T Recommendation X.731 (1992), Information technology— Open Systems Interconnection— Systems management: State management function.~~
- ~~ITU-T Recommendation Y.1730 (2004), Requirements for OAM functions in Ethernet based networks and Ethernet services.~~
- ~~ITU-T Recommendation Y.1731 (2006), OAM functions and mechanisms for Ethernet based networks.~~
- ~~IEEE Standard 802-2001, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.~~
- ~~IEEE Standard 802.1D-2004, IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges.~~
- ~~IEEE Standard 802.1Q-2005, IEEE Standards For Local And Metropolitan Area Networks: Virtual Bridged Local Area Networks.~~
- ~~IEEE Standard 802.1ad-2005, IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks, Amendment 4: Provider Bridges.~~
- ~~IEEE Standard 802.1ah-2008, IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks, Amendment 7: Provider Backbone Bridges.~~
- ~~IEEE Standard 802.1Qaw-2009, IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks, Amendment 9: Management of Data Driven and Data Dependent Connectivity Faults.~~
- ~~IEEE Standard 802.1aj-2009, IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks, Amendment 11: Two Port Media Access Control (Mac) Relay.~~
- ~~IEEE Standard 802.2-1998, Information Technology— Telecommunications and Information Exchange Between Systems— Local and metropolitan area networks— Specific Requirements— Part 2: Logical Link Control.~~
- ~~IEEE Standard 802.3-2002, Information Technology— Telecommunication and Information Exchange Between Systems— LAN/MAN— Specific Requirements— Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.~~
- ~~IEEE Standard 802.3AE-2002, IEEE Standard for Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications— Media Access Control (MAC) Parameters, Physical Layer and Management Parameters for 10 Gb/s Operation.~~
- ~~IETF RFC 2684 (1999), Multiprotocol Encapsulation over ATM Adaptation Layer 5.~~
- ~~IETF RFC 3031 (2001), Multiprotocol Label Switching Architecture.~~

[\[ITU-T G.707\]](#) [Recommendation ITU-T G.707/Y.1322 \(2007\), Network node interface for the synchronous digital hierarchy \(SDH\).](#)

| | |
|---------------------------------------|--|
| [ITU-T G.709] | Recommendation ITU-T G.709/Y.1331 (2020), <i>Interfaces for the Optical Transport Network (OTN)</i>. |
| [ITU-T G.800] | Recommendation ITU-T G.800 (2016), <i>Unified functional architecture of transport networks</i>. |
| [ITU-T G.805] | Recommendation ITU-T G.805 (2000), <i>Generic functional architecture of transport networks</i>. |
| [ITU-T G.809] | Recommendation ITU-T G.809 (2003), <i>Functional architecture of connectionless layer networks</i>. |
| [ITU-T G.7041] | Recommendation ITU-T G.7041/Y.1303 (2016), <i>Generic framing procedure</i>. |
| [ITU-T G.7710] | Recommendation ITU-T G.7710/Y.1701 (2020), <i>Common equipment management function requirements</i>. |
| [ITU-T G.8012] | Recommendation ITU-T G.8012/Y.1308 (2004), <i>Ethernet UNI and Ethernet NNI</i>. |
| [ITU-T G.8013] | Recommendation ITU-T G.8013/Y.1731 (2015), <i>Operations, administration and maintenance (OAM) functions and mechanisms for Ethernet-based networks</i>. |
| [ITU-T G.8021] | Recommendation ITU-T G.8021/Y.1341 (2018), <i>Characteristics of Ethernet transport network equipment functional blocks</i>. |
| [ITU-T G.8031] | Recommendation ITU-T G.8031/Y.1342 (2015), <i>Ethernet linear protection switching</i>. |
| [ITU-T G.8110.1] | Recommendation ITU-T G.8110.1/Y.1370.1 (2012), <i>Architecture of the Multi-Protocol Label Switching transport profile layer network</i>. |
| [ITU-T X.731] | Recommendation ITU-T X.731 (1992), <i>Information technology – Open Systems Interconnection – Systems management: State management function</i>. |
| [ITU-T Y.1730] | Recommendation ITU-T Y.1730 (2004), <i>Requirements for OAM functions in Ethernet-based networks and Ethernet services</i>. |
| [IEEE 802] | IEEE 802 (2014), <i>IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture</i>. |
| [IEEE 802.1Q] | IEEE 802.1Q (2018), <i>IEEE Standard for Local And Metropolitan Area Networks: Bridges and Bridged Networks</i>. |
| [IEEE 802.3] | IEEE 802.3 (2018), <i>IEEE Standard for Ethernet</i>. |
| [IETF RFC 2684] | IETF RFC 2684 (1999), <i>Multiprotocol Encapsulation over ATM Adaptation Layer 5</i>. |
| [ISO/IEC/IEEE 8802.2] | ISO/IEC/IEEE 8802.2, <i>International Standard – Information Technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control</i>. |

3 Terms and definitions

3.1 Terms defined elsewhere

3.1.1 ~~This Recommendation uses the following t~~Terms defined in ~~[ITU-T Rec. G.805]:~~

- a) access point;
- b) bidirectional reference point;
- c) component link;
- d) compound link;
- e) connection point;
- f) link;
- g) link connection;
- h) network connection;
- i) network operator;
- j) serial-compound link;
- k) service provider;
- l) termination connection point;
- m) trail;
- n) trail termination.

3.1.2 ~~This Recommendation uses the following t~~Terms defined in ~~[ITU-T Rec. G.809]:~~

- a) access point;
- b) adaptation;
- c) adapted information;
- d) characteristic information;
- e) client/server relationship;
- f) connectionless trail;
- g) flow;
- h) flow domain;
- i) flow domain flow;
- j) flow point;
- k) flow point pool;
- l) flow point pool link;
- m) flow termination;
- n) flow termination sink;
- o) flow termination source;
- p) layer network;
- q) link flow;
- r) matrix;
- s) network;
- t) network flow;
- u) port;
- v) reference point;

- w) traffic unit;
- x) transport;
- y) transport entity;
- z) transport processing function;
- aa) termination flow point;
- bb) termination flow point pool.

3.1.3 Terms defined in [ITU-T G.8013]

- a) maintenance entity group;
- b) maintenance entity.

3.2.3 Terms defined in this Recommendation~~This Recommendation uses the following terms defined in Rec. ITU-T G.8001/Y.1354:~~

This Recommendation defines the following terms:

3.2.1 traffic conditioning function: A "transport processing function" which accepts the characteristic information of the layer network at its input, classifies the traffic units according to configured rules, meters each traffic unit within its class to determine its eligibility, polices non-conformant traffic units and presents the remaining traffic units at its output as characteristic information of the layer network.

3.2.2 maintenance entity group end point compound sink function: A compound transport processing function which accepts the characteristic information of the layer network at its input, extracts and processes the OAM information related to the maintenance entity group's monitoring, filters the OAM information from within to the maintenance entity group, adapts the information and presents it as the characteristic information of the layer or a client layer at its output, potentially as a (client) layer maintenance signal (e.g., AIS).

3.2.3 maintenance entity group end point compound source function: A compound transport processing function which accepts the characteristic information of the layer or a client layer network at its input, adapts that information, filters it for OAM information interfering with its own OAM information, adds OAM information to allow the maintenance entity group to be monitored and presents the resulting information at its output.

3.2.4 maintenance entity group intermediate point compound function: A compound transport processing function which accepts the characteristic information of the layer network at its input, reacts to OAM information related to the maintenance entity group's on-demand monitoring and presents the characteristic information without the OAM it reacted to at its output.

3.2.5 proactive monitoring: A method to continuously infer the status and performance of a maintenance entity group with the purpose to detect disturbances, faults and degradations immediately after their occurrence in order to verify the service level agreement and/or initiate recovery actions to restore the service to the guaranteed level.

3.2.6 on-demand monitoring: A method to infer a specific status or performance characteristic of a maintenance entity or a set of maintenance entities within a maintenance entity group at a specific point in time with the purpose to obtain a snapshot of the performance, or to diagnose an identified fault condition or performance degradation.

3.2.7 ETH CI group: A group of ETH CI signals that is monitored as a single MEG. For this purpose, ETH OAM is added to one of the ETH CI signals in the group.

3.2.8 ETH CI traffic unit: The following set of signals: ETH CI Data (D), ETH CI priority (P), ETH CI drop eligibility (DE), ETH CI server signal fail (SSF) and optionally ETH CI automatic protection switching (APS). The ETH CI D signal carries the traffic unit that consists of the

following fields: destination address (DA), source address (SA) and MAC service data unit (M_SDU).

3.2.9 ETH path: The highest ETH MEG level in a set of eight MEG levels.

3.2.10 ETH tandem connection: An intermediate ETH MEG level in a set of eight MEG levels.

3.2.11 ETH section: The lowest ETH MEG level in a set of eight MEG levels.

~~3.3.1 traffic conditioning function~~

~~3.3.2 maintenance entity group~~

~~3.3.3 maintenance entity~~

~~3.3.4 maintenance entity group end point compound sink function~~

~~3.3.5 maintenance entity group end point compound source function~~

~~3.3.6 maintenance entity group intermediate point compound function~~

~~3.3.7 proactive monitoring~~

~~3.3.8 on-demand monitoring~~

~~3.3.9 ETH_CI group~~

~~3.3.10 ETH path~~

~~3.3.11 ETH tandem connection~~

~~3.3.12 ETH section~~

~~Editor's Note: The "traffic conditioning function" (defined in the original ITU-T G.8010) was redefined as "traffic conditioning and shaping function" in ITU-T G.8010 Amendment 1.~~

~~4 Aeronyms and abbreviations~~ Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

| | |
|-------|--------------------------------------|
| 1DM | One-way delay measurement |
| AIS | Alarm Indication Signal |
| AI | Adapted Information |
| AP | Access Point |
| APS | Automatic Protection Switching |
| ARP | Address Resolution Protocol |
| ATM | Asynchronous Transfer Mode |
| BP | Bridge Protocol |
| CCM | Connectivity Check Message |
| CI | Characteristic Information |
| cLink | component Link |
| CLPS | Connectionless Packet Switched |
| CO-CS | Connection-Oriented Circuit Switched |
| CO-PS | Connection-Oriented Packet Switched |
| CoS | Class of Service |
| CP | Connection Point |
| DA | Destination MAC address |

| | |
|------------------|--|
| DMM | Delay Measurement Message |
| DMR | Delay Measurement Reply |
| DP | Dropping Precedence |
| EC | Ethernet Connection |
| ETC | Ethernet Coding sublayer of ETY |
| ETCn | Ethernet Coding sublayer of order n |
| ETH | Ethernet layer network |
| ETHDe | ETH Diagnostic function within ETH _x MEP |
| ETHDi | ETH Diagnostic function within ETH _x MIP |
| ETHG | ETH Group |
| ETHS | ETH Segment |
| ETH _x | ETH at level x (x = path, tandem connection, section) |
| ETY | Ethernet PHY layer network |
| ETY _n | Ethernet PHY layer network of order n |
| FCS | Frame Check Sequence |
| FD | Flow Domain |
| FDF | Flow Domain Flow |
| FDFr | Flow Domain Fragment |
| FP | Flow Point |
| FPP | Flow Point Pool |
| FT | Flow Termination |
| GARP | Generic Attribute Registration Protocol |
| GFP | Generic Framing Procedure |
| GFP-F | Frame-mapped GFP |
| GFP-T | Transparent GFP |
| IP | Internet Protocol |
| LAN | Local Area Network |
| LBM | Loopback Message |
| LBR | Loopback Reply |
| LCAS | Link Capacity Adjustment Scheme |
| LCK | Locked |
| LF | Link Flow |
| LMM | Loss Measurement Message |
| LMR | Loss Measurement Reply |
| LTM | Link Trace Message |
| LTR | Link Trace Reply |
| M_SDU | MAC Service Data Unit |
| MAC | Media Access Control |
| ME | Maintenance Entity |

| | |
|---------|--|
| MEG | Maintenance Entity Group |
| MEL | Maintenance Entity Group Level |
| MEP | Maintenance entity group End Point |
| MFD | Matrix Flow Domain |
| MFDFr | Matrix Flow Domain Fragment |
| MIP | Maintenance entity group Intermediate Point |
| MPLS | Multi-Protocol Label Switching |
| NF | Network Flow |
| NNI | Network Node Interface |
| OAM | Operations, Administration and Maintenance |
| ODU | Optical Channel Data Unit |
| ODUk | Optical Channel Data Unit-k |
| ODUk-Xv | X virtually concatenated ODUks |
| OTH | Optical Transport Hierarchy |
| OTN | Optical Transport Network |
| PCS | Physical Coding Sub-layer of PHY |
| PDU | Protocol Data Unit |
| PHY | Ethernet Physical Layer entity consisting of the PCS, the PMA, and, if present, the PMD sub-layers |
| PMA | Physical Medium Attachment sub-layer of PHY |
| PMD | Physical Medium Dependent sub-layer of PHY |
| SA | Source MAC Address |
| SDH | Synchronous Digital Hierarchy |
| SDU | Service Data Unit |
| SLA | Service Level Agreement |
| TC | Traffic Conditioning |
| TCP | Termination Connection Point |
| TCS | Traffic Conditioning and Shaping |
| TFP | Termination Flow Point |
| TFPP | Termination Flow Point Pool |
| TP | Transmission Path |
| TST | Test PDU |
| TT | Trail Termination |
| UNI | User Network Interface |
| UNI-C | Customer side of UNI |
| UNI-N | Network side of UNI |
| VC | Virtual Channel |
| VC-n | Virtual Container-n |
| VC-n-Xc | X contiguously concatenated VC-ns |
| VC-n-Xv | X virtually concatenated VC-ns |

| | |
|------|-------------------------|
| VID | VLAN Identifier |
| VLAN | Virtual LAN |
| VPN | Virtual Private Network |

5 Conventions

The diagrammatic convention for connection-oriented layer networks described in this Recommendation is that of [ITU-T G.805](#) ~~ITU-T Rec. G.805~~.

The diagrammatic convention for connectionless layer networks described in this Recommendation is that of [ITU-T G.809](#) ~~ITU-T Rec. G.809~~ with the exception of the colouring of atomic function and port symbols.

For the purpose of this Recommendation, the following additional diagrammatic convention (see Figure 5-1) is defined as a shorthand notation for two co-located Flow Points in opposite directions:

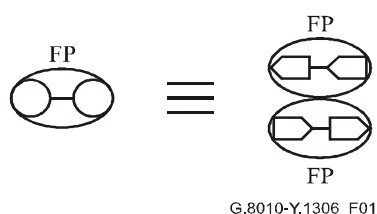


Figure 5-1/~~G.8010/Y.1306~~ – Diagrammatic convention for two co-located Flow Points in opposite directions

For the purpose of this Recommendation, the following (see Figure 5-2) symbol is defined to represent an ETH flow point pool (FPP) link or component link:

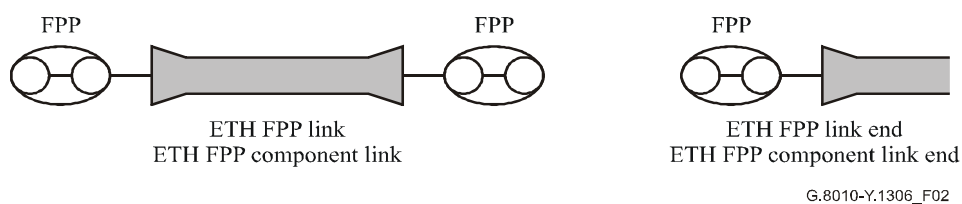


Figure 5-2/~~G.8010/Y.1306~~ – Diagrammatic convention for ETH FPP (component) link (end)

The diagrammatic convention for a traffic conditioning and shaping function is shown in Figure 5-3. The TCS sink function provides the traffic conditioning process. The TCS source function provides the shaping process.

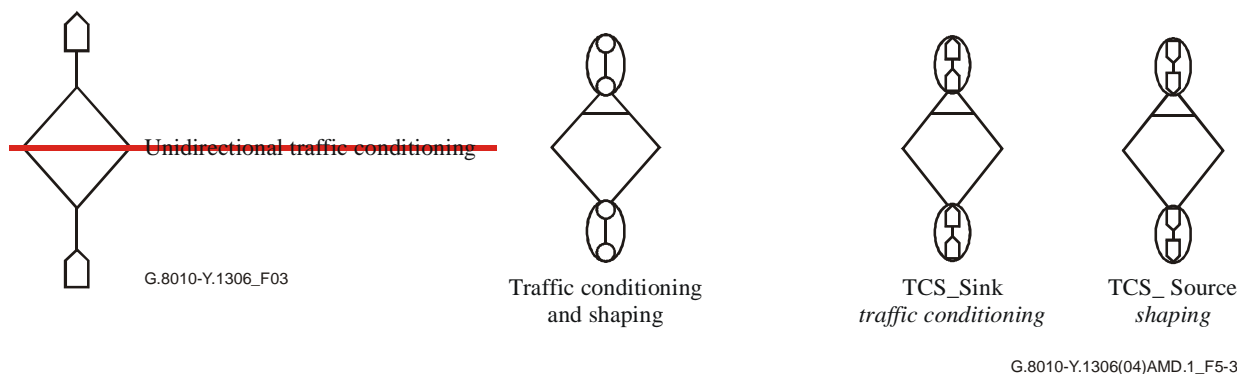


Figure 5-3/G.8010/Y.1306 – Diagrammatic convention for unidirectional traffic conditioning and shaping function

This Recommendation describes the topology using both the FPPs and FPs. The FPP (as defined in [ITU-T G.809](#) ~~ITU-T Rec. G.809~~) is "a group of co-located flow points that have a common routing". The FPP is used to describe the architecture of the Ethernet layer networks when aggregate flows are of more interest than individual flows. The FP is used when individual flows are of interest.

The diagrammatic convention for a MEG end point (MEP) compound function is shown in Figure 5-4.

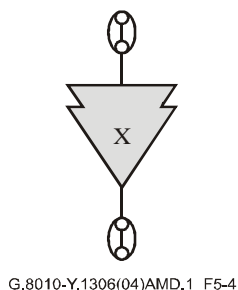


Figure 5-4 – Diagrammatic convention for MEG end point (MEP) compound function

The diagrammatic convention for a MEG intermediate point (MIP) compound function is shown in Figure 5-5.

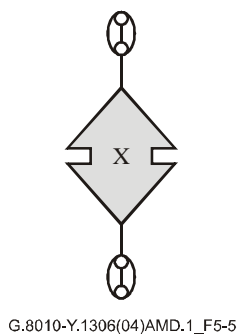


Figure 5-5 – Diagrammatic convention for MEG intermediate point (MIP) compound function

6 Functional architecture of Ethernet transport networks

6.1 General

The functional architecture of Ethernet transport networks is described using the generic rules defined in [\[ITU-T G.805\]](#)~~ITU-T Recs G.805~~ and [\[ITU-T G.809\]](#)~~G.809~~. The specific aspects regarding the characteristic information, client/server associations, the topology, the connection supervision, multipoint capabilities and partitioning of Ethernet transport networks are provided in this Recommendation. This Recommendation uses the terminology and functional architecture and diagrammatic conventions defined in [\[ITU-T G.805\]](#)~~ITU-T Recs G.805~~ and [\[ITU-T G.809\]](#)~~G.809~~.

6.2 Ethernet network layered structure

Two layer networks are defined in the Ethernet transport network architecture:

- Ethernet (ETH) layer network;
- Ethernet PHY (ETY) layer network.

The ETH layer network is a path layer network. The ETY layer network is a section layer network. The ETH layer network characteristic information can be transported through ETH links supported by trails in the server layer networks (e.g., ETY, SDH VC-n, OTN ODUk, MPLS, ATM).

6.3 Ethernet (ETH) layer network

The ETH layer network provides the transport of adapted information through an ETH connectionless trail between ETH access points. The adapted information is a (non-)continuous flow of MAC Service Data Units ([\[IEEE 802.3\]](#)).

An example of the ETH layer network containing the following transport processing functions, transport entities, topological components and reference points is shown in Figure [46-1](#):

- ETH connectionless trail;
- ETH flow termination source (ETH_FT_So);
- ETH flow termination sink (ETH_FT_Sk);
- ETH network flow (NF);
- ETH link flow (LF);
- ETH flow domain flow (FDF);
- ETH flow domain (FD);
- ETH access point (AP);
- ETH flow point (FP);
- ETH termination flow point (TFP).

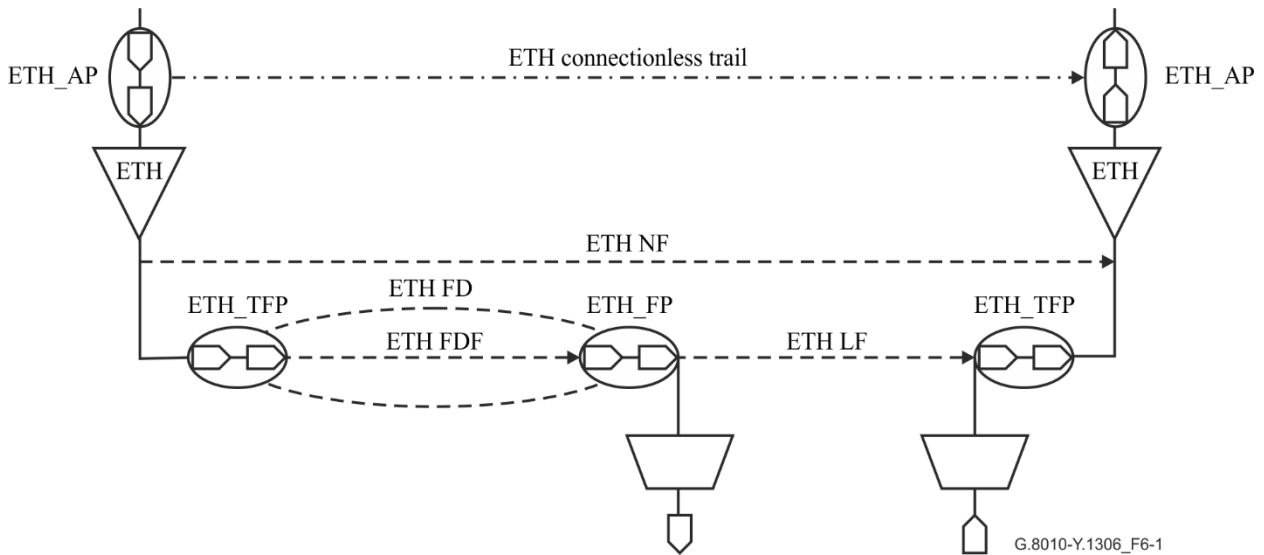


Figure 6-14/G.8010/Y.1306 – ETH layer network example (unicast flow)

6.3.1 ETH characteristic information

The ETH_CI consists of the following set of signals: ETH_CI Data (D), ETH_CI Priority (P), ETH_CI Drop Eligibility (DE), ETH_CI Server Signal Fail (SSF) and optionally ETH_CI Automatic Protection Switching (APS). The ETH_CI_D signal carries the traffic unit that consists of the following fields: Destination Address (DA), Source Address (SA) and MAC Service Data Unit (M_SDU).

The ETH_CI traffic unit is transported over an ETH FPP Link within a link specific frame or packet, of which the generic format is depicted in Figure 56-2. The Priority and Drop Eligibility signals may be transported implicitly or explicitly.

Refer to Appendix IV for further considerations on ETH_CI.

NOTE 1 – The Preamble (PA), Start-of-Frame Delimiter (SFD) and Frame Check Sequence (FCS) are considered part of the MAC frame ([IEEE 802.3] clause 3). In the layer network model, this PA/SFD/FCS is associated with the ETH FPP link, not with the ETH characteristic information. This modelling does not change the requirement, in ~~IEEE 802.1D~~ and [IEEE 802.1Q], regarding introducing undetected frame errors.

NOTE 2 – Refer to Appendix III for VLAN ID considerations.

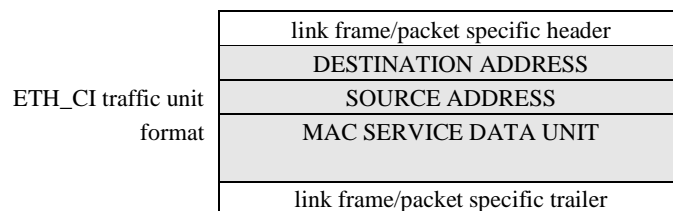


Figure 6-25/G.8010/Y.1306 – ETH characteristic information (ETH_CI) traffic unit format when mapped into a link specific frame or packet

The ETH_CI traffic unit may be a *unicast*, *multicast* or *broadcast* frame as identified by the MAC Destination Address ([IEEE 802]).

6.3.2 ETH topological components

The ETH topological components are:

- ETH layer network;

- ETH flow domain;
- ETH flow point pool link;
- ETH access group.

The ETH layer network can be partitioned into one or more ETH flow domains interconnected by ETH FPP links.

6.3.2.1 ETH layer network

The ETH layer network is defined by the complete set of ETH access groups that may be associated for the purpose of transferring information. The information transferred is characteristic of the ETH layer network and is termed ETH characteristic information. The associations of the ETH flow terminations (that form a connectionless trail) in the ETH layer network are defined on a per traffic unit basis, which is the ETH_CI traffic unit (see 6.3.1). The topology of the ETH layer network is described by ETH access groups, ETH flow domains and the ETH flow point pool links between them. The structures within the ETH layer network and its server and client layer networks are described by the components below.

6.3.2.2 ETH flow domain

An ETH flow domain is defined by the set of ETH (termination) flow points that are available for the purpose of transferring information. ETH_CI traffic unit transfers, across the ETH flow domain that corresponds to a particular association between ingress and egress ETH (termination) flow points, need not be present at all times. In general, ETH flow domains may be partitioned into smaller flow domains interconnected by ETH flow point pool links. The matrix (e.g., bridge) is a special case of an ETH flow domain.

An ETH flow domain provides broadcast connectivity between the connected ETH (termination) flow points. An ETH_CI traffic unit received via an input port (e.g., A in Figure 6-3) of the ETH flow domain is forwarded to all output ports on the ETH flow domain (B, C, D), with the exception of the output port (A) that is in the same bidirectional ETH (termination) flow point as the input port.

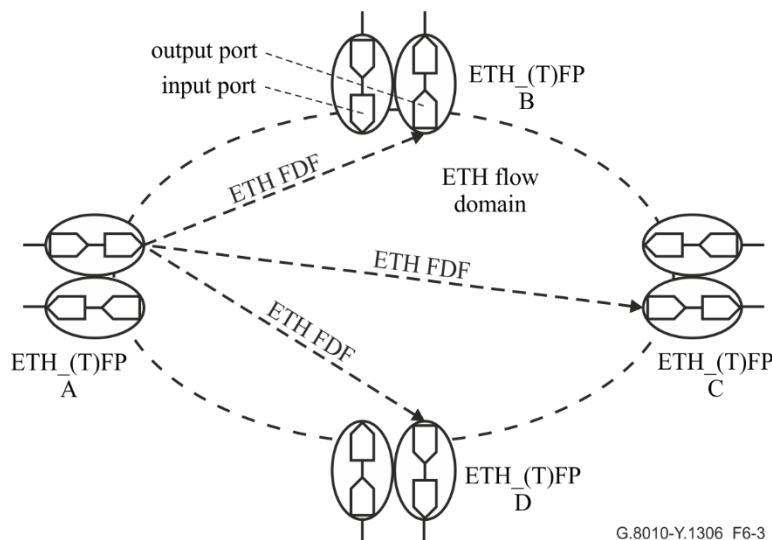


Figure 6-3/G.8010/Y.1306 – Broadcast connectivity in ETH Flow Domain

By means of ETH network management, ETH control plane actions and/or MAC learning, connectivity in an ETH flow domain can be restricted.

NOTE – The description of split-horizon functionality in an ETH flow domain is for further study.

6.3.2.3 ETH flow point pool link

An ETH flow point pool link (FPP link) consists of a subset of the ETH flow points at the edge of one ETH flow domain or ETH access group that are associated with a corresponding subset of ETH flow points at the edge of another ETH flow domain or ETH access group for the purpose of transferring ETH characteristic information.

The ETH FPP link represents the topological relationship and available capacity between a pair of ETH flow domains, or an ETH flow domain and an ETH access group, or a pair of ETH access groups.

Multiple ETH FPP links may exist between any given ETH flow domain and ETH access group or pair of ETH flow domains or ETH access groups.

6.3.2.4 ETH access group

An ETH access group is a group of co-located ETH flow termination functions that are connected to the same ETH flow domain or ETH FPP link.

6.3.2.5 Partitioning ETH topological components

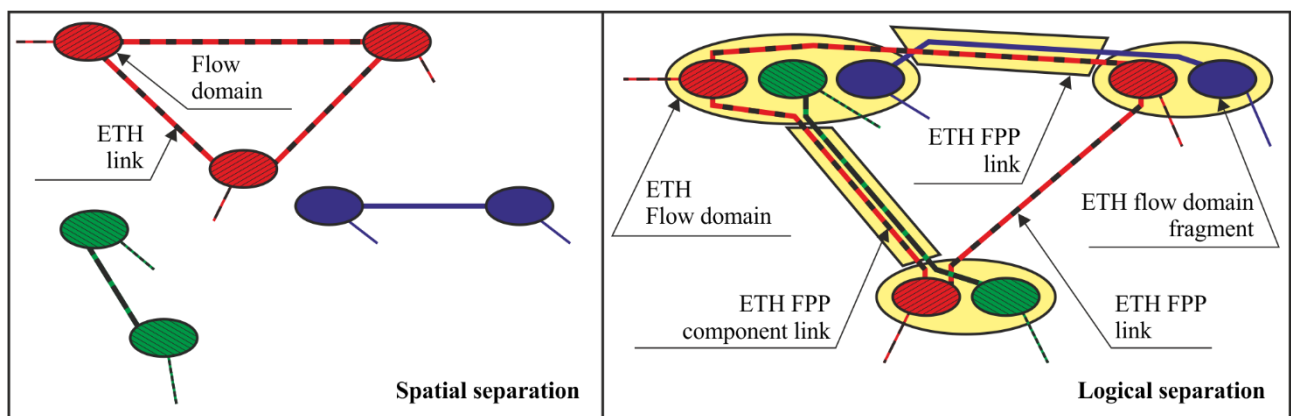
Subsets of ETH topological components can be allocated to specific users, creating ETH VPNs. Traffic within an ETH VPN is bound to that ETH VPN and will not cross over to another ETH VPN.

NOTE – ETH VPNs may be deployed for other purposes as well, e.g., to segregate two or more applications.

6.3.2.5.1 Fragmenting an ETH layer network

The ETH layer network can be fragmented in ETH VPNs such that either:

- two ETH VPNs do not have any components (flow domains, FPP links, access groups) in common (spatial separation) (see Figure 6-47); or
- flow domains and links are shared by multiple ETH VPNs and ETH VPN separation is obtained via the allocation of flow domain fragments, component links and/or links to each ETH VPN (logical separation) (see Figure 6-47).



G.8010-Y.3106_F6-4

Figure 6-47/G.8010/Y.1306 – Spatially and logically separated ETH VPNs

6.3.2.5.2 Fragmenting an ETH flow domain

An ETH flow domain can be fragmented into ETH flow domain fragments (FDFr) (see Figure 6-58). Refer to Annex A. An ETH FDFr provides connectivity between the (termination) flow points in the fragment.

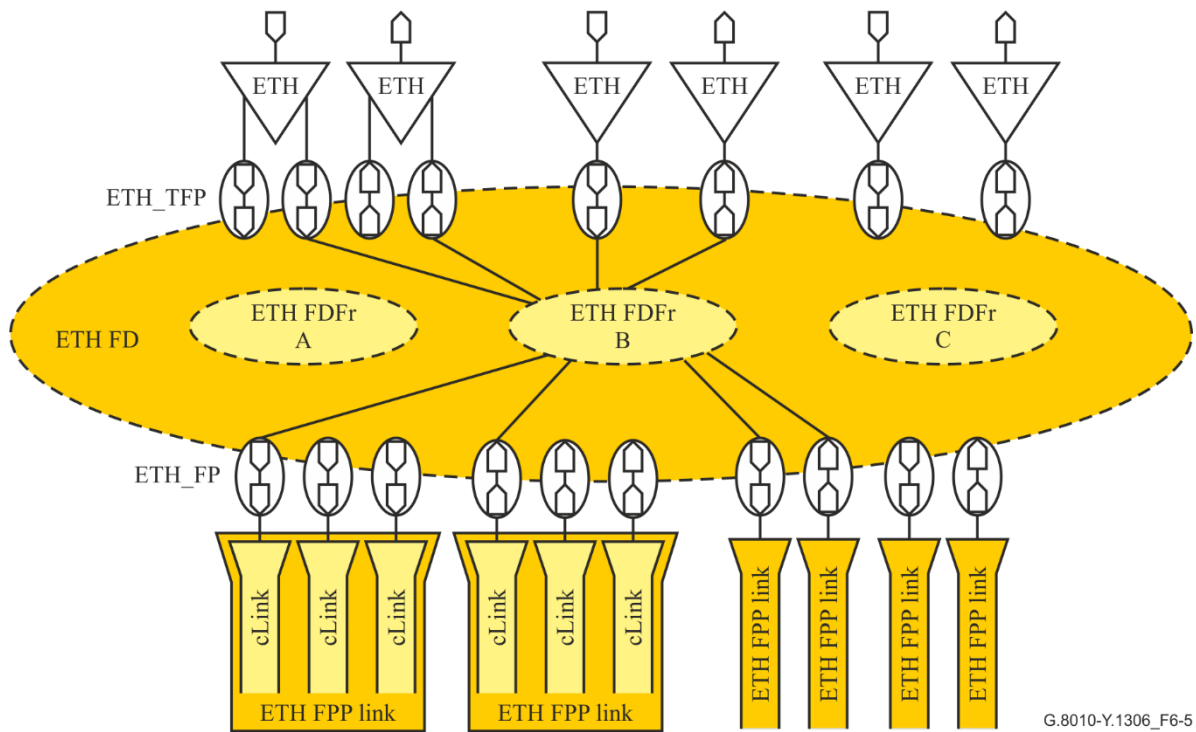


Figure 6-58/G.8010/Y.1306 – ETH flow domain fragments

NOTE – There is in general no theoretical limit to the number of fragments in an ETH flow domain. [IEEE 802.1Q] implementations, however, have a limit of 4094 fragments due to the use of the VLAN IDs for the identification of flow domain fragments.

6.3.2.5.3 Partitioning an ETH flow point pool link

An ETH flow point pool link can be partitioned into ETH flow point pool component links (cLink) (see Figures 8-6-5 and 6-69). The input and output ports of an ETH FPP cLink can be bound to output and input ports of ETH Flow Domains and/or ETH Flow Termination functions. ETH FPP cLinks provide the same connectivity as an ETH FPP link.

NOTE – The ETH layer network technology supporting component links within the ETH FPP link is the VLAN technology. MAC frames are extended with an additional VLAN tag (see [IEEE 802.3] clause 3.5, [IEEE 802.1Q] clause 9) including a VLAN ID to identify the ETH VPN these frames belong to. There is a maximum number of ETH FPP cLinks within an ETH FPP link that can be supported with the VLAN technology.

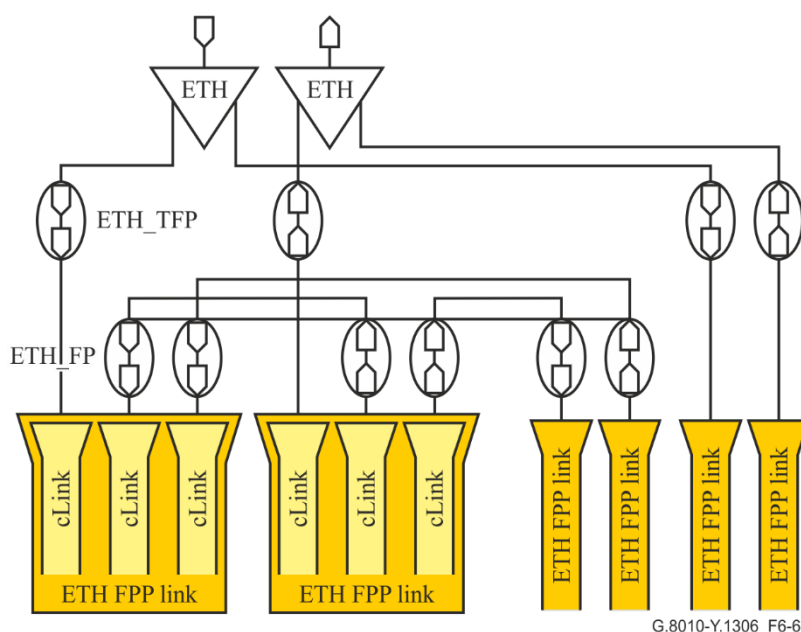


Figure 96-6/G.8010/Y.1306 – ETH FPP component links

6.3.3 ETH transport entities

The ETH transport entities are:

- ETH link flow;
- ETH flow domain flow;
- ETH network flow;
- ETH connectionless trail.

6.3.4 ETH transport processing functions

The ETH transport processing functions are:

- ETH flow termination function;
- ETH to client layer network adaptation functions;
- ETH traffic conditioning function.

6.3.4.1 ETH flow termination function

See clause 7.5.1

6.3.4.2 ETH traffic conditioning and shaping function

The bidirectional ETH traffic conditioning and shaping (ETH_TCS) function is performed by a co-located pair of ETH traffic conditioning and shaping source (ETH_TCS_So) and sink (ETH_TCS_Sk) functions.

The ETH_TCS_So function performs the following shaping processes:

- For further study.

The ETH_TCS_Sk function performs the following traffic conditioning processes:

- *Classification*: This process classifies each ETH_CI traffic unit.
- *Metering*: This process meters every ETH_CI traffic unit within its class in order to determine the eligibility of the ETH_CI traffic unit.
- *Marking*: This process sets the drop eligibility if applicable.

- *Policing*: This process disposes of the ETH_CI traffic unit according to the result from the metering process. There are only two dispositions for an ETH_CI traffic unit, passing to the ETH_FP or discarding.

The ETH_TCS function is assigned on a per ETH_FPP basis, as shown in Figure 7-16. The ETH_FPP may include a single ETH_FP or multiple ETH_FPs.

6.3.5 ETH reference points

The ETH reference points (see Figures 4, 12 and 13) are:

- ETH access point (AP);
- ETH termination flow point (TFP);
- ETH flow point (FP);
- ETH flow point pool (FPP);
- ETH termination flow point pool (TFPP);

6.3.5.1 ETH access point

An ETH access point (ETH_AP) represents the binding between an ETH flow termination function and one or more ETH/Client adaptation functions.

6.3.5.2 ETH termination flow point

An ETH Termination Flow Point (ETH_TFP) represents the binding between an ETH flow termination function and either an ETH flow domain, or an ETH flow point pool link (see Figure 106-7).

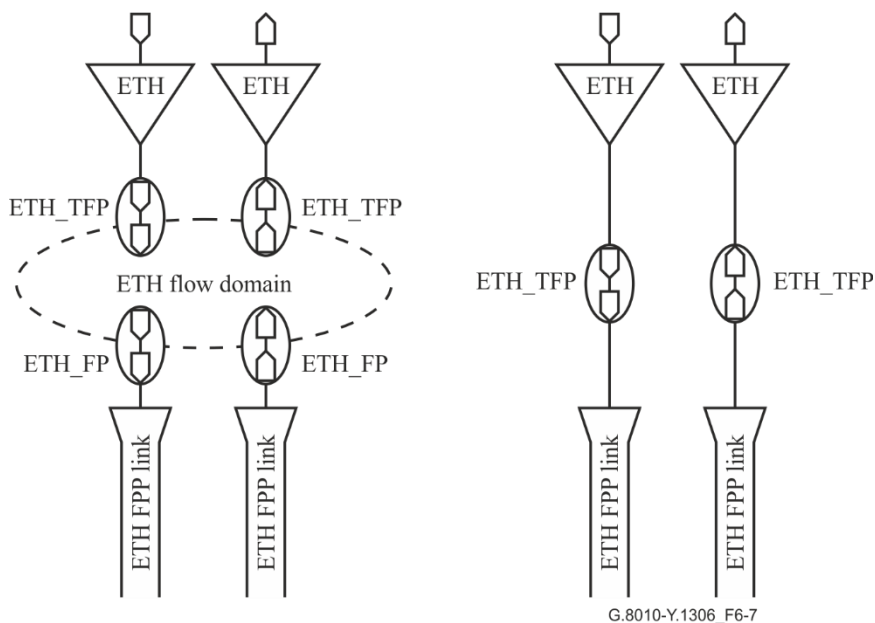


Figure 106-7/G.8010/Y.1306 – ETH termination flow points between ETH_FT function and ETH flow domain or ETH FPP link

6.3.5.3 ETH flow point

An ETH flow point represents the binding of an ETH FPP link with an ETH flow domain or another ETH FPP link (see Figure 116-8). This flow point is provided through the Server/ETH adaptation function.

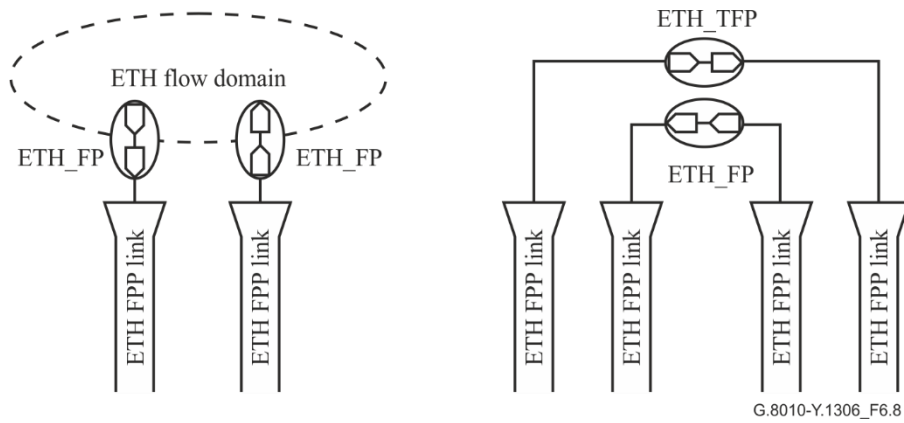


Figure 116-8/G.8010/Y.1306 – ETH flow points between ETH FPP links and ETH flow domain

An ETH flow point, from the network viewpoint, is transparent to both the source address and destination address of any ETH_CI traffic unit that traverses it.

6.3.5.4 ETH flow point pools

A group of co-located ETH flow points that have a common routing is referred to as an ETH flow point pool (FPP). An FPP has the same properties as its member flow points.

6.3.5.5 ETH termination flow point pools

A group of co-located ETH termination flow points is referred to as an ETH termination flow point pool (TFPP). A TFPP has the same properties as its termination flow points.

6.3.5.6 Partitioning ETH reference points

6.3.5.6.1 Partitioning an ETH flow point

An ETH flow point can be partitioned to generate new ETH flow points (see Figure 126-9).

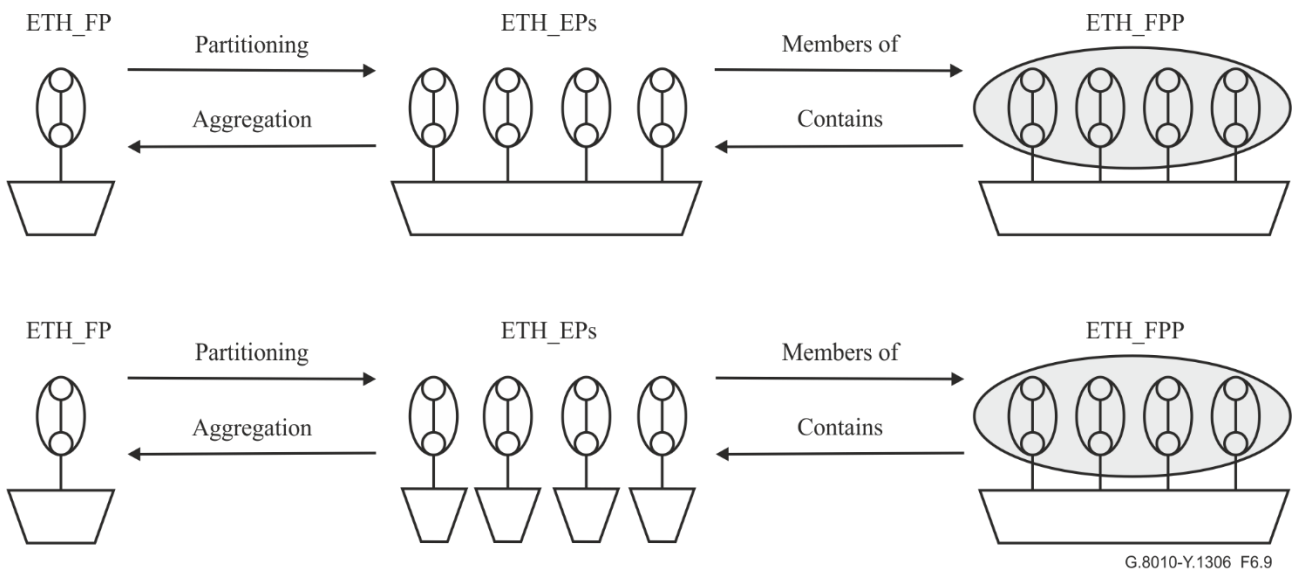


Figure 126-9/G.8010/Y.1306 – ETH flow point partitioning

This mechanism is used, for example, to generate additional flow points in the ETH layer network as a result of creating logically separated VPNs (see 6.3.2.5.1). This results from the fragmenting of an ETH flow domain, resulting in one ETH flow point for each of the fragments attached to the ETH FPP link containing the ETH flow points. The set of ETH flow points that results from this partitioning is contained within an ETH flow point pool. The new ETH flow points have the same properties as the original ETH flow point.

The additional ETH flow points may represent the ETH FPP component link ends (see Figure 12-6-9, top) or the ETH FPP link ends (see Figure 12-6-9, bottom). In the former case the additional flow points are supported by the Ethernet VLAN technology; in the latter case the additional flow points are supported by a CO-CS (e.g., ETY, SDH VC-n), CO-PS (e.g., MPLS, ATM VC), or CLPS (e.g., IP tunnel) layer technology.

For the ETH layer network, the property of flow point partitioning results in two Server/ETH adaptation functions as described in 6.5.2.

6.3.5.6.2 Partitioning an ETH termination flow point

An ETH termination flow point can be partitioned to generate new ETH termination flow points (see Figure 13-6-10).

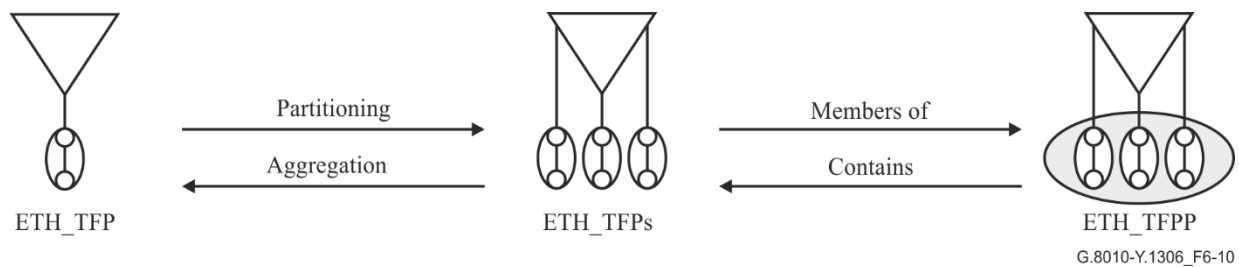


Figure 13-6-10/G.8010/Y.1306 – ETH termination flow point partitioning

6.4 Ethernet PHY (ETY) layer network

The ETYn layer network provides the transport of adapted ETH characteristic information through an ETYn trail between ETYn access points. The adapted information is a continuous bit stream with appropriate line encoding as specified in [IEEE 802.3] and IEEE-802.3ae. The ETYn characteristic information is the physical section signal that will be transported over the medium (e.g., fibre, copper).

The ETYn layer network contains the following transport processing functions, transport entities and topological components (see Figure 14-6-11):

- ETYn trail;
- ETYn trail termination source (ETYn_TT_So);
- ETYn trail termination sink (ETYn_TT_Sk);
- ETYn network connection (NC);
- ETYn link connection (LC);
- ETYn link (not shown specifically in Figure 14-6-11).

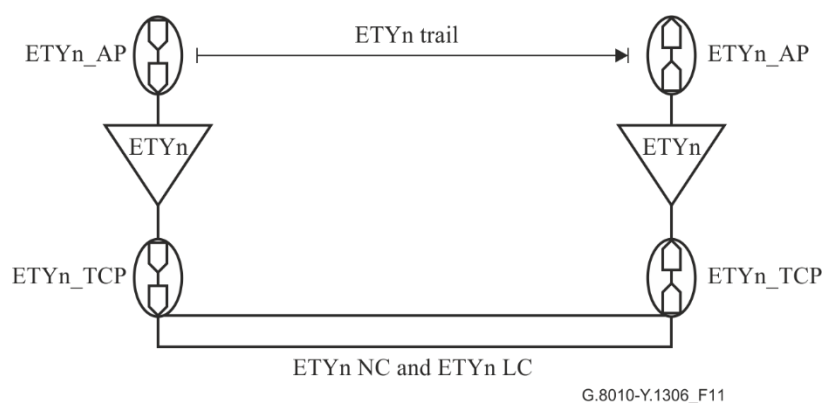


Figure 146-11/G.8010/Y.1306 – ETYn layer network example

6.4.1 ETYn characteristic information

The ETYn layer network characteristic information is a digital, optical or electrical (coded) signal of defined power, bit rate, pulse width and wavelength transported over the physical medium. Specific ETYn signal types are defined in [IEEE 802.3]. Examples of those signal types, grouped by rate, are shown in Table 1.

Table 1/G.8010/Y.1306 – ETYn signal type examples

| n | ETYn |
|---|-------------------------|
| 1 | 10BASE set of signals |
| 2 | 100BASE set of signals |
| 3 | 1000BASE set of signals |
| 4 | 10GBASE set of signals |

6.4.2 ETY topological components

The ETYn topological components are:

- ETYn layer network;
- ETYn link;
- ETYn access group.

The ETYn link connection is supported by the medium (e.g., fibre, copper).

6.4.3 ETY transport entities

The ETYn transport entities are:

- ETYn link connection;
- ETYn network connection;
- ETYn trail.

6.4.4 ETY transport processing functions

The ETYn transport processing functions are:

- ETYn trail termination function;
- ETYn to ETH adaptation function.

6.4.4.1 ETY trail termination function

The bidirectional ETY_n Trail Termination (ETY_n_TT) function is performed by a co-located pair of ETY_n trail termination source (ETY_n_TT_So) and sink (ETY_n_TT_Sk) functions.

The ETY_n_TT_So function performs the following process between its input and its output:

- Generates the physical signal on the medium.

The ETY_n_TT_Sk function performs the following process between its input and its output:

- Receives the physical signal from the medium.

6.4.5 ETY reference points

The ETY reference points (see Figure [46-11](#)) are:

- ETY access point;
- ETY termination connection point.

6.5 Server/Client associations

6.5.1 ETH/Client adaptation

The ETH/Client adaptation (ETH/Client_A) is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the client-specific processes is outside the scope of this Recommendation.

The adaptations make use of either type or length field encapsulation as specified in [\[IEEE 802.3\]](#) clause 3.

When using type field encapsulation, the type field indicates the type of the payload (e.g., IP). This indicates the source/destination client.

When using length field encapsulation, the length field indicates the length of the payload. A Logical Link Control (LLC) header that indicates the source and destination client follows the length field. The LLC sublayer is defined in [\[ISO/IEC/IEEE 8802.2\]](#)~~IEEE 802.2~~.

Two examples of server-specific ETH/Client adaptations are described below.

6.5.1.1 ETH/Bridge protocols

The bidirectional ETH/BP adaptation (ETH/BP_A) function is performed by a co-located pair of ETH/BP adaptation source (ETH/BP_A_So) and sink (ETH/BP_A_Sk) functions.

The ETH/BP_A_So performs one of the following server-specific processes between its input and output:

- Length field encapsulation.
- Set the protocol ID, source address and destination address value.
- Generate the Priority and Drop Eligibility signals.
- Multiplex the frame towards the ETH_FT.

The ETH/BP_A_Sk performs one of the following server-specific processes between its input and output:

- Demultiplex the frame towards the BP client.
- Remove the length field encapsulation.
- Remove the protocol ID.

6.5.1.2 ETH/IP

The bidirectional ETH/IP adaptation (ETH/IP_A) function is performed by a co-located pair of ETH/IP adaptation source (ETH/IP_A_So) and sink (ETH/IP_A_Sk) functions.

The ETH/IP_A_So performs one of the following server-specific processes between its input and output:

- Type field encapsulation.
- Insert the source address and destination address.
- Generate the Priority and Drop Eligibility signals
- Multiplex the frame towards the ETH_FT.

The ETH/IP_A_Sk performs one of the following server-specific processes between its input and output:

- Demultiplex the frame towards the IP client.
- Remove the type field encapsulation.

6.5.1.3 ETH/MPLS and ETH/MPLS-TP

The bidirectional ETH/MPLS adaptation (ETHP/MPLS_A) function is performed by a co-located pair of ETH/MPLS adaptation source (ETHP/MPLS_A_So) and sink (ETHP/MPLS_A_Sk) functions.

The bidirectional ETH/MPLS-TP adaptation (ETHP/MT_A) function is performed by a co-located pair of ETH/MPLS-TP adaptation source (ETHP/MT_A_So) and sink (ETHP/MT_A_Sk) functions.

NOTE – The server-specific processes for both functions are the same. The client-specific processes differ.

The ETHP/MPLS_A_So and ETHP/MT_A_So perform the following server-specific processes between its input and output:

- Type field encapsulation.
- Insert the source address and destination address.
- Generate the priority and drop eligibility signals.
- Output the frame towards the ETH_FT.

The ETHP/MPLS_A_Sk and ETHP/MT_A_Sk perform the following server-specific processes between its input and output:

- Verify that the DA field within a traffic unit contains the value of the local MAC address; otherwise discard the traffic unit.
- Remove the type field encapsulation.

6.5.2 Server/ETH adaptation

The Server/ETH adaptation function provides the ETH link end functionality.

The Server/ETH adaptation function is considered to consist of two types of processes: client-specific processes and server-specific processes. The client-specific processes are associated with the ETH_CI traffic units, which ingress/egress via the ETH_FPs. The server-specific processes are associated with the aggregate stream of traffic units.

There are two basic types of Server/ETH adaptation functions as illustrated in Figure 456-12: single ETH flow point (Srv/ETH_A) and multiple ETH flow points (Srv/ETH-m_A).

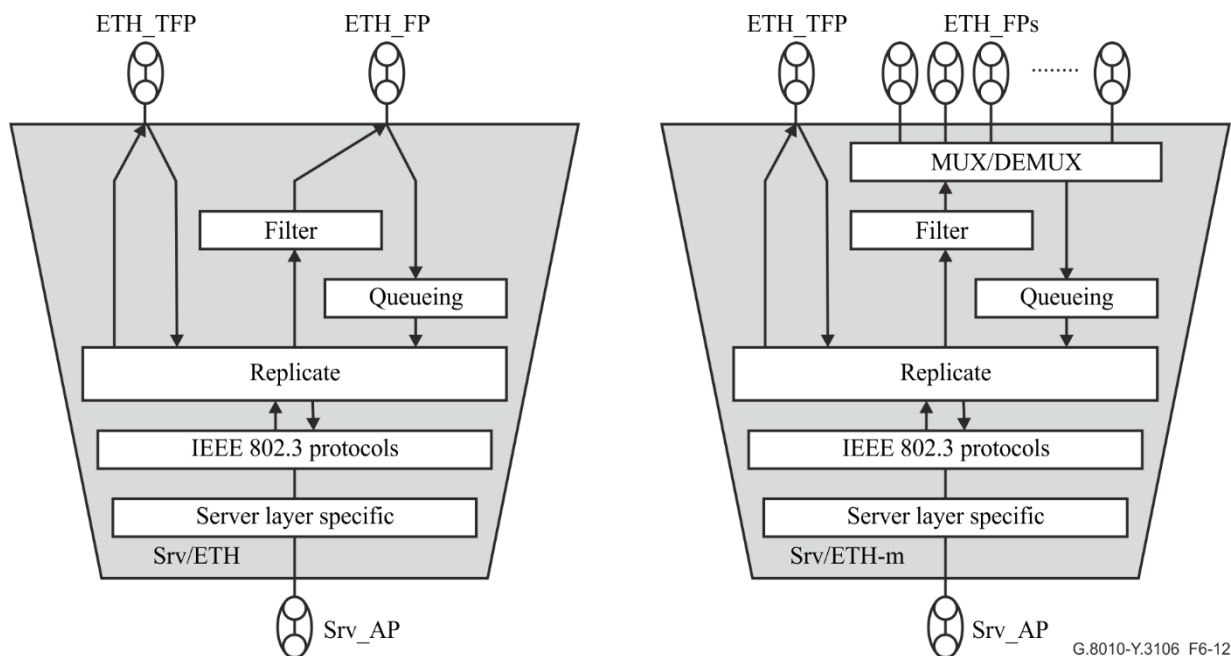


Figure 156-12/G.8010/Y.1306 – Server to ETH adaptation functions

Each of these adaptation functions has an ETH_TFP and one or more ETH_FPs. The ETH_TFP represents the binding with an ETH_FT function; the ETH_FPs represent the bindings with either an ETH flow domain, or an Srv/ETH(-m)_A function or an ETH_x (x = P, T, S) flow termination or adaptation function as introduced in 7.5 and specified in [ITU-T G.8021](#) [ITU-T Rec. G.8021/Y.1341](#).

The Srv/ETH_A function has *one* ETH_TFP and *one* ETH_FP associated with it. These flow points allow any valid ETH_CI traffic unit to be transported across it.

The Srv/ETH-m_A function has *one* ETH_TFP and *N* ($N = 1..4094$) ETH_FPs associated with it. Each of the ETH_FPs is associated with a separate ETH FPP component link. ETH link frames/packets include an identifier, which relates a frame/packet to one of the ETH FPP component links. This identifier is the VLAN ID (VID) value in the VLAN Tag (optional) in the M_SDU (see [Figure 166-13](#)) within the ETH link frame/packet. This adaptation function operates either in customer mode, or in service provider mode as configured. Refer to Appendix III.

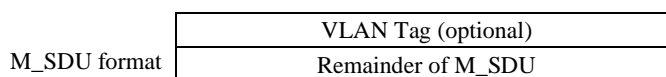


Figure 166-13/G.8010/Y.1306 – MAC service data unit format with optional VLAN tag

NOTE – The SRV/ETH-m_A function may be expanded into a SRV/ETH_A, ETH_x_FT and ETH_x/ETH-m_A function when the aggregate (all-to-one) signal requires fragment/connection monitoring. An SRV/ETH-m adaptation function is *not* capable of originating and terminating proactive ETH OAM signals and of originating, responding to and terminating on-demand ETH OAM signals. It is deployed for the case where all-to-one fragment/connection monitoring is not applicable.

The bidirectional Srv/ETH adaptation (Srv/ETH_A) or Srv/ETH-m adaptation (Srv/ETH-m_A) functions are performed by a co-located pair of source and sink Srv/ETH or Srv/ETH-m adaptation functions.

The Srv/ETH_A and Srv/ETH-m_A source functions perform the following processes between their inputs and output:

- For the case of the Srv/ETH-m_A source function, multiplex ETH_CI traffic units from the N ETH_FPs and insert a VLAN Tag as appropriate.
- For the case of the Srv/ETH_A_So function, insert a Priority-Tag to encode the ETH_CI_P and ETH_CI_DE information as appropriate.
- Perform queuing and scheduling.
- Replicate ETH_CI traffic units received on the input from the queuing process and deliver them to the ETH_TFP and [IEEE 802.3] protocol processes. Replicate ETH_CI traffic units received on the input from the ETH_TFP and deliver them to the filter process and IEEE 802.3 protocol process.
- Server layer related specific source processes as described in the subclauses hereafter. This may include the optional generation and insertion of [IEEE 802.3] protocol (e.g., PAUSE) ETH_CI traffic units.

The Srv/ETH_A and Srv/ETH-m_A sink functions perform the following processes between their input and outputs:

- Server layer related specific sink processes as described in the subclauses hereafter.
- Replicate ETH_CI traffic units received on the input from the [IEEE 802.3] protocol process and deliver them to the ETH_TFP and filter process.
- Filtering of ETH_CI traffic units that have their Destination Address matching a configured subset of the Reserved and GARP Application addresses specified in [IEEE 802.1Q].
- For the case of the Srv/ETH-m adaptation function, demultiplex ETH_CI traffic units according to the VID value in the VLAN Tag or the configured VID value.
- On detection of a Signal Fail condition, block the ETH_CI traffic units and insert the ETH-AIS signal at the client's MEG level. ETH-AIS insertion can be disabled; e.g., when the client MEG is under control of a spanning tree protocol.
- Output the ETH_CI or ETH-AIS traffic unit via the associated ETH_FP.

6.5.2.1 ETY/ETH adaptation

The bidirectional ETYn/ETH adaptation (ETYn/ETH_A, ETYn/ETH-m_A) function is performed by a co-located pair of source and sink ETYn/ETH and ETYn/ETH-m adaptation functions. The ETYn/ETH and ETYn/ETH-m adaptations can be further decomposed for the purpose of transporting for example an 8B/10B encoded stream using GFP-T. The adaptations can be decomposed into an ETCn/ETH and ETCn/ETH-m adaptation (ETC, Ethernet Coding), an ETCn source/sink termination, and an ETYn/ETCn adaptation function (see Figure 476-14).

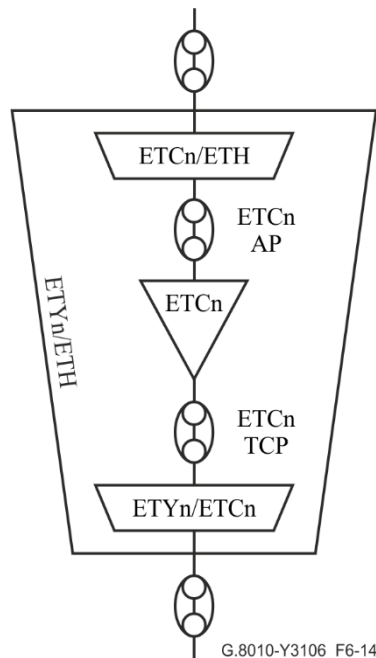


Figure 176-14/G.8010/Y.1306 – Decomposition of ETYn/ETH adaptation function

The exact processes performed in the different functions depend on the specific PHY used (e.g., 10BASE-T, 100BASE-T); this clause only lists possible functions.

6.5.2.1.1 ETCn/ETH adaptation

The ETCn/ETH and ETC/ETH-m adaptation source (ETCn/ETH_A_So, ETCn/ETH-m_A_So) functions perform (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Optionally generate and insert [IEEE 802.3](#) protocol (e.g., PAUSE) traffic units
- Compute MAC FCS over the ETH_CI traffic unit.
- Map the ETH_CI traffic unit and its FCS into an ETH link (i.e., MAC) frame.
- Other processes such as insertion of preamble, inter-frame gaps, line encoding, etc., as specified in [IEEE 802.3](#).

The ETCn/ETH and ETC/ETH-m adaptation sink (ETCn/ETH_A_Sk, ETCn/ETH-m_A_Sk) functions perform (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Perform line decoding, frame alignment, etc., as specified in [IEEE 802.3](#).
- Check MAC FCS and discard corrupted link (MAC) frames.
- Demap ETH_CI traffic units from their link (MAC) frames.
- Optionally terminate [IEEE 802.3](#) protocol traffic units.

6.5.2.1.2 ETC trail termination

The bidirectional ETCn trail termination (ETCn_TT) function is performed by a co-located pair of source and sink ETCn trail termination functions.

The ETCn_TT_So function connects its input and output and does not perform any specific functions.

The ETCn_TT_Sk function connects its input and output and checks the encoded stream for code violations.

The ETCn_CI is the stream of 8-bit characters and their data/control indication ("8+control") as defined within the various PCS blocks in [\[IEEE 802.3\]](#).

6.5.2.1.3 ETYn/ETCn adaptation

The ETYn/ETCn adaptation source (ETYn/ETCn_A_So) performs one or more of the following processes between its input and its output:

- Serialization of code groups, encoding the ETCn_CI, etc., as specified in [\[IEEE 802.3\]](#).

The ETYn/ETCn adaptation sink (ETYn/ETCn_A_Sk) performs one or more of the following processes between its input and its output:

- De-serialization of code groups, codegroup alignment, decoding the ETCn_CI, clock recovery, etc., as specified in [\[IEEE 802.3\]](#).

6.5.2.2 TP/ETH adaptation

The transmission path (TP) layer networks provide the transport of adapted ETH characteristic information through a TP trail between TP access points. The adapted information is a continuous bit stream with appropriate encapsulation and mapping as specified in other ITU-T Recommendations, for example, [\[ITU-T G.7041\]G.7041/Y.1303](#), [\[ITU-T G.707\]G.707/Y.1322](#) and [\[ITU-T G.709\]G.709/Y.1331](#).

6.5.2.2.1 SDH Path/ETH adaptation

The adaptation to the SDH VC-n and VC-n-Xc path layer networks is performed in Sn/ETH, Sn/ETH-m, Sn-Xc/ETH, Sn-Xc/ETH-m, Sn-X/ETH and Sn-X/ETH-m adaptation (S/ETH_A, S/ETH-m_A) functions. The S/ETH_A and S/ETH-m_A are considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional S/ETH and S/ETH-m adaptation functions are performed by a co-located pair of source and sink S/ETH and S/ETH-m adaptation functions.

The S/ETH and S/ETH-m adaptation source (S/ETH_A_So, S/ETH-m_A_So) functions perform (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Compute MAC FCS over the ETH_CI traffic unit.
- Map the ETH_CI traffic unit and its FCS into the ETH link specific frame as specified in [\[ITU-T G.8012\]ITU-T Rec. G.8012/Y.1308](#).
- Map the stream of link specific frames into the payload of the SDH VC signal (e.g., VC-n/VC-n-Xv/VC-n-Xc).

The S/ETH and S/ETH-m adaptation sink (S/ETH_A_Sk, S/ETH-m_A_Sk) functions perform (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Extract the ETH link specific frame stream from the payload of the TP signal.
- Demap the ETH_CI traffic unit and its FCS from the link specific frame as specified in [\[ITU-T G.8012\]ITU-T Rec. G.8012/Y.1308](#).
- Check MAC FCS and discard corrupted ETH_CI traffic units.

6.5.2.2.2 OTN path/ETH adaptation

The adaptation to the OTN ODUk path layer networks is performed in ODUkP/ETH, ODUkP/ETH-m, ODUkP-X/ETH and ODUkP-X/ETH-m adaptation (ODU/ETH_A, ODU/ETH-m) functions. The ODU/ETH_A and ODU/ETH-m_A are considered to consist of two types of

processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional ODU/ETH and ODU/ETH-m adaptation functions are performed by a co-located pair of source and sink ODU/ETH and ODU/ETH-m adaptation functions.

The ODU/ETH and ODU/ETH-m adaptation source (ODU/ETH_A_So, ODU/ETH-m_A_So) functions perform (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Compute MAC FCS over the ETH_CI traffic unit.
- Map the ETH_CI traffic unit and its FCS in a GFP-F frame as specified in [\[ITU-T G.8012\]](#)~~ITU-T Rec. G.8012/Y.1308~~.
- Map the GFP frame stream into the payload of the OTN ODU signal (e.g., ODUk/ODUk-Xv) as specified in [\[ITU-T G.709\]](#)~~ITU-T Rec. G.709/Y.1331~~.

The ODU/ETH and ODU/ETH-m adaptation sink (ODU/ETH_A_Sk, ODU/ETH-m_A_Sk) functions perform (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Extract the GFP frame stream from the payload of the TP signal.
- Demap the ETH_CI traffic unit and its FCS from the GFP-F frame as specified in [\[ITU-T G.8012\]](#)~~ITU-T Rec. G.8012/Y.1308~~.
- Discard corrupted ETH_CI traffic units.

6.5.2.2.3 MPLS path/ETH and MPLS-TP/ETH adaptation

The adaptation to the MPLS and MPLS-TP path layer networks is performed in MPLS/ETH and MPLS-TP/ETH adaptation (MPLS/ETH_A, MT/ETH_A) functions. The MPLS/ETH_A and MT/ETH_A are considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes for MPLS/ETH adaptation is outside the scope of this Recommendation. The description of the server-specific processes for MPLS-TP/ETH adaptation is specified in [\[ITU-T G.8110.1\]](#)~~ITU-T Rec. G.8110.1/Y.1370.1~~.

The bidirectional MPLS/ETH and MPLS-TP/ETH adaptation function is performed by a co-located pair of source and sink MPLS/ETH and MPLS-TP/ETH adaptation functions.

The MPLS/ETH and MPLS-TP/ETH adaptation source (MPLS/ETH_A_So, MT/ETH_A_So) function performs (in addition to the server layer non-specific processes as described in 6.5.2) the following server-layer related specific processes:

- Map the ETH_CI traffic unit in the ETH over MPLS specific frame as specified in [\[ITU-T G.8012\]](#)~~ITU-T Rec. G.8012/Y.1308~~.
- Map the ETH over MPLS link specific frame in the payload of the MPLS packet.

The MPLS/ETH and MPLS-TP/ETH adaptation sink (MPLS/ETH_A_Sk, MT/ETH_A_Sk) function performs (in addition to the server-layer non-specific processes as described in 6.5.2) the following server-layer related specific process:

- Extract ETH_CI traffic units from the MPLS or MPLS-TP payload field.

6.5.2.2.4 ATM VC/ETH adaptation

The adaptation to the ATM VC layer network is performed in VC/ETH adaptation (VC/ETH_A) functions. The VC/ETH_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional VC/ETH adaptation function is performed by a co-located pair of source and sink VC/ETH adaptation functions.

The VC/ETH adaptation source (VC/ETH_A_So) function performs (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Compute MAC FCS over the ETH_CI traffic unit.
- Map the ETH_CI traffic unit with or without its MAC FCS in the ETH over ATM specific frame as specified in [IETF RFC 2684].
- Map the ETH over ATM link specific frame in the payload of the ATM cell.

The VC/ETH adaptation sink (VC/ETH_A_Sk) function performs (in addition to the server layer non-specific processes as described in 6.5.2) the following server layer related specific processes:

- Perform Ethernet over ATM related processing.
- Extract ETH_CI traffic units from the payload of the ATM cell.
- Discard corrupted ETH_CI traffic units if MAC FCS is present.

6.5.3 TP/ETCn adaptation

The transmission path (TP) layer networks provide the transport of adapted ETCn characteristic information through a TP trail between TP access points. The adapted information is a continuous bit stream with appropriate encapsulation and mapping as specified in other ITU-T Recommendations, for example, [ITU-T G.7041]G.7041/Y.1303 and [ITU-T G.707]G.707/Y.1322.

6.5.3.1 VC-4-7v/ETC3 adaptation

The VC-4-7v path layer networks provide the transport of adapted ETC3 characteristic information through a VC-4-7v trail between VC-4-7v access points.

The adaptation to the SDH VC-4-7v path layer networks is performed in S4-7/ETC3 functions. The S4-7/ETC3_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional S4-7/ETC3 adaptation function is performed by a co-located pair of source and sink S4-7/ETC3 adaptation functions.

The S4-7/ETC3 adaptation source (S4-7/ETC3_A_So) function performs the following client-specific process between its input and its output:

- Map the ETC3_CI stream via GFP-T into the payload of the VC-4-7v, as defined in [ITU-T G.7041] and [ITU-T G.707]ITU-T Recs G.7041/Y.1303 and G.707/Y.1322.

The S4-7/ETC3 adaptation sink (S4-7/ETC3_A_Sk) function performs the following client-specific process between its input and its output:

- Demap the ETC3_CI stream within GFP-T from the payload of the VC-4-7v, as defined in [ITU-T G.7041] and [ITU-T G.707]ITU-T Recs G.7041/Y.1303 and G.707/Y.1322.

6.5.3.2 VC-4-64c/ETC4 adaptation

The VC-4-64c path layer networks provide the transport of adapted ETC4 characteristic information through a VC-4-64c trail between VC-4-64c access points.

The ETC4_CI is the signal at the output of the 10GBASE-R PCS coding block in [IEEE 802.3]ae, including the 64B/66B coding and the rate adaptation to the SDH (VC-4-64c payload) clock.

The adaptation to the SDH VC-4-64c path layer networks is performed in S4-64/ETC4 functions. The S4-64/ETC4_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional S4-64/ETC4 adaptation function is performed by a co-located pair of source and sink S4-64/ETC4 adaptation functions.

The S4-64/ETC4 adaptation source (S4-64/ETC4_A_So) performs the following client-specific process between its input and its output:

- Map the ETC4_CI stream into the payload of the VC-4-64c, as defined in Annex F of [ITU-T G.707/Y.1322](#).

The S4-64/ETC4 adaptation sink (S4-64/ETC4_A_Sk) performs the following client-specific process between its input and its output(s):

- Demap the ETC4_CI stream from the payload of the VC-4-64c, as defined in Annex F of [ITU-T G.707/Y.1322](#).

6.6 Ethernet network topology

An ETH layer network contains one or more ETH links and zero or more ETH flow domains. Such an ETH layer network is able to support point-to-point connectivity and/or multipoint connectivity between two or more flow points and/or termination flow points at the edges of the ETH layer network administrative domain.

Furthermore, the ETC sublayer in the ETY layer network is able to support point-to-point connections between two of its connection points at the edges of the ETC sublayer network administrative domain.

6.6.1 Point-to-point ETH connection

A point-to-point ETH connectivity is provided via an ETH FPP link or ETH serial compound FPP link between an ETH flow point A and an ETH flow point Z located at the edge of the ETH layer network administrative domain (see Figures [18-6-15](#) and [19-6-16](#)).

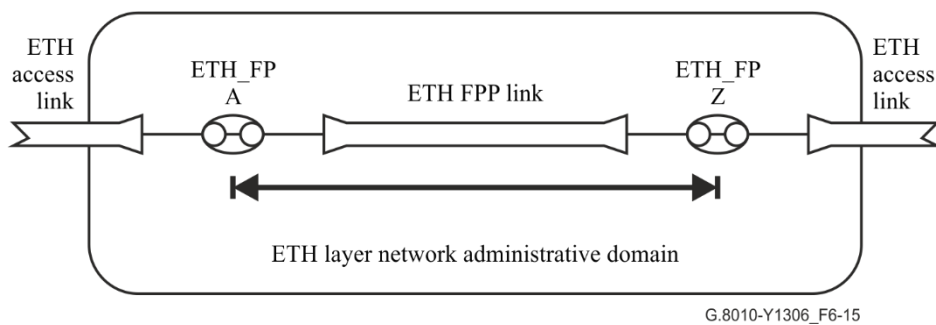


Figure [18-6-15/G.8010/Y.1306](#) – Point-to-point ETH connection (single link)

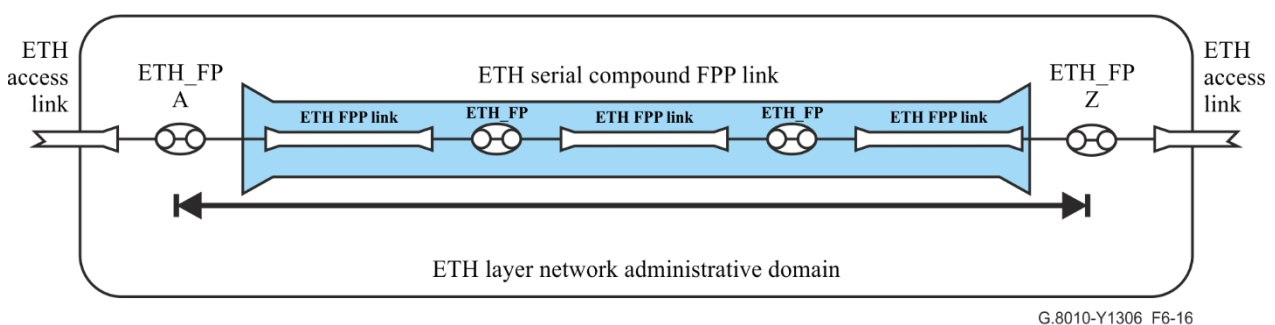


Figure [19-6-16/G.8010/Y.1306](#) – Point-to-point ETH connection (serial compound link)

6.6.2 Multipoint ETH connectivity

Multipoint ETH connectivity is provided via an ETH flow domain between two or more ETH flow points located at the edge of the ETH layer network administrative domain (see Figure 206-17).

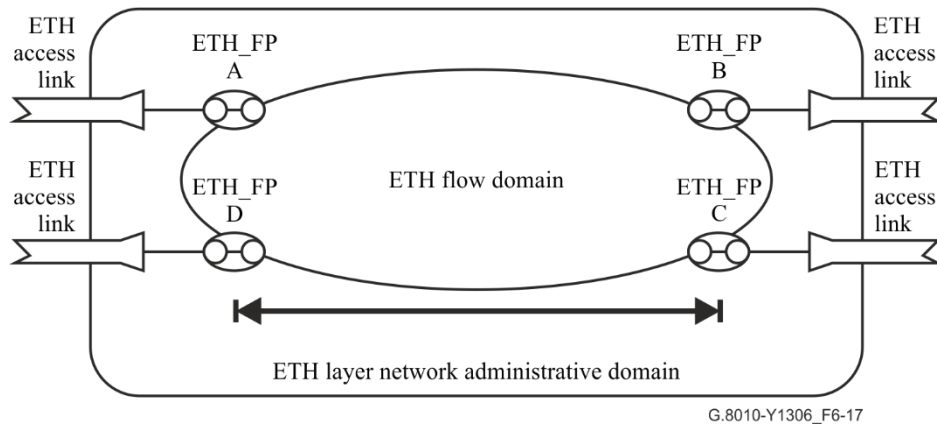


Figure 206-17/G.8010/Y.1306 – Multipoint ETH connectivity

The ETH flow domain in a multipoint ETH connectivity can be decomposed into one or more ETH flow domains and zero or more ETH FPP links as illustrated in Figure 216-18.

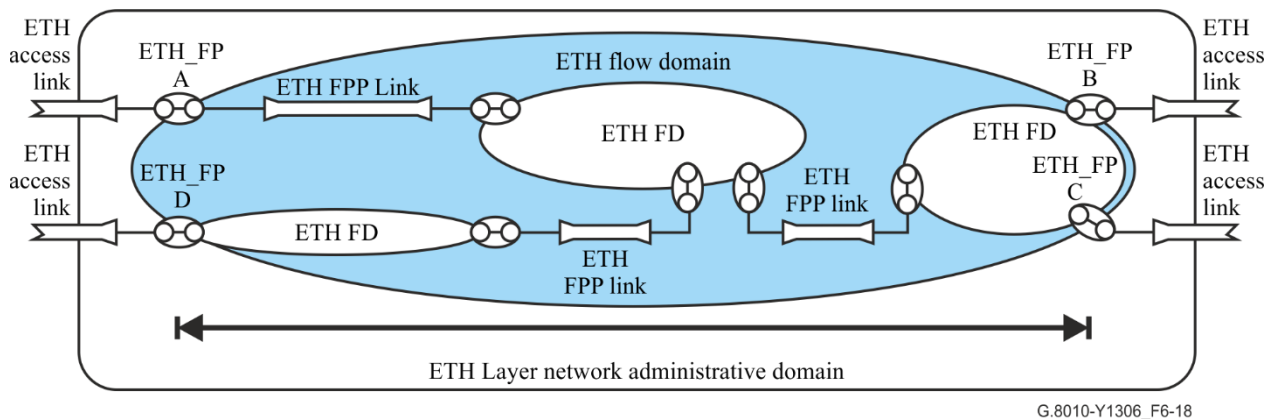


Figure 216-18/G.8010/Y.1306 – Example of ETH flow domain partitioning for multipoint ETH connectivity

6.6.3 Point-to-point ETC connection

A point-to-point ETC connection is provided via an ETC link between an ETC connection point A and an ETC connection point Z located at the edge of the ETC sublayer network administrative domain (see Figure 226-19).

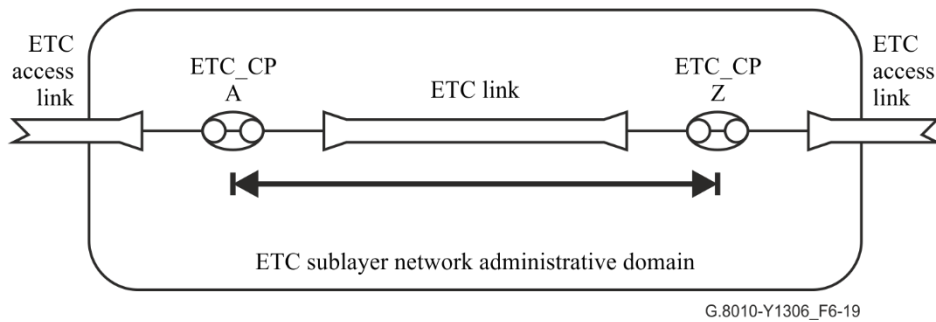


Figure 226-19/G.8010/Y.1306 – Point-to-point ETC connection

7 Ethernet network management

This clause describes network management for the Ethernet transport network. In particular, it describes the maintenance entities, maintenance entity supervision techniques and layer network management requirements for fault, performance and configuration management, management communications and client/server interaction management. Generic fault, configuration and performance management

The Ethernet transport network shall provide support for fault, configuration and performance management end-to-end and also within and between administrative boundaries.

It shall provide a means of detection and notification in the event of a misconnection.

The Ethernet transport network shall provide facilities to detect faults, isolate faults and initiate recovery actions where applicable. The Ethernet transport network shall provide facilities for single-ended maintenance.

In the event of a signal within the server layer being interrupted, upstream and downstream network entities in the server layer shall be notified.

The Ethernet transport network shall be able to detect performance degradations to avoid failures and verify quality of service.

Generic management communications

The Ethernet transport network shall support communications between:

- OSs and remote NEs;
- craft terminals and local or remote NEs.

These forms of communication may also be supported externally to the Ethernet transport network.

7.1 Ethernet maintenance entity groups

The basic maintenance entities in the Ethernet network are the ETY_n (section) trail (see Figure 146-11) and the ETH (path) connectionless trail (see Figure 46-1). Those (connectionless) trails monitor the ETY network connection and the ETH network flow between a pair of termination connection/flow points at the boundary of their layer network.

The ETH layer network may contain multiple administrative domains: e.g., user, service provider and one or more network operator domains. Each of these administrative domains has an associated maintenance entity group located between a set of ETH flow points at the boundaries of that ETH layer network administrative domain. Maintenance entity groups also exist between a set of ETH flow points at the boundary of two adjacent ETH layer network administrative domains. Figures 7-1 (top left, bottom) and 7-2 illustrate such ETH layer network administrative domain maintenance entities and maintenance entity groups for the point-to-point and multipoint connection/fragment cases.

NOTE – Figure 7-123 (top right) illustrates a second case; an ETH FPP link is supported over multiple (e.g., two) network operator administrative domains. There are no ETH flow points at the boundary of the two networks and the ETH intra-domain maintenance entities are single-ended. Monitoring of those (virtual) maintenance entities is not possible at the ETH layer network and is to be performed at the ETH's server layer.

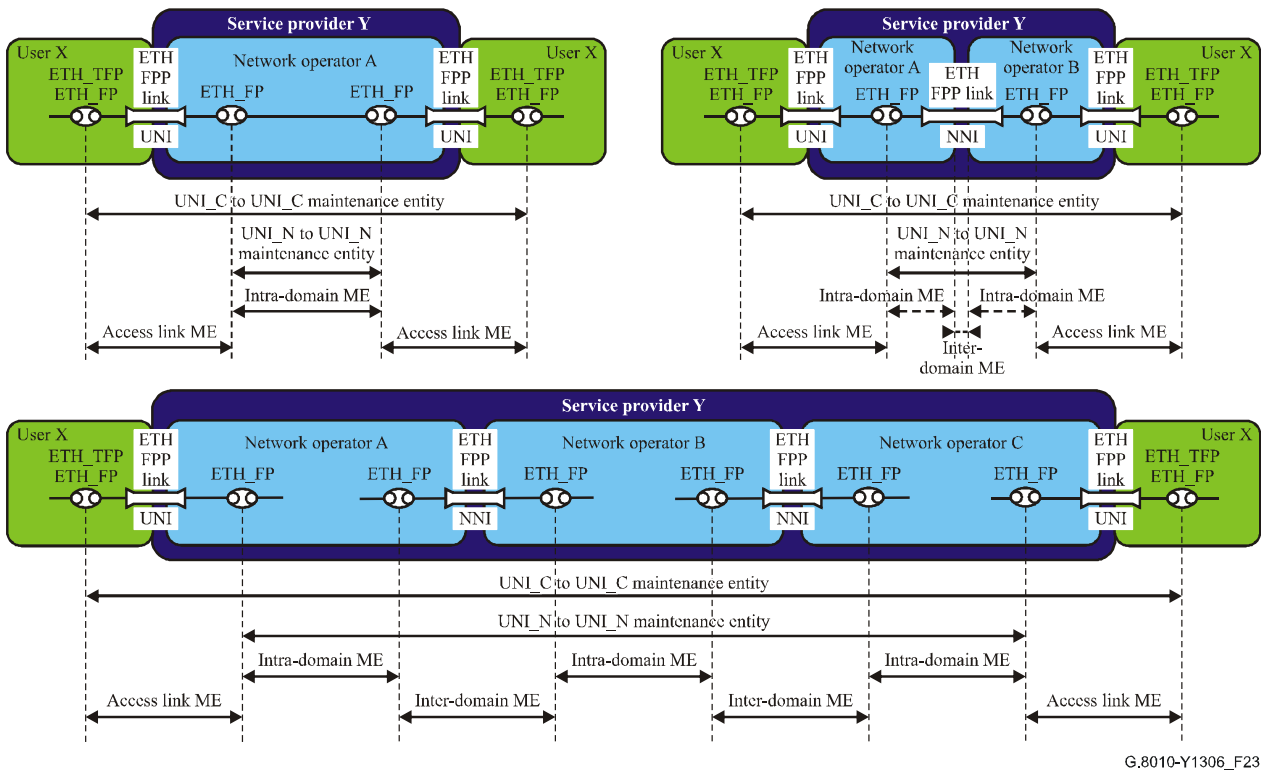


Figure 7-1/G.8010/Y.1306 – Point-to-point ETH connection administrative domain associated maintenance entities

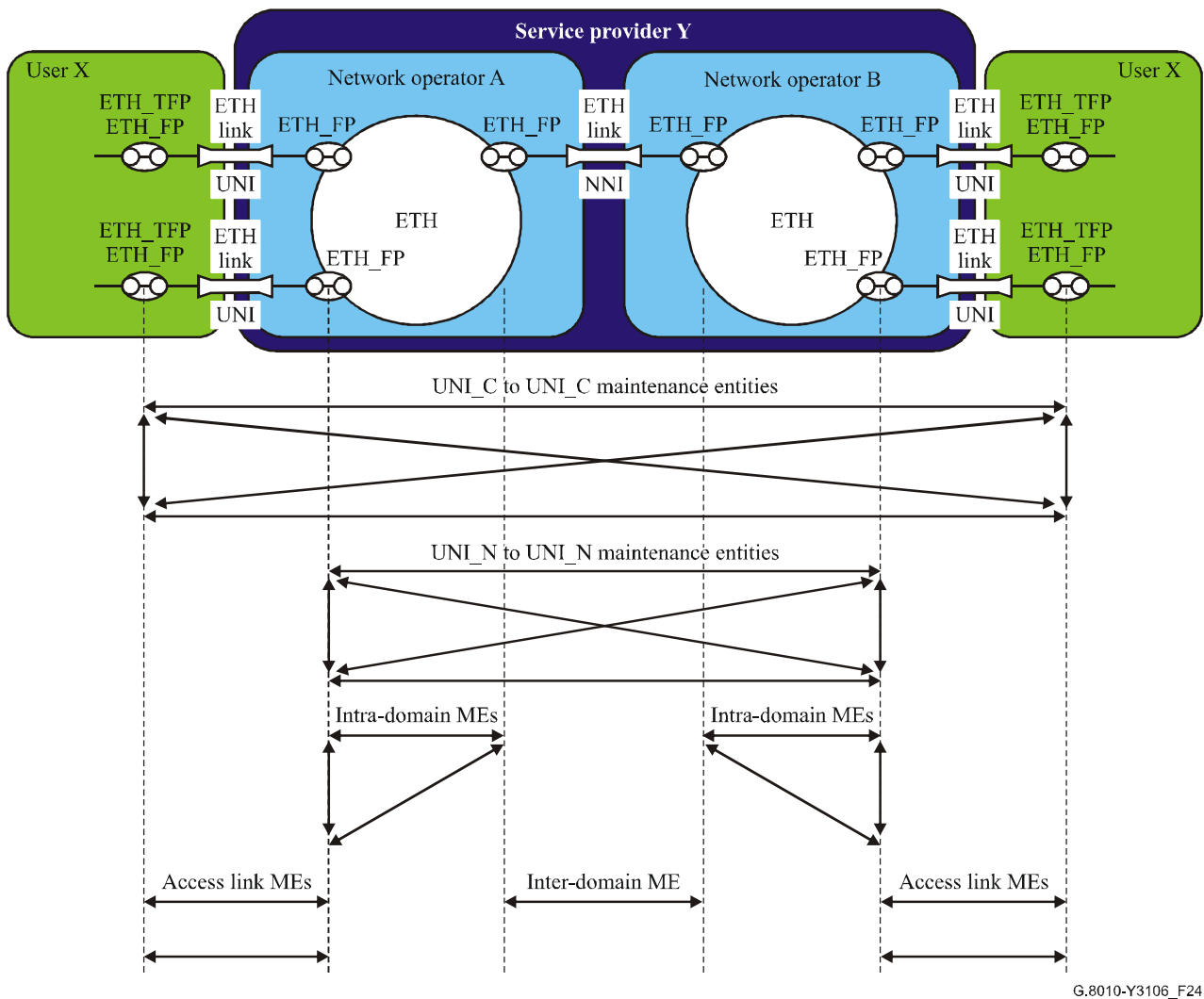


Figure 7-2/G.8010/Y.1306 – Multipoint ETH connectivity administrative domain associated maintenance entities

Protection switching/restoration applications as well as testing applications may require the presence of ETH layer network maintenance entities for their operation. Such maintenance entities can be between any two ETH flow points in the ETH layer network.

The ETC sublayer creates a maintenance entity associated with an ETC connection (see Figure 7-325).

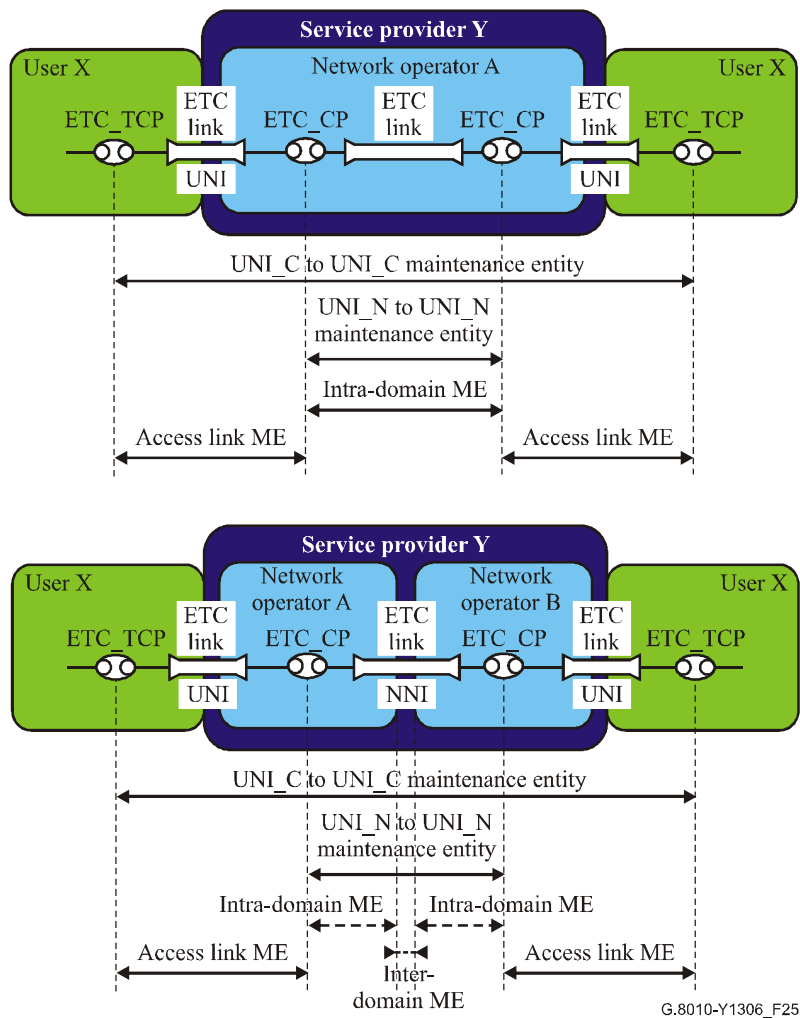


Figure 7-3/G.8010/Y.1306 – ETC connection administrative domain associated maintenance entities

7.2 Ethernet maintenance entity group supervision techniques

Maintenance entity group supervision is the process of monitoring the integrity of a given maintenance entity group in the Ethernet section (ETY_n) layer, ETC sublayer or Ethernet path (ETH) layer networks. The integrity may be verified by means of detecting and reporting continuity, connectivity and transmission performance defects for a given maintenance entity group. [ITU-T G.805](#) ~~ITU-T Rec. G.805~~ defines four types of monitoring techniques for maintenance entity groups.

The maintenance entity group supervision process can be applied to network connections or connection segments (an arbitrary series of subnetwork connections and link connections) and network flows and flow domain segments (an arbitrary series of flow domain flows and link flows).

7.2.1 Inherent monitoring

Ethernet maintenance entity groups may be indirectly monitored by using the inherently available data from the server layers and computing the approximate state of the client connection from the available data.

ETH layer network maintenance entity groups may be indirectly monitored by using the inherently available data from the ETH server layers (e.g., SDH VC, OTH ODU, MPLS LSP, ATM VC) and computing the approximate state of the ETH maintenance entity group from the available data.

ETC sublayer network maintenance entity groups may be indirectly monitored by using the inherently available data from the ETC server layers SDH VC and ETY and computing the approximate state of the ETC maintenance entity group from the available data.

Inherent monitoring is not applicable in the ETY as the server layer is the physical media and provides no data.

7.2.2 Non-intrusive monitoring

For further study.

7.2.3 Intrusive monitoring

For the diagnostic tests of certain parameters (e.g., throughput) an intrusive measurement has to be performed that interrupts the user data traffic in the diagnosed entity. The diagnostic tests can be performed as unidirectional or bidirectional tests (loopback). In case of unidirectional tests the user data traffic in one direction is interrupted. In case of bidirectional tests the user data traffic in both directions is interrupted. A LCK signal is inserted for the immediate client MEG at the egress of the interrupted entity.

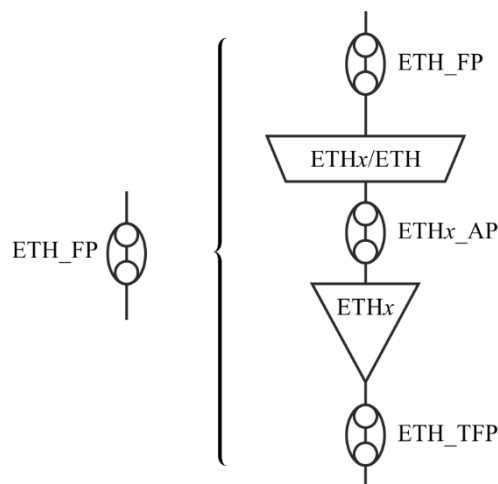
This technique is restricted to the set-up, or intermittent testing.

7.2.4 Sublayer monitoring

Additional OAM is added to the original characteristic information such that the maintenance entity group of interest can be directly monitored by a (connectionless) trail created in a sublayer. With this technique all parameters can be tested directly. This scheme can provide for nested sublayer (connectionless) trail monitored maintenance entity groups.

ETH layer network maintenance entity groups may be directly monitored by means of insertion of ETH OAM at the ingress of the maintenance entity group and extraction and processing of this OAM at the egress of the maintenance entity group. Insertion and extraction and processing of this ETH OAM is functionally performed in ETH tandem connection or section flow termination functions ETH_x_FT, which establish ETH connectionless tandem connection ($x = T$) or section ($x = S$) trails. For this purpose, the ETH_FP is expanded into an ETH_FP, ETH_x/ETH_A function, ETH_x_AP, ETH_x_FT and ETH_TFP as illustrated in Figure 7-4.

NOTE – ETH OAM requirements are defined in [ITU-T Y.1730](#) ~~ITU-T Rec. Y.1730~~. ETH OAM mechanisms are defined in ~~ITU-T Rec. Y.1731~~ [ITU-T G.8013](#). Refer to Appendix VI for an overview of the allocation of ~~ITU-T G.8013~~ [Y.1731](#) ETH OAM messages to [ITU-T G.8010](#) atomic functions.



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Figure 7-4/~~G.8010/Y.1306~~ – Creating an ETH sublayer by expansion of an ETH_FP

Sublayer monitoring is not available for ETY layer and ETC sublayer.

7.2.5 Layer monitoring

OAM is added to the adapted information such that the network connection c.q. network flow can be directly monitored by a (connectionless) trail created in the layer network. With this technique all parameters can be tested directly.

ETH network flows may be directly monitored by means of insertion of ETH OAM at the ingress of the ETH connectionless trail and extraction and processing of this OAM at the egress of the connectionless trail. Insertion and extraction and processing of this ETH OAM is functionally performed in ETH flow termination functions ETHx_FT ($x = p$), which establish ETH connectionless trails.

NOTE – ETH OAM requirements are defined in [ITU-T Rec. Y.1730](#) [ITU-T Y.1730]. ETH OAM functions and mechanisms are defined in [ITU-T Rec. Y.1731](#) [ITU-T G.8013]. Refer to Appendix VI for an overview of the allocation of [ITU-T G.8013](#) ~~Y.1731~~ ETH OAM messages to [ITU-T G.8010](#) atomic functions.-

ETY network connections are monitored for continuity by the ETY trail.

7.2.6 Maintenance entity group levels

Ethernet OAM has defined eight fragment/connection monitoring maintenance entity group (MEG) levels: one path, up to six tandem connection and one section level as defined in Table 7-1. The section level may also be deployed as a seventh tandem connection level.

Maintenance entity group (MEG) levels can be nested, such that MEG level k encompasses MEG levels $k-1$ to 0. Overlapping is not supported.

Table 7-1 – MEG level and allocation

| MEG level | Fragment/connection monitoring MEG |
|-----------|------------------------------------|
| 7 | Path |
| 6 | Tandem connection 6 |
| 5 | Tandem connection 5 |
| 4 | Tandem connection 4 |
| 3 | Tandem connection 3 |
| 2 | Tandem connection 2 |
| 1 | Tandem connection 1 |
| 0 | Section [or Tandem connection 0] |

The ETH layer network supports the addition of one or two VLAN tags to the ETH characteristic information for the purpose of ETH_CI aggregation. The addition of the VLAN tag encapsulates, amongst others, the client MEG OAM flows within the aggregated ETH_CI signals. After such encapsulation, another set of eight MEG levels is available for potential use by applications (Figure 7-5).

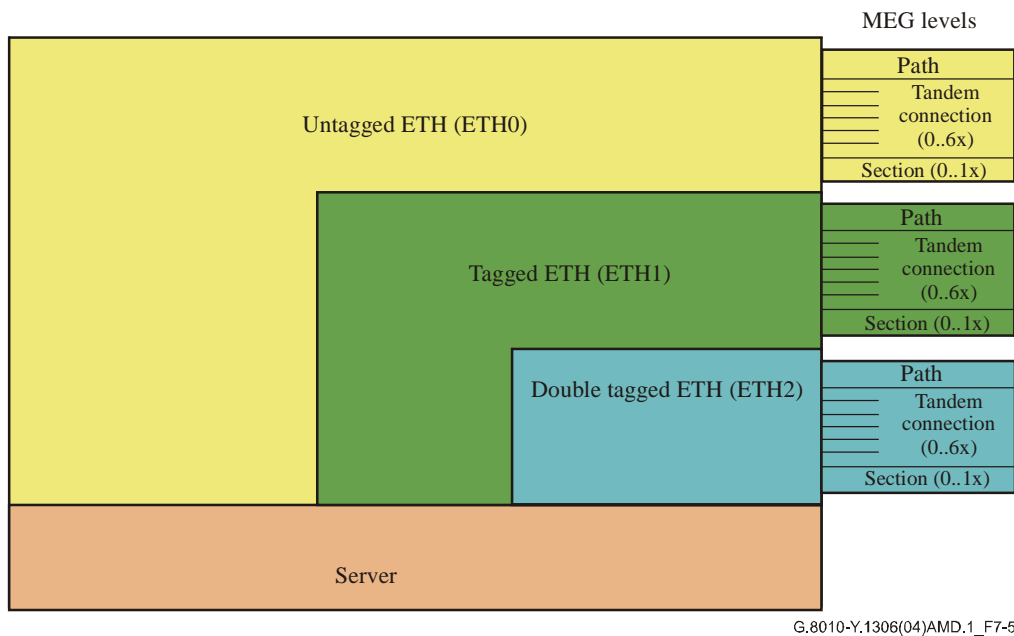
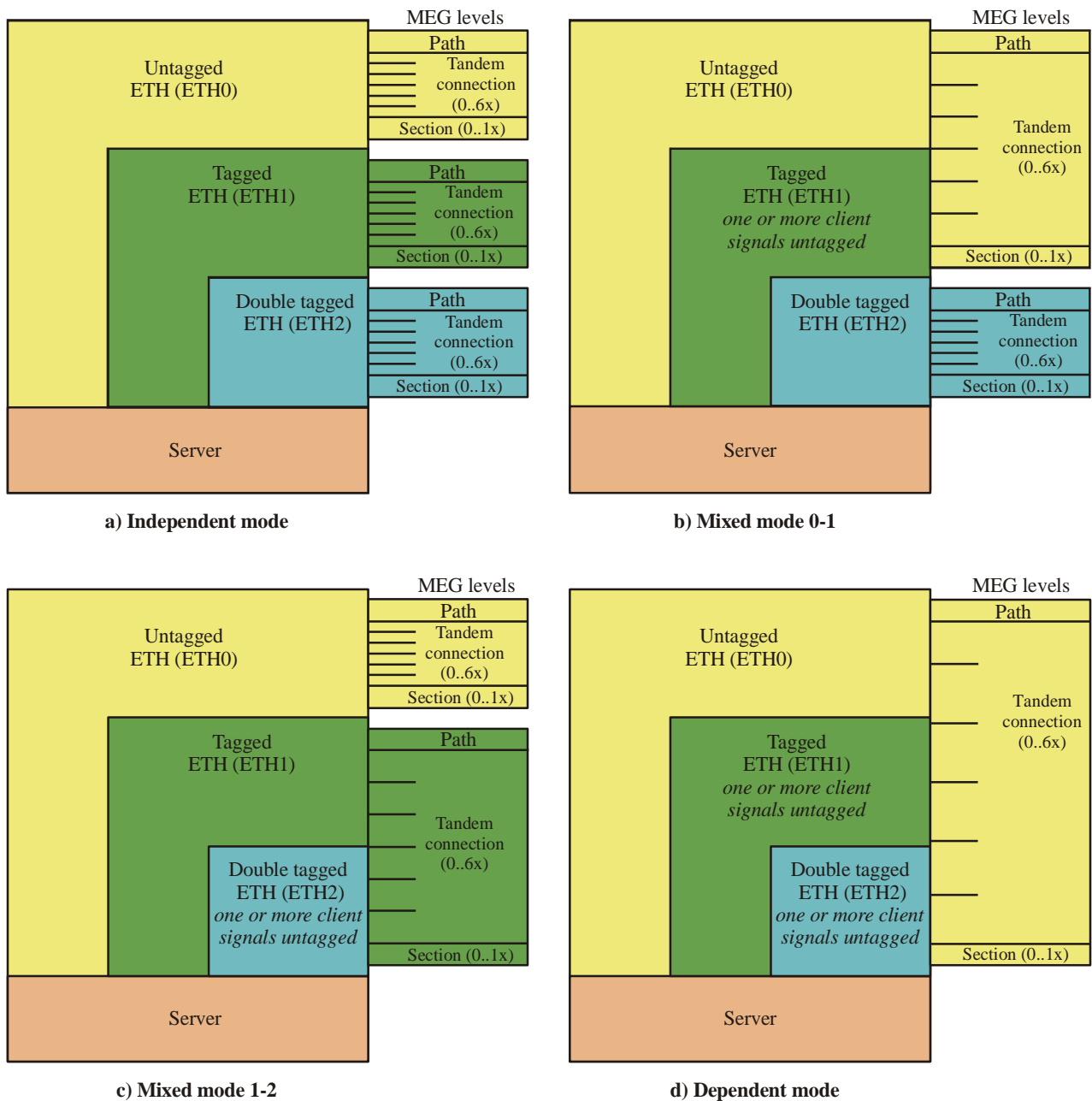


Figure 7-5 – Multiple sets of Ethernet MEG levels

VLAN tags may be added to all ETH_CI signals being aggregated, or to a subset of those signals. In the latter case, one or more ETH_CI signals will be a member of the "untagged set" as defined in [IEEE 802.1Q], and no new set of eight MEG levels will be available; the client and the server share one set of eight MEG levels. With three sets of eight MEG levels, four modes are available (Figure 7-6):

- Independent mode: ETH0, ETH1, ETH2 each have their own set of eight MEG levels;
- Mixed mode 0-1: ETH0 and ETH1 share one set of eight MEG levels, while ETH2 has its own set of eight MEG levels;
- Mixed mode 1-2: ETH0 has its own set of eight MEG levels, while ETH1 and ETH2 share one set of eight MEG levels;
- Dependent mode: ETH0, ETH1, ETH2 all share one set of eight MEG levels.

When ETH_CI signals are aggregated in the Ethernet transport network, it is recommended adding a VLAN tag to all the client signals being aggregated. This maximizes the ETH OAM transparency for the ETH_CI client signals.



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Figure 7-6 – Four ETH OAM MEG level alternatives

Maintenance Entity Group level allocation

When the network provides an EC service, the ETH MEG levels are allocated to the ownership roles in the EC. The allocation is specified in the service level agreement of the EC service.

Two basic fragment/connection monitoring relationships can be distinguished:

- "client/server";
- "peering".

In the "client/server" fragment/connection monitoring relationship, client and server each have eight maintenance entity group levels. In the "peering" fragment/connection monitoring relationship, client and server share eight maintenance entity group levels.

The recommended fragment/connection monitoring relationships are:

- customer/network: "client/server"

- service provider/network operator: "peering"

Some default allocation examples are presented in Appendix V.

7.2.7 Maintenance entity group level filtering

ETH maintenance entity group end point source compound functions (MEP_So) add their ETH connection monitoring Ethernet OAM to the incoming ETH_CI. At ETH tandem connection and section level MEP_So compound functions, the incoming ETH_CI may contain ETH_CI traffic units carrying Ethernet OAM for one or more MEG levels.

To secure the operation of the local ETH tandem connection or section, the ETH MEP source compound function prevents that Ethernet OAM at its own or lower MEG level ($k, k-1, \dots, 0$) from entering its maintenance entity group. Ethernet OAM of higher MEG levels ($7, \dots, k+1$) only is transparently passed through. See example in Figure 7-7. The ETH tandem connection or section MEP sink compound function prevents that Ethernet OAM at its own, or a lower MEG level, from leaving the maintenance entity group.

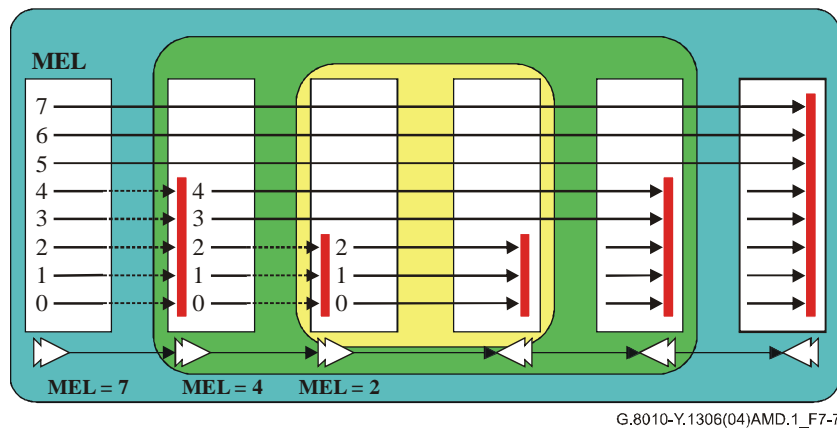


Figure 7-7 – OAM filtering example

ETH path level MEP source compound functions, which encapsulate and optionally multiplex its client signal(s), pass through all ETH OAM within its client signal(s) (Figure 7-8). The function is the start of an additional set of eight maintenance entity group levels.

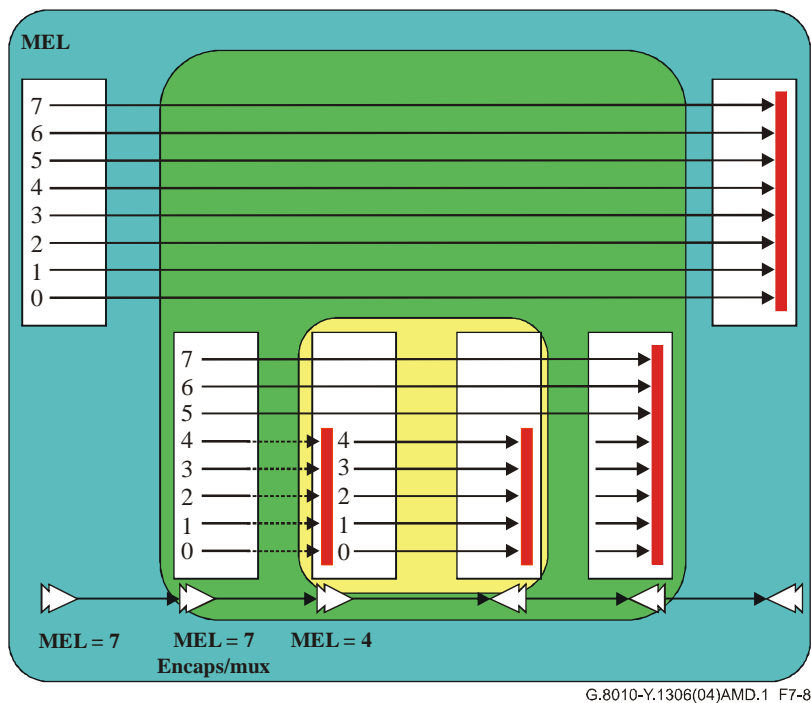


Figure 7-8 – OAM filtering example

7.2.8 ETH maintenance entity group monitoring

7.2.8.1 ETH MEG proactive monitoring

ETH maintenance entity groups may be proactively monitored by means of insertion of ETH OAM at the ingress of the ETH maintenance entity group and extraction and processing of this ETH OAM at the egress of the ETH maintenance entity group. Results (alarm, threshold report, 15 min/24 h performance counts) are autonomously reported to network management as part of the fault management and performance monitoring applications (refer to clauses 7 and 10 of [ITU-T G.7710](#) [ITU-T Rec. G.7710/Y.1701](#)).

An ETH maintenance entity group may operate at the path (maintenance entity group level 7), tandem connection (maintenance entity group levels 6 to 1) or section (maintenance entity group level 0).

Insertion and extraction and processing of this ETH OAM is functionally performed in an ETH path (P), tandem connection (T) or section (S) flow termination function ETH_x_FT (x : P, T, S). (Refer to 7.5.1). Refer to 7.5.2 for a description of the ETH adaptation functions.

The ETH_x_FT function at the ingress/egress of an N point ETH maintenance entity group terminates the maintenance entity group and N-1 point-to-point maintenance entities.

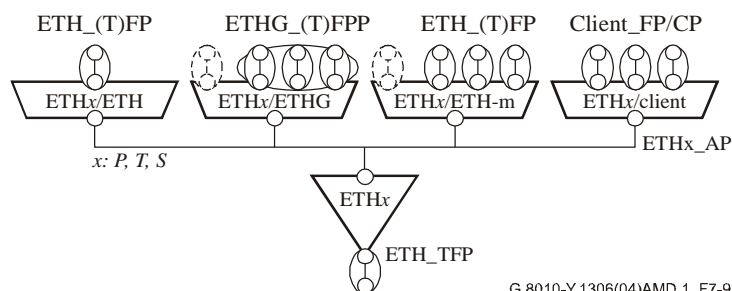


Figure 7-9 – ETH MEG proactive monitoring functions

7.2.8.2 ETH MEG group monitoring

A group of ETH signals may be proactively monitored by means of insertion of ETH OAM at the ingress of the ETH MEG group maintenance entity group, and by extraction and processing of this ETH OAM at the egress of the ETH MEG group maintenance entity group.

Insertion, extraction and processing of this ETH OAM is functionally performed in ETH group flow termination functions ETHG_FT. Refer to 7.5.1.

For this purpose, the ETH_FPP is expanded into an ETH_FPP, ETHG/ETH_A function, ETHG_APP, ETHG_FT and ETH_TFPP as illustrated in Figure 7-10.

The ETH MEG group connection monitoring may be deployed at a tandem connection or at section MEG level.

The ETHG_FT function at the ingress/egress of an N point ETH group maintenance entity group terminates the group maintenance entity group and N-1 point-to-point group maintenance entities.

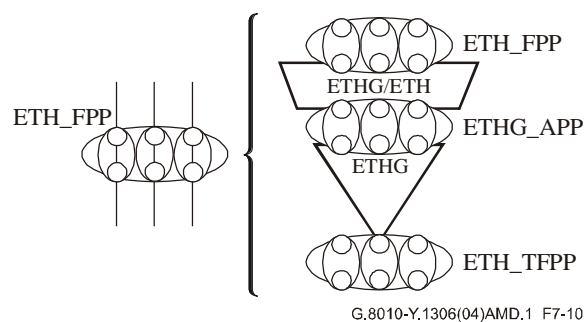


Figure 7-10 – Creating ETH proactive bundle monitoring functions by expansion of an ETH_FPP

7.2.8.3 ETH MEG on-demand monitoring

On-demand ETH MEG monitoring application complements the proactive ETH MEG monitoring application. On-demand ETH MEG monitoring application provides performance characterization and fault localization capabilities. The latter allows for discovering the node in which an ETH continuity or connectivity fault is located. On-demand ETH OAM can be inserted at the ingress of the ETH maintenance entity, which is then replied to from intermediate and/or egress points of the ETH maintenance entity group. The result (pass/fail, value/value set) is reported to the requester. The exchanged OAM information may be in the form of a single instance, a single series within a restricted period of time, a repetitive instance or a repetitive series. A repetitive instance or series is an instance or series which repeats after a specified period (e.g., one hour).

Insertion, extraction and processing of this on-demand ETH OAM is functionally performed in ETH diagnostic flow termination functions ETHDy_FT. For this purpose, the ETH_FP is expanded into an ETH_FP, ETHDy/ETH_A function, ETHD_AP, ETHDy_FT and ETH_TFP as illustrated in Figure 7-11.

An ETHDy_FT function has two modes: originator and responder (refer to 7.5.1.3). Both modes are enabled in the ETHDe_FT function, which is part of an ETH MEP compound function (see 7.2.8.4). The responder mode is enabled in the ETHDi_FT function, which is part of an ETH MIP compound function (see 7.2.8.5).

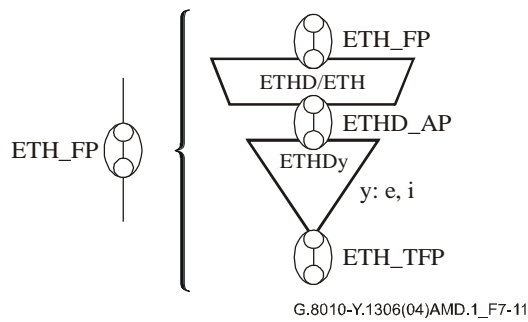


Figure 7-11 – Creating ETH on-demand monitoring functions by expansion of an ETH_FP

7.2.8.4 ETH MEP compound functions

The ETH MEP flow termination functions combine the following atomic functions (Figures 7-12 and 7-13):

- ETH path/tandem connection/section/group to ETH or ETH adaptation;
- ETH path/tandem connection/section/group flow termination;
- ETH diagnostic to ETH adaptation;
- ETH diagnostic flow termination.

An ETH MEP function is capable of originating and terminating proactive ETH OAM signals and of originating, responding to and terminating diagnostic ETH OAM signals.

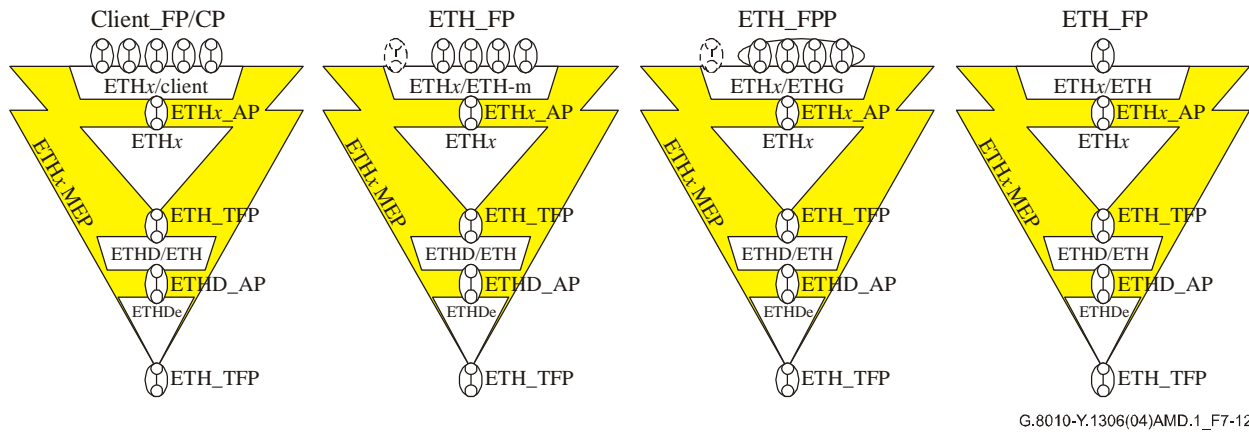


Figure 7-12 – ETH_x (x = P, T, S) MEP compound functions

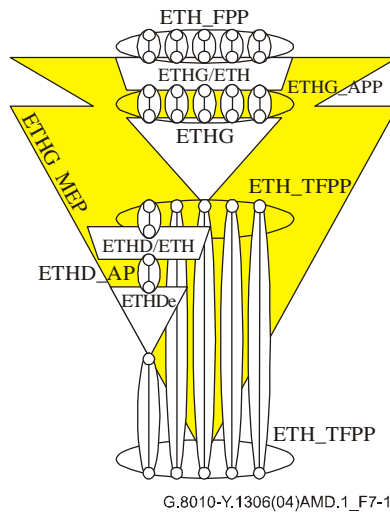


Figure 7-13 – ETHG MEP compound function

7.2.8.5 ETH MIP compound function

The ETH MIP compound function consists of two pairs of the ETH diagnostic adaptation and flow termination functions, each facing in opposite directions (Figure 7-14).

An ETH MIP function is capable of responding to on-demand ETH OAM signals.

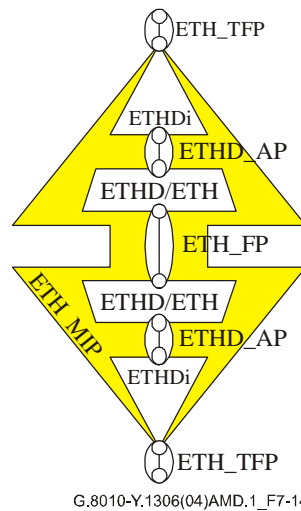


Figure 7-14 – ETH MIP compound function

A variant of this ETH MIP compound function is the half-MIP compound function which consists of a single pair of the ETH diagnostic adaptation and flow termination functions (Figure 7-15).

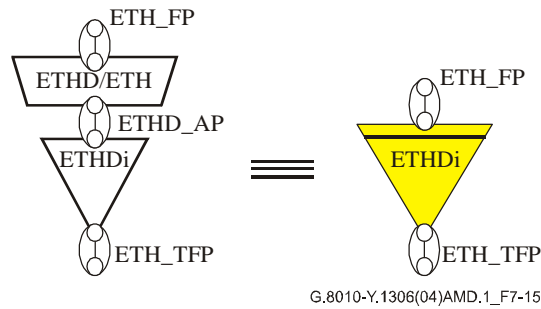


Figure 7-15 – ETH half-MIP compound function

7.3 Ethernet layer network management requirements

Refer to ~~ITU-T Rec. Y.1730~~ [ITU-T Y.1730](#) for ETH OAM requirements based on ETH reference models and MEs and refer to [ITU-T G.8013](#) ~~ITU-T Rec. Y.1731~~ for ETH OAM functions and mechanisms. Further Ethernet layer network management requirements are for further study.

7.4 Ethernet layer network traffic management

ETH traffic management refers to all network actions aiming to meet the network performance objectives and negotiated quality of service commitments, and to avoid congested conditions. One of the elements of this traffic management concerns the conditioning of the ingress traffic at an ETH administrative domain to enforce the traffic parameters defined in the service level agreement (SLA). Another element of this traffic management concerns the shaping of the egress traffic at an ETH administrative domain to adapt it to the traffic parameters defined in the service level agreement. For this purpose, the ETH_FPP can be expanded into an ETH_FPP, ETH_TCS function and ETH_FPP as illustrated in Figure 7-16.

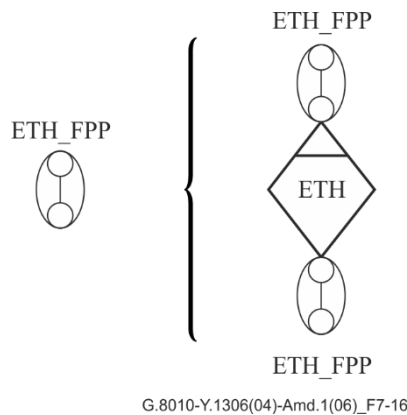


Figure 7-16/G.8010/Y.1306 – Expanding an ETH_FPP for the purpose of traffic conditioning and shaping

7.5 ETH transport processing functions

The ETH transport processing functions are:

- ETH flow termination function;
- ETH-to-ETH adaptation functions;
- ETH-to-client adaptation functions;
- Server-to-ETH adaptation functions.

This clause describes the functionality of the ETH flow termination functions and the ETH-to-ETH adaptation functions. The ETH-to-client adaptation functions are described in 6.5.1 and the server-to-ETH adaptation functions are described in 6.5.2. Refer to [ITU-T Rec. G.8021/Y.1341](#) [ITU-T G.8021] for specifications of these functions.

7.5.1 ETH flow termination functions

The bidirectional ETH flow termination (ETH_x_FT, x = P, T, S) function is performed by a co-located pair of ETH flow termination source (ETH_x_FT_So) and sink (ETH_x_FT_Sk) functions.

The following generic processes may be assigned to an ETH connection monitoring flow termination:

- validation of connectivity integrity;
- assessment of transmission quality;
- transmission defect detection and indication;
- connectivity fault localization.

The ETH_x_FT_So function accepts adapted information from a client (sub)layer network at its input, inserts the ETH trail termination OAM (with MEG level set to *local* MEG level) as a separate and distinct logical data stream and presents the characteristic information of the ETH connection monitoring sublayer network at its output.

The ETH_x_FT_Sk accepts the characteristic information of the ETH connection monitoring sublayer network at its input, extracts and processes the ETH OAM destined for the function and presents the remainder as adapted information at its access point output, while presenting the ETH maintenance entity group fault and performance status at its management point output.

There are several ETH flow termination functions defined, each for a specific application:

- ETH path (ETHP), tandem connection (ETHT) and section (ETHS) flow termination;
- ETH group (ETHG) flow termination;
- ETH diagnostic (ETHD) flow termination.

7.5.1.1 ETH path, tandem connection, section flow termination function

The ETH_x_FT function is the endpoint of the ETH maintenance entity group.

The ETH_x_FT_So function inserts a path, tandem connection or section level ETH-CCM OAM signal, which carries the connectivity check, frame loss measurement and remote defect indication information.

The ETH_x_FT_Sk function extracts and processes path, tandem connection or section level ETH-CCM, ETH-AIS and ETH-LCK OAM signals.

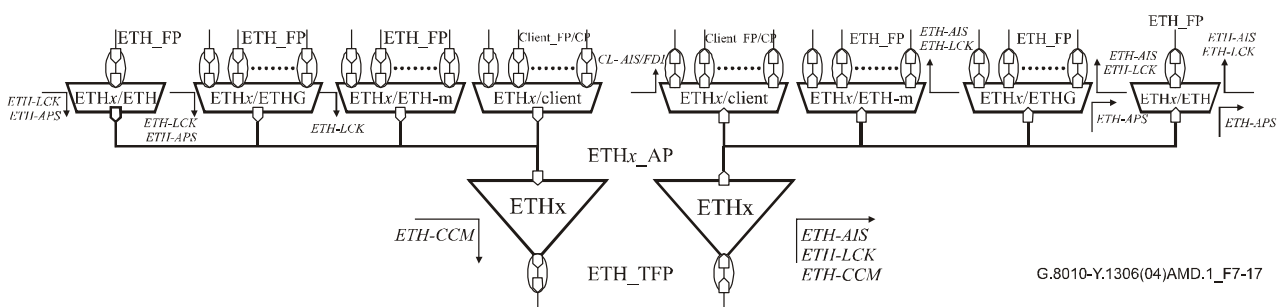


Figure 7-17 – ETH_x atomic functions and their ETH OAM signals

7.5.1.2 ETH group (ETHG) flow termination function

The ETHG_FT function is the endpoint of the ETH group maintenance entity group level (ETH MEG level in the range 7 to 1). The ETH group MEG performs monitoring for the group of ETH_CI signals within the ETH_FPP. The ETH_FPP may include the complete range of ETH_FPs, or a subset of them.

The ETH OAM is carried over either the ETH_FP with the lowest number in the contiguous range of ETH_FPs, or over a selected ETH_FP within the group of arbitrary ETH_FPs. Note that this selected group member must always be present, with or without user traffic.

The ETHG_FT_So function may insert tandem connection or section level ETH CCM OAM signals.

The ETHG_FT_Sk function extracts and processes tandem connection or section level ETH CCM, AIS and LCK OAM signals.

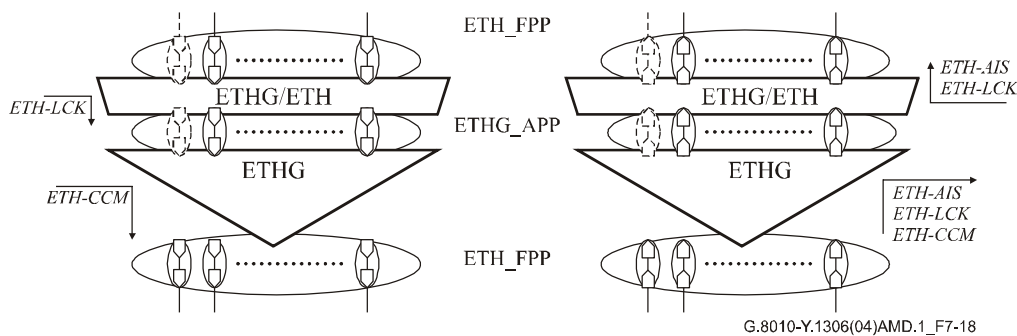


Figure 7-18 – ETHG atomic functions and their ETH OAM signals

7.5.1.3 ETH diagnostic (ETHD) flow termination function

The ETHD_FT function is an endpoint (ETHDe) or intermediate point (ETHDi) of ETH on-demand OAM frames for an ETH path, tandem connection or section maintenance entity group. As an endpoint of on-demand OAM, it acts as originator and responder, as an intermediate point, it acts only as responder.

The ETHDe_FT_So function (endpoint role) is able to insert ETH LBM, TST, LTM, LMM and/or DMM OAM signals with MEG level as per configuration when ordered to do so via its management point. The ETHDe_FT_So function inserts ETH LBR, LMR or DMR OAM frames when ordered to do so via its remote point that is controlled by its associated ETHD_FT_Sk function and inserts ETH LTR OAM frames when ordered to do so via its management point. For LMR, it inserts the transmit frame count, while for DMR, it inserts the transmit timestamp.

The ETHDi_FT_So function (intermediate point role) inserts ETH LTM OAM signals with MEG level as per configuration when ordered to do so via its management point. The ETHDi_FT_So function inserts ETH LBR OAM frames when ordered to do so via its remote point that is controlled by its associated ETHD_FT_Sk function, and inserts ETH LTR OAM frames when ordered to do so via its management point.

The ETHD_FT_So functions receive from one or more on-demand functions in the EMF on-demand OAM frames, including OAM-specific fields, destination address and MEG-independent common fields via their management point, and insert the MEG level, type and source addresses to construct the on-demand OAM-specific frame. For the case of LMM, it also inserts the frame count, and for DMM, it inserts the timestamp.

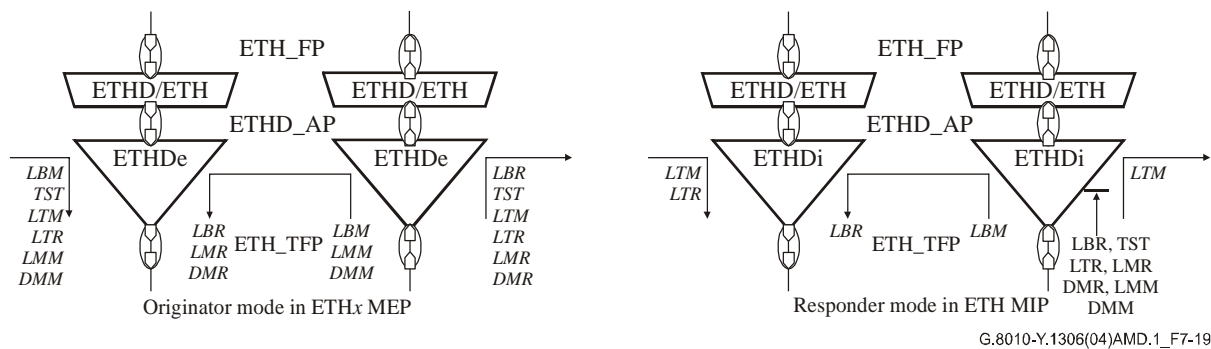


Figure 7-19 – ETHD atomic functions and their ETH OAM signals

The ETHDe_FT_Sk function (endpoint role) extracts and processes ETH LBM, LBR, TST, LTM, LTR, LMM, LMR, DMM and DMR OAM signals with MEG level as per configuration and matches the destination address (unicast, multicast) of the ETHDe_FT function. It forwards the received LBR, TST, LTM, LTR, LMR and DMR OAM signals to its management point; the LMR OAM signal with the additional receive frame count and the DMR OAM signal with the additional receive timestamp. The ETHDe_FT_Sk function controls the insertion, by its associated ETHDe_FT_So function, of the LBM, LMM and DMM associated reply OAM frames (LBR, LMR, DMR) after insertion of the receive frame count value in the LMM frame and receive timestamp in the DMM frame.

The ETHDi_FT_Sk function (intermediate point role) extracts ETH LBM, LBR, TST, LTM, LTR, LMM, LMR, DMM and DMR OAM signals with MEG level as per configuration and matches the destination address (unicast, multicast) of the ETHDi_FT function. It forwards the received LTM OAM signals to its management point. The ETHDi_FT_Sk function controls the insertion, by its associated ETHDi_FT_So function, of the LBM associated reply OAM frame (LBR). The ETHDi_FT_Sk function discards the extracted LBR, TST, LTR, LMM, LMR, DMM and DMR OAM signals.

7.5.2 ETH adaptation functions

The bidirectional ETH_x/ETH adaptation (ETH_x/ETH_A, $x = P, T, S$) function is performed by a co-located pair of ETH connection monitoring adaptation source (ETH_x/ETH_A_So) and sink (ETH_x/ETH_A_Sk) functions.

The following generic processes may be assigned to an ETH MEG monitoring adaptation:

- forwarding or blocking client signals depending on the administrative state;
- filtering incoming OAM frames to secure MEG monitoring operation;
- generation of OAM maintenance signals AIS and LCK (refer to Figures 7-17 and 7-18);
- multiplexing or demultiplexing ETH_CI signals, including addition or removal of a tributary identifier.

There are five ETH_x/ETH adaptation functions defined:

- ETH_x/ETH-m adaptation function, which is the endpoint of a path, tandem connection or section monitoring ETH sublayer carrying a multiplexed set of ETH_CI signals;
- ETH_x/ETH adaptation function, which is the endpoint of a path, tandem connection or section monitoring ETH sublayer;
- ETH_x/ETHG adaptation function, which is the endpoint of a path, tandem connection or section monitoring ETH sublayer carrying a multiplexed set of ETH_CI signals of an ETH group;

- ETHG/ETH adaptation function, which is the endpoint of either a tandem connection or a section connection monitoring ETH sublayer carrying an aggregated set of ETH_CI signals;
- ETHD/ETH adaptation function, which is the ETH diagnostic sublayer entry/exit.

7.5.2.1 ETHx/ETH-m adaptation

The ETHx/ETH-m adaptation source (ETHx/ETH-m_A_So) performs the following processes between its set of input ETH_FPs and its output ETHx_AP:

- Supports configuration of *client* MEG Level for each ETH_FP;
- Forwards or blocks forwarding of all the ETH_CI signals depending on the administrative state (refer to [ITU-T Rec. X.731](#) [ITU-T X.731]) of the ETHx/ETH-m_A function. Blocks forwarding of ETH_CI signals when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level;
- Multiplexes ETH_CI traffic units from the *N* ETH_FPs and insert a VLAN tag as appropriate;
- Supports configuration of the *local* MEG level;
- Filters ETH OAM frames within the ETH_CI signals to secure the ETH OAM deployment within this ETH MEG. ETH OAM frames with a MEG level lower than or equal to the local MEG level should be discarded, while ETH OAM frames with a MEG level higher than the local MEG level should be forwarded transparently;
- Outputs the resulting ETHx_AI.

The ETHx/ETH-m adaptation sink (ETHx/ETH-m_A_Sk) performs the following processes between its input ETHx_AP and its set of output ETH_FPs:

- Supports configuration of the *local* MEG level;
- Filters ETH OAM frames within the ETHx_AI signal to confine the ETH OAM to this ETH MEG. ETH OAM frames with MEG level lower than or equal to the local MEG level should be discarded, while ETH OAM frames with MEG level higher than the local MEG level should be forwarded transparently;
- Demultiplexes ETH_CI traffic units according to the VID value in the VLAN tag or the configured VID value;
- Supports configuration of *client* MEG level for each ETH_FP;
- On detection of a Signal Fail condition, adds ETH-AIS OAM at the client's MEG level to all ETH_CI signals;
- Forwards or blocks forwarding of all the ETH_CI signals depending on the administrative state (refer to [ITU-T Rec. X.731](#) [ITU-T X.731]) of the ETHx/ETH-m_A function. Blocks forwarding of ETH_CI signals when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level in all ETH_CI signals;
- Outputs the resulting ETH_CI traffic units on the appropriate ETH_FP.

7.5.2.2 ETHx/ETH adaptation

The ETHx/ETH adaptation source (ETHx/ETH_A_So) performs the following processes between its ETH_FP input and its ETHx_AP output:

- Supports configuration of the *client* MEG level and *local* MEG level;
- Forwards or blocks forwarding of the ETH_CI signal depending on the administrative state (refer to [ITU-T X.731](#) [ITU-T Rec. X.731]) of the ETHx/ETH_A function. Blocks forwarding of the ETH_CI signal when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level;
- Generates AI_P and AI_DE signals based on CI_P, CI_DE and local configuration;

- Filters ETH OAM frames within the ETH_CI signal to secure the ETH OAM deployment within this ETH MEG. ETH OAM frames, with an MEG level lower than or equal to the local MEG level, should be discarded, while ETH OAM frames, with an MEG level higher than the local MEG level, should be forwarded transparently;
- Generates the APS OAM signal (with the *local* MEG level) to transport the CI_APS information.

The ETH_x/ETH adaptation sink (ETH_x/ETH_A_Sk) performs the following processes between its ETH_x_AP input and its ETH_FP output:

- Supports configuration of *client* MEG level and *local* MEG level;
- Extracts the APS OAM frame and retrieves the APS information to forward it as CI_APS;
- Filters ETH OAM frames within the ETH_x_AI signal to confine the ETH OAM to this ETH MEG. ETH OAM frames, with an MEG level lower than or equal to the local MEG Level should be discarded, while ETH OAM frames, with an MEG level higher than the local MEG level should be forwarded transparently;
- Processes AI_P and AI_DE signals and generates CI_P, CI_DE;
- On detection of a Signal Fail condition, adds ETH-AIS OAM at the client's MEG level to the ETH_CI signal;
- Forwards or blocks forwarding of the ETH_CI signal depending on the administrative state (refer to [\[ITU-T X.731\]](#)~~ITU-T Rec. X.731~~) of the ETH_x/ETH_A function. Blocks forwarding of the ETH_CI signal when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level.

NOTE – For the case where this function is deployed in an ETH SNC/S protection scheme (refer to [\[ITU-T G.8031\]](#)~~ITU-T Rec. G.8031/Y.1342~~) the administrative state should not be set to LOCKED.

7.5.2.3 ETH_x/ETHG adaptation

The ETH_x/ETHG adaptation function is a combination of the ETH_x/ETH-m adaptation function and the ETH_x/ETH adaptation function. The ETH_x/ETH-m adaptation function supports an arbitrary and independent set of one to 2^N–2 client ETH_CI signals; the ETH_x/ETHG adaptation function supports a single group of up to "G" client ETH_CI signals of which only a single ETH_CI signal in the group carries a client MEG OAM.

This ETH_x/ETHG adaptation function multiplexes the individual ETH_CI signals in the ETH group created in an ETHG/ETH adaptation function, which is typically located at the other end of the UNI or NNI.

The ETH_x/ETHG adaptation source (ETH_x/ETHG_A_So) performs the following processes between its ETH_FPP input and its ETH_x_AP output:

- Supports configuration of *client* MEG level and ETH_FP in the ETH_FPP, which will carry the ETHG's MEG OAM;
- Forwards or blocks forwarding of all the ETH_CI signals in the ETH group, depending on the administrative state (refer to [\[ITU-T X.731\]](#)~~ITU-T Rec. X.731~~) of the ETH_x/ETHG_A function. Blocks forwarding of the ETH_CI signals in the group when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level in the ETH_CI carrying the ETHG's OAM;
- Multiplexes ETH_CI traffic units from the *N* ETH_FPs and inserts a VLAN tag as appropriate;
- Performs ETH multiplexing to form an aggregate ETH signal;
- Supports configuration of the *local* MEG level;

- Filters ETH OAM frames within the aggregate ETH signal to secure the ETH OAM deployment within this ETH MEG. ETH OAM frames, with an MEG level lower than or equal to the local MEG level, should be discarded, while ETH OAM frames, with an MEG level higher than the local MEG level, should be forwarded transparently;
- Generates the APS OAM signal (with the *local* MEG level) to transport the CI_APS information;
- Outputs the resulting ETH_x_AI.

The ETH_x/ETHG adaptation sink (ETH_x/ETHG_A_Sk) performs the following processes between its input ETH_x_AP and its output ETH_FPP:

- Supports configuration of the *local* MEG level;
- Extracts the APS OAM frame and retrieves the APS information to forward it as CI_APS;
- Filters ETH OAM frames within the ETH_x_AI signal to confine the ETH OAM to this ETH MEG. ETH OAM frames, with an MEG level lower than or equal to the local MEG level should be discarded, while ETH OAM frames, with an MEG level higher than the local MEG level, should be forwarded transparently;
- Demultiplexes ETH_CI traffic units according to the VID value in the VLAN tag or the configured VID value;
- Supports configuration of the *client* MEG level and ETH_FP in the ETH_FPP that will carry the ETHG's MEG OAM;
- On detection of a Signal Fail condition, adds ETH-AIS OAM at the client's MEG level to the ETH_CI carrying the ETHG's OAM;
- Forwards or blocks forwarding of all the ETH_CI signals in the ETH group depending on the administrative state (refer to [\[ITU-T X.731\]](#)~~ITU-T Rec. X.731~~) of the ETH_x/ETHG_A function. Blocks forwarding of the ETH_CI signals in the group when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level in the ETH_CI carrying the ETHG's OAM;
- Outputs the resulting ETH_CI traffic units on the appropriate ETH_FP.

7.5.2.4 ETHG/ETH adaptation

The ETHG/ETH adaptation source (ETHG/ETH_A_So) performs the following processes between its ETH_FPP input and its ETHG_APP output:

- Supports configuration of the *client* MEG level for each ETH_FP;
- Forwards or blocks forwarding of all the ETH_CI signals depending on the administrative state (refer to [\[ITU-T X.731\]](#)~~ITU-T Rec. X.731~~) of the ETHG/ETH_A function. Blocks forwarding of the ETH_CI signals when the administrative state is LOCKED and inserts the ETH-LCK maintenance signals at the client's MEG level;
- Supports configuration of the *local* MEG level;
- Filters ETH OAM frames within the ETH_CI signal (if present) that will carry the ETH group MEG's ETH OAM to secure the ETH OAM deployment within this ETH group MEG. ETH OAM frames, with an MEG level lower than or equal to the local MEG level should be discarded, while ETH OAM frames, with an MEG level higher than the local MEG level should be forwarded transparently;
- Outputs the resulting ETH_x_AI.

The ETHG/ETH adaptation sink (ETHG/ETH_A_Sk) performs the following processes between its ETHG_APP input and its ETH_FPP output:

- Supports configuration of the *local* MEG level;

- Filters ETH OAM frames within the ETHG_AI signal to confine the ETH OAM to this ETH Group MEG. ETH OAM frames, with an MEG level lower than or equal to the local MEG level should be discarded, while ETH OAM frames, with an MEG level higher than the local MEG level, should be forwarded transparently;
- Supports configuration of the *client* MEG level for each ETH_FP;
- On detection of a Signal Fail condition, adds ETH-AIS OAM at the client's MEG level to all ETH_CI signals in the group;
- Forwards or blocks forwarding of the group of ETH_CI signals depending on the administrative state (refer to [\[ITU-T X.731\]](#)~~ITU-T Rec. X.731~~) of the ETHG/ETH_A function. Blocks forwarding of the group of ETH_CI signals when the administrative state is LOCKED and inserts the ETH-LCK maintenance signal at the client's MEG level in all ETH_CI signals within the group of ETH_CI signals.

7.5.2.5 ETHD/ETH adaptation

The ETHD/ETH adaptation source (ETHD/ETH_A_So) performs the following process between its ETH_FP input and its ETHD_AP output:

- Forwards signal at input to output.

The ETHD/ETH adaptation sink (ETHD/ETH_A_Sk) performs the following process between its ETHD_AP input and its ETH_FP output:

- Forwards signal at input to output.

8 Ethernet survivability techniques

For further study.

9 Transport functional architecture of Ethernet networks (using [\[ITU-T G.800\]](#))

This clause presents the functional architecture of Ethernet layer networks based on [Recommendation \[ITU-T G.800\]](#) – Unified functional architecture of transport networks. This functional architecture covers the Ethernet network structure and behaviour specified in [\[ITU-T G.8013\]](#) and [\[IEEE802.1Q\]](#)~~the following standards:~~

- ~~• IEEE 802.1D-2004, *Media Access Control (MAC) Bridges.*~~
- ~~• IEEE 802.1Q-2005, *Virtual Bridged Local Area Networks.*~~
- ~~• IEEE 802.1ad-2005, *Virtual Bridged Local Area Networks, Amendment 4: Provider Bridges.*~~
- ~~• IEEE 802.1ag-2007, *Virtual Bridged Local Area Networks, Amendment 5: Connectivity Fault Management.*~~
- ~~• Recommendation ITU-T Y.1731 (2006), *OAM functions and mechanisms for Ethernet based networks.*~~
- ~~• IEEE 802.1ah-2008, *Virtual Bridged Local Area Networks, Amendment 7: Provider Backbone Bridges.*~~
- ~~• IEEE 802.1Qaw-2009, *Virtual Bridged Local Area Networks, Amendment 9: Management of Data Driven and Data Dependent Connectivity Faults.*~~
- ~~• IEEE 802.1aj-2009, *Virtual Bridged Local Area Networks, Amendment 11: Two-Port Media Access Control (Mac) Relay.*~~

The functional architecture covers functions within the Ethernet layer network and common aspects of client and server adaptation functions. It does not cover details specific to client or server layer networks or common adaptation functions that are independent of the described Ethernet layer network functions (e.g., there is no discussion of LLC/SNAP or specific PHY functions).

9.1 General principles

Ethernet transport networks provide a connectionless frame (packet) transport service for frames carrying client information. Additional functions are provided for multiplexing, supervision and survivability of the Ethernet transport entities that convey frames in the Ethernet network. The transport functional architecture of Ethernet networks is described using the generic principles defined in [Recommendations \[ITU-T G.805\]](#) and [\[ITU-T G.800\]](#) (using conventions as noted in Appendix VIII). The architectural aspects regarding layer network structure, characteristic information, transport entities, transport processing functions, client/server associations, topology and partitioning of Ethernet transport networks are provided in this Recommendation.

9.2 Ethernet transport network layered structure

An Ethernet network layer structure may include any of a large number of media specific layer networks or other server layer networks (e.g., SDH, OTN, etc.) that can provide the MAC service Ethernet expects of its server layers. One of the most important Ethernet server layers is the IEEE 802.3 ~~family of~~ media specific layer networks. Figure 9-1 shows the basic Ethernet layer network structure.

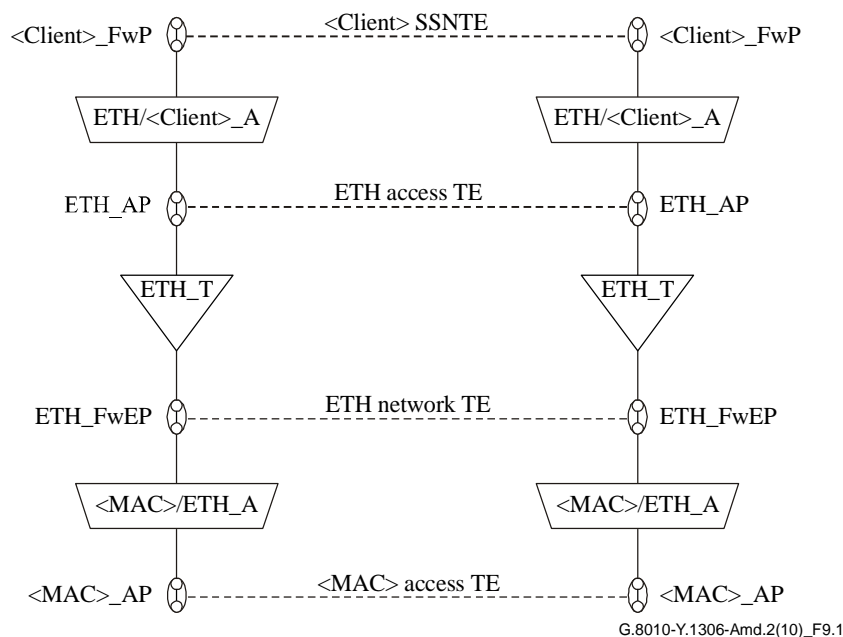


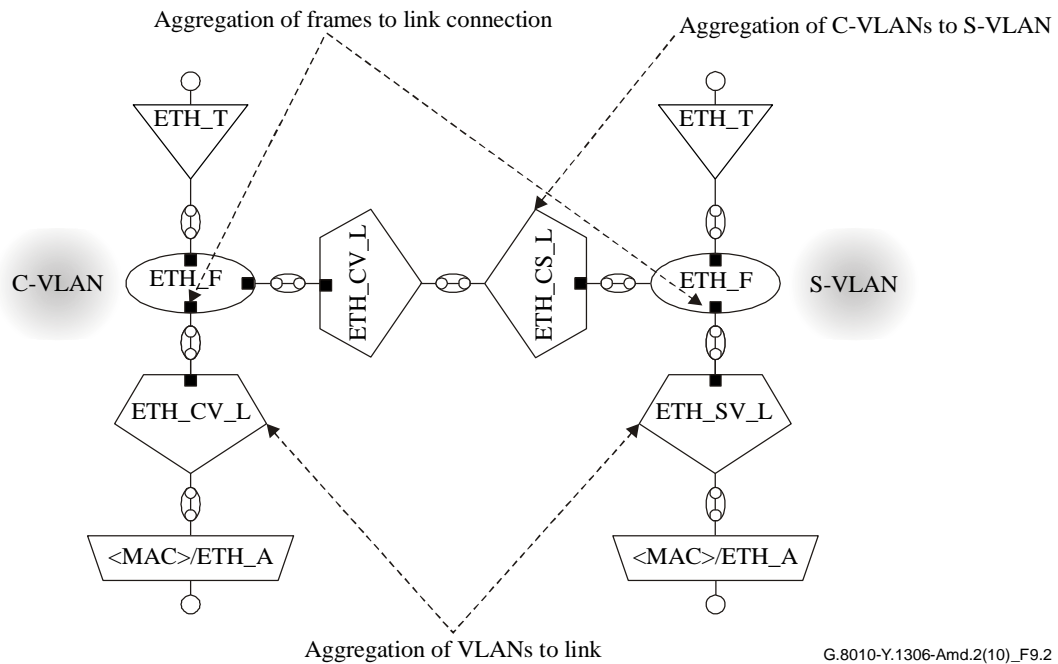
Figure 9-1 – Ethernet layer network structure

Within the media independent layer (ETH) of an Ethernet network, three types of aggregation are supported:

- Aggregation of multiple instances of ETH_CI (MAC frames) into a link connection or server subnetwork transport entity (e.g., LAN). This is shown in Figure 9-2 as "Aggregation of frames to link connection".
NOTE – Sufficient labelling is provided by the MAC destination address (DA) and source address (SA) associated with the frame, so no additional labelling is needed.
- Aggregation of multiple ETH subnetwork transport entities (VLANs) into a monitored aggregate with the addition of a label (VID). Note that one (and only one) of the VLANs may not have a label added. This is shown in Figure 9-2 as "Aggregation of VLANs to link".

- Aggregation of multiple ETH subnetwork transport entities into another ETH subnetwork transport entity (i.e., C-VLANs into an S-VLAN) with the addition of a label (C-VID). This is shown in Figure 9-2 as "Aggregation of C-VLANs to S-VLAN".

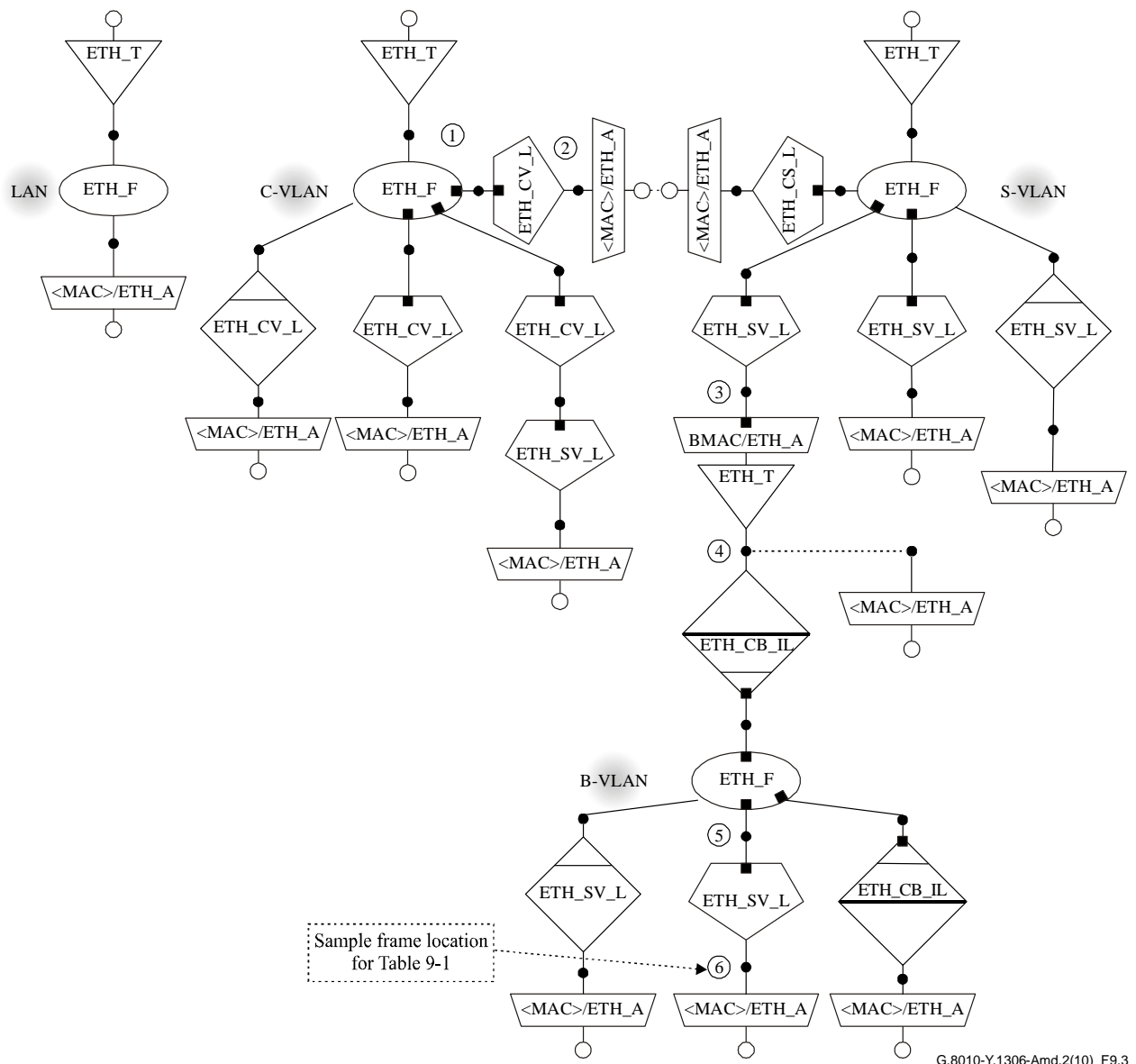
Aggregation within an Ethernet layer network may create significant administrative sublayers that can be independently monitored and managed.



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Figure 9-2 – Ethernet aggregation types

A more comprehensive picture of Ethernet layer network structure is shown in Figure 9-3. This figure combines the layering in Figure 9-1 with the aggregation options shown in Figure 9-2 and includes the layering of Ethernet over Ethernet (called provider backbone bridging). The functions shown in Figure 9-3 are described in the clauses below. In addition, Figure 9-3 is used as a reference model for describing the information structure of Ethernet layer networks shown in Table 9-1 below.



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Figure 9-3 – Ethernet layer and aggregation structure

9.3 Ethernet MAC (ETH) layer network

Ethernet networks bridge (provide forwarding between) a variety of media specific and/or limited reach (local area) network technologies. Whether an Ethernet network comprises a single media network or multiple media networks interconnected by bridges is intended to be invisible to the client. For this reason the service interface is called a "media access control" or MAC service interface¹. Therefore a "MAC service access point" (MAC SAP) corresponds to the Ethernet (ETH) layer network access point and the term "MAC termination" may be used to denote the ETH layer network termination function (ETH_T).

¹ Note that the IEEE may in the future revise the definition of the MAC service, and such a revision may impact the description of the MAC service interface as used in this Recommendation.

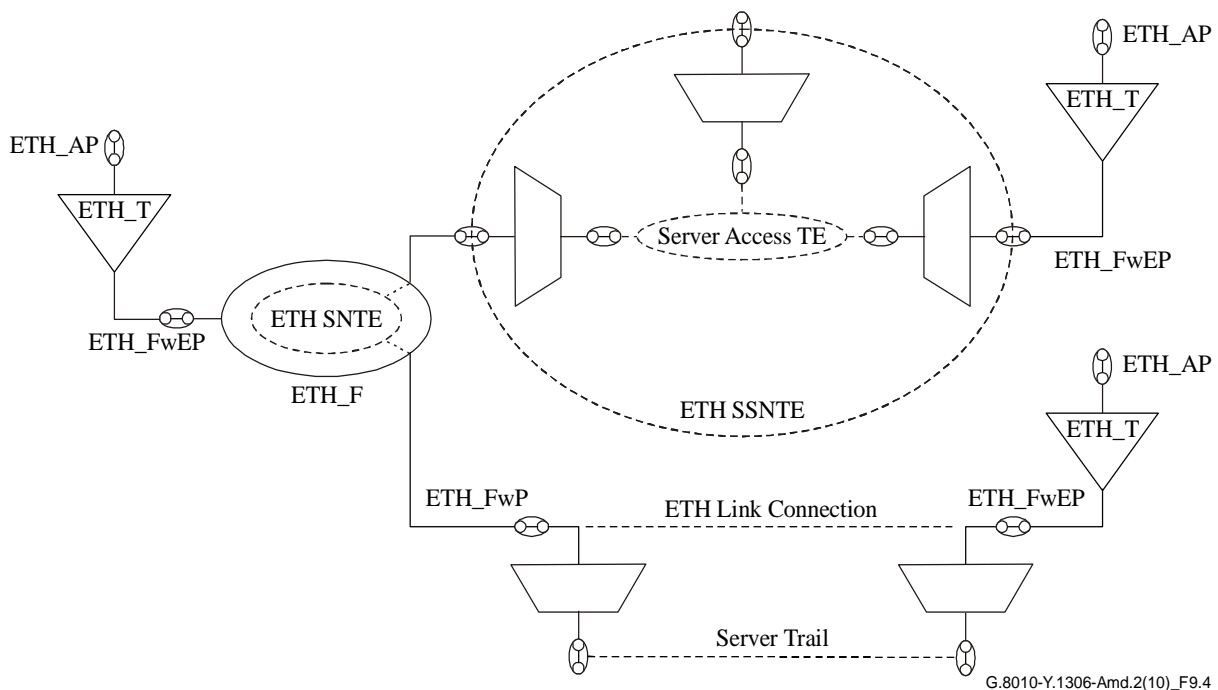


Figure 9-4 – ETH layer network example

The ETH layer network is bounded by ETH access points associated with ETH termination (MAC termination) functions. The ETH forwarding function supports multipoint subnetwork transport entities (ETH SNTEs or VLANs) and the interconnection between ETH forwarding elements may be point-to-point (ETH link connection – ETH_LC) or multipoint (ETH server subnetwork transport entity – ETH SSNTE). An ETH SSNTE must support a broadcast function allowing a single frame to be sent to all ETH forwarding elements (bridges) bound to that SSNTE. An ETH SNTE is bound to an SSNTE or LC at an ETH forwarding point (ETH_FwP). An ETH_T is bound to an ETH SNTE, SSNTE, or LC at a forwarding end point (ETH_FwEP). Figure 9-4 shows an example of a portion of an ETH layer network. Note that the diagram shows bidirectional reference points since Ethernet layer network operation depends on bidirectional connectivity.

9.3.1 ETH information structure

From the viewpoint of any given ETH transport processing function an instance of ETH_CI (an Ethernet MAC frame) comprises the following: [DA][SA][Tag(optional)][MSDU].

This information structure is decomposed into a payload to be carried transparently (the MAC service data unit – MSDU), a number of parameters passed directly between functions which include:

- destination address;
- source address;
- priority;
- discard eligible indication;
- frame check sequence;

and parameters encoded in the MSDU to pass between non-adjacent functions which include:

- tag protocol identifier;
- priority;
- discard eligible indication;
- VLAN identifier;

- backbone service instance identifier.

This information (ETH_CI) can be further classified as adapted information (ETH_AI), layer information (ETH_LI), or inter-layer information (ETH_ILI). ETH_AI is the information transferred transparently between ETH access points of a given ETH layer network. ETH_LI is the information that must be encoded by functions within the ETH layer network. ETH_LI may in some cases be encoded by an ETH/client adaptation function, but if it is not provided by the adaptation function it must be provided by a function within the ETH layer network (e.g., ETH_T). Finally, ETH_ILI is information that must be encoded by an ETH/client adaptation function and is also processed by a function within the ETH layer network.

Table 9-1 below shows the visibility of ETH characteristic information to the various ETH functions using an example based on the ETH layer network structure shown in Figure 9-3. The first column of the table is a breakdown of the structure of an example Ethernet frame which has entered Figure 9-3 at the upper middle ETH access port and is examined at the location indicated in the bottom of that figure. The columns of the table indicate the functions through which the example frame passes.

In the figure the visibility of a piece of information (row) to a given function (column) is shown by the shading of the table cell as follows:

- information that does not exist is hashed;
- information that is not visible (i.e., which is in the MSDU or is not directly represented) is shaded; and
- information that is visible is not shaded (clear).

Where a piece of information exists, the use of that piece of information by a given function is indicated by the entry in each table cell as follows:

- information that is transparently transferred by a function is marked "T" (transparent);
- information that is (or may be) processed by a function is marked "P" (processed); and
- information that is represented in the functional model as a port on the function is marked "RP" (reference port).

In Table 9-1 below, the following abbreviations are used for the information elements in the Ethernet frame:

B-DA – Backbone Destination Address
 B-SA – Backbone Source Address
 TPID – Tag Protocol Identifier
 PCP – Priority Code Point
 DEI – Discard Eligibility Indicator
 I-SID – Backbone Service Instance Identifier
 C-DA – Customer Destination Address
 C-SA – Customer Source Address
 S-VID – Service VLAN Identifier
 C-VID – Customer VLAN Identifier
 MSDU – MAC Service Data Unit

These terms and information elements are further defined in IEEE specifications.

Table 9-1 – Example showing ETH information visibility

| Frame information (Note 1) | | ETH function | | | | | | | | | | | | | | | | | | | |
|----------------------------|------------------|--------------|-------|------------|---|--------------|--------------|------------|---|--------------|-------|-------------|-------------|-------------|-------------|---|---|---|---|---|---|
| | | ① ETH_T | ETH_F | ② ETH_CV_L | | ETH_CS_L | ETH_F | ③ ETH_SV_L | | ④ BMAC/ETH_A | ETH_T | ETH_CB_IL | ETH_F | ⑤ ETH_SV_L | ⑥ | | | | | | |
| B-DA | B-SA | | | | | CID (Note 3) | CID (Note 3) | P | P | P | P | P | T | | | | | | | | |
| | B-SA | | | | | CID (Note 3) | CID (Note 3) | P | P | T | P | T | | | | | | | | | |
| B-Tag | TPID | | | | | | | | | | | P | | | | | | | | | |
| | PCP/DEI | | | | | | | | | | | P | T | T | T | P | | | | | |
| | B-VID (Note 4) | | | | | | | | | | | | | RP | RP (Note 2) | P | | | | | |
| I-Tag | TPID | | | | | | | | | | | P | T | P | T | T | | | | | |
| | PCP/DEI | | | | | | | | | | | P | P | T | P | T | T | T | | | |
| | I-SID | | | | | | | | | | | RP (Note 2) | P | T | P | T | T | T | | | |
| | C-DA | | | | | | | | | | | P | P | T | T | P | T | T | T | T | T |
| C-SA | P | P | T | T | P | T | T | T | T | T | T | T | | | | | | | | | |
| S-Tag | TPID | | | | | | | | | | | P | T | T | T | T | | | | | |
| | PCP/DEI | | | | | | | | | | | P | P | T | P | T | T | T | T | T | |
| | S-VID | | | | | | | | | | | RP | RP | RP (Note 2) | P | T | T | T | T | T | |
| C-Tag | TPID | | | | | | | | | | | P | T | T | T | T | | | | | |
| | PCP/DEI (Note 5) | | | | | | | | | | | P | T | P | P | T | T | T | T | T | T |
| | C-VID | | | | | | | | | | | RP (Note 2) | RP (Note 2) | P | P | T | T | T | T | T | T |
| Payload | MSDU | T | T | T | T | T | T | T | T | T | T | T | T | | | | | | | | |

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NOTE 1 – In addition to the information shown in this table, IEEE 802.1 specifications include a service access point identifier parameter (SAPID) that represents the MAC service access point or internal sublayer service access point over which a frame (service primitive) is received. This parameter is not included in the table because its role is identical to the reference points already represented. Furthermore, information that currently applies only to OAM functions (i.e., the UCA bit in the I-Tag) is not shown in the table.

NOTE 2 – In the functional model, a VID is represented in the ETH_T and ETH_F functions as a distinct forwarding end port or forwarding port rather than a parameter. These ports may be bound to ports on ETH link connections, server subnetwork transport entities, or subnetwork transport entities. Similarly, the backbone service instance is represented in the ETH_SV_L function as a forwarding port that is bound to a BMAC/ETH_A function port.

NOTE 3 – The ETH_F and ETH_SV_L functions do not have direct access to the B-DA and B-SA values; however, the BMAC/ETH_A function provides an internal parameter (connection_identifier or CID) which accompanies frames and proxies for the backbone address, enabling the client ETH_F function to "learn" how to directly reach points across the server subnetwork. The ETH_F and ETH_SV_L functions do not attach any significance to the CID value and the CID value will likely be null except at a backbone service instance MAC SAP (i.e., one supported by the BMAC/ETH_A function).

NOTE 4 – The B-VID is encoded in a service VLAN tag which is identical to the encoding of the S-VID, so the distinction between B-VLANs and S-VLANs is not made in the atomic functions but instead is a distinction made by management to describe the role of the service VLAN in the operator's layer network structure.

NOTE 5 – The DEI bit shown in the customer VLAN tag is currently specified as CFI (canonical format indicator) in IEEE 802.1Q but this bit is not used in transport applications, so in these applications the bit may be used for DEI instead (corresponding to the use of the bit in the service VLAN tag).

Table 9-1 – Example showing ETH information visibility

| Frame Information (Note 1) | | ETH Function | | | | | | | | | | | | | | | | | | |
|-------------------------------|---------------------|--------------------|-------|-----------------------|----------------|--------------------|-----------------|----------------|--------------------|------------|--------------------|-----------------------|---|---|--|---|---|---|----|----------------|
| | | ETH_T ^① | ETH_F | ETH_CV_L ^② | ETH_CS_L | ETH_F ^③ | ETH_SV_L | BMAC/ETH_A | ETH_T ^④ | ETH_CBP_IL | ETH_F ^⑤ | ETH_SV_L ^⑥ | | | | | | | | |
| | B-DA | | | | | CID (Note 3) | CID (Note 3) | P | P | P | P | T | | | | | | | | |
| | B-SA | | | | | CID (Note 3) | CID (Note 3) | P | P | T | P | T | | | | | | | | |
| B-Tag | TPID | | | | | | | | | | | | | | | P | | | | |
| | PCP/DEI | | | | | | | | | | | | | | | P | T | T | T | P |
| | B-VID (Note 4) | | | | | | | | | | | | | | | | | | RP | RP (Note 2) |
| I-Tag | TPID | | | | | P | T | P | T | T | | | | | | | | | | |
| | PCP/DEI | | | | | | | P | P | T | T | | | | | | | | | |
| | I-SID | | | | | | | RP (Note 2) | P | T | P | T | T | | | | | | | |
| | C-DA | | | | | P | P | T | T | P | T | T | T | T | | | | | | |
| C-SA | P | | | | | P | T | T | P | T | T | T | T | T | | | | | | |
| S-Tag | TPID | | | | | P | T | T | T | T | T | | | | | | | | | |
| | PCP/DEI | | | | | P | P | T | P | T | T | T | T | | | | | | | |
| | S-VID | | | | | RP | RP | RP (Note 2) | P | T | T | T | T | | | | | | | |
| C-Tag | TPID | | | P | P | T | T | T | T | T | T | | | | | | | | | |
| | PCP/DEI (Note 5) | | | P | T | P | P | T | T | T | T | T | | | | | | | | |
| | C-VID | | | RP (Note 2) | RP (Note 2) | P | P | T | T | T | T | T | T | | | | | | | |
| Payload | MSDU | T | T | T | T | T | T | T | T | T | T | | | | | | | | | |

NOTE 1 – In addition to the information shown in this table [IEEE 802.1] specifications include a service access point identifier parameter (SAPID) that represents the MAC service access point or internal sublayer service access point over which a frame (service primitive) is received. This parameter is not included in the table because its role is identical to the reference points already represented. Furthermore, information that currently applies only to OAM functions (i.e., the UCA bit in the I-Tag) is not shown in the table.

NOTE 2 – In the functional model a VID is represented in the ETH_T and ETH_F functions as a distinct forwarding end port or forwarding port rather than a parameter. These ports may be bound to ports on ETH link connections, server subnetwork transport entities, or subnetwork transport entities. Similarly the Backbone Service Instance is represented in the ETH_SV_L function as a forwarding port that is bound to a BMAC/ETH_A function port.

NOTE 3 – The ETH_F and ETH_SV_L functions do not have direct access to the B-DA and B-SA values; however, the BMAC/ETH_A function provides an internal parameter (connection_identifier or CID) which accompanies frames and proxies for the backbone address, enabling the client ETH_F function to "learn" how to directly reach points across the server subnetwork. The ETH_F and ETH_SV_L functions do not attach any significance to the CID value and the CID value will likely be null except at a Backbone Service Instance MAC SAP (i.e., one supported by the BMAC/ETH_A function).

NOTE 4 – The B-VID is encoded in a Service VLAN Tag which is identical to the encoding of the S-VID, so the distinction between B-VLANs and S-VLANs is not made in the atomic functions but instead is a distinction made by management to describe the role of the service VLAN in the operator's layer network structure.

NOTE 5 – The DEI bit shown in the Customer VLAN Tag is currently specified as CFI (canonical format indicator) in [IEEE 802.1Q] but this bit is not used in transport applications, so in these applications the bit may be used for DEI instead (corresponding to the use of the bit in the Service VLAN Tag).

9.3.2 ETH transport processing functions

The ETH transport processing functions are:

- ETH termination (ETH_T)
- ETH forwarding (ETH_F)
- ETH C-VLAN layer processor (ETH_CV_L)
- ETH S-VLAN layer processor (ETH_SV_L)
- ETH C-VLAN to S-VLAN layer processor (ETH_CS_L)
- ETH customer backbone inter-layer processor (ETH_CB_IL)

9.3.2.1 ETH termination function

The ETH termination function is present at the boundary of the ETH layer network. The bidirectional ETH Termination (ETH_T) function is performed by a co-located pair of ETH termination source (ETH_T_So) and sink (ETH_T_Sk) functions.

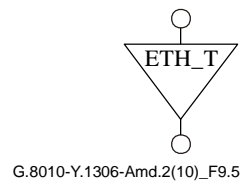


Figure 9-5 – ETH termination function

The ETH_T_So function provides the following functions:

- receives ETH_AI at its input access port;
- sets the values of the following parameters if they are not provided by the ETH/client adaptation function:
 - destination address;
 - source address;
 - priority;
 - drop eligible;
- sends ETH_CI at its output forwarding end port.

The ETH_T_Sk function provides the following functions:

- receives ETH_CI at its input forwarding end port;
- optionally filters frames whose DA is not in a list of addresses associated with its AP;
- sends ETH_AI at its output access port.

9.3.2.2 ETH forwarding function

The ETH forwarding function (ETH_F) provides multipoint subnetwork transport entities (SNTEs) between sets of forwarding ports. Each SNTE has one or more associated VLAN identifiers (VIDs) and accepts ETH_CI traffic units (frames) at its input ports and forwards each frame to zero or more of its output ports. Forwarding of a frame within an SNTE is controlled by a set of forwarding rules from which one is selected based on the frame's DA and the SNTE's VID. Several rules are present by default, including a "flooding" rule that, if the frame's DA does not match any other forwarding rule, forwards a frame to all active output ports on the SNTE except the output port paired with the input port on which the frame was received.

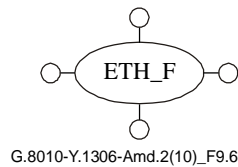


Figure 9-6 – ETH forwarding function

When a frame is received, a forwarding rule may be "learned" associating the frame's SA with the receive port. Learned forwarding rules may be applied to one or more SNTEs. If an SNTE meets certain criteria (e.g., has exactly two ports) no rules beyond the default forwarding rules are needed.

Forwarding rules may also be provisioned (static filtering entries) and these take precedence over learned rules. Wildcard rules governing the forwarding of frames with group destination addresses and/or specified VIDs can also be provisioned.

An individual SNTE may be bidirectional (i.e., have bidirectional ports) or a bidirectional SNTE may be constructed from multiple unidirectional SNTEs (SNTEs with unidirectional ports). A bidirectional SNTE is commonly called a VLAN.

The ETH forwarding function supports three types of SNTE – "customer" (C-VLAN), "service provider" (S-VLAN), and two port MAC relay (TPMR). The default forwarding rules differ for these three SNTE types with the C-VLAN having the largest set of reserved addresses that are always filtered (i.e., never forwarded) by the VLAN and the TPMR having the smallest set.

9.3.2.3 ETH VLAN layer processor function

The bidirectional ETH VLAN layer processor functions (ETH_CV_L, ETH_SV_L) are performed by a co-located pair of ETH VLAN layer processor source (ETH_CV_L_So, ETH_SV_L_So) and sink (ETH_CV_L_Sk, ETH_SV_L_Sk) functions.

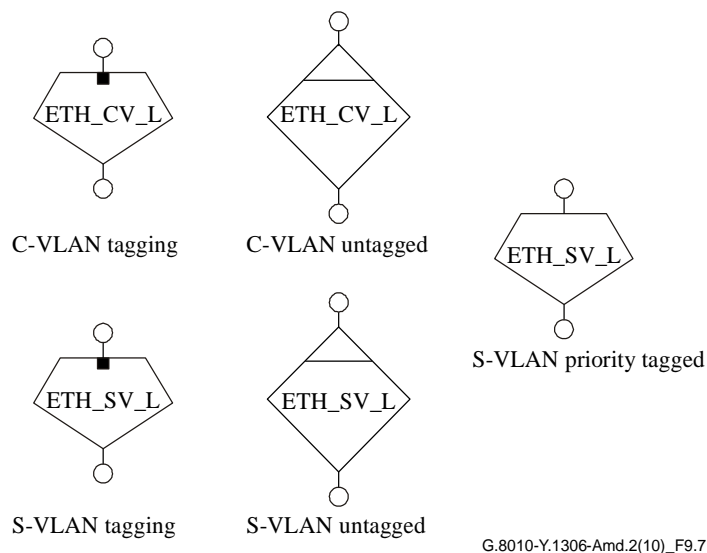


Figure 9-7 – ETH VLAN layer processor functions

The ETH_xV_L_So functions perform the following processes:

- receive ETH_CI on an input port bound to an SNTE output port;
- optionally add a VLAN tag encoding the SNTE's VID and the PCP and DEI parameters to frames received at an input port;

- optionally translate the VID value (ETH_SV_L only);
- output the resulting frame on the output port.

The ETH_xV_L_Sk functions perform the following processes:

- if a VLAN tag of the type recognized by the function is present in the MSDU received at the input port, decode the VID, PCP, and DEI and remove the tag from the frame;
- optionally discard either 1) frames whose VID is not 0 or 2) frames whose VID is 0 or have no VLAN tag of the recognized type;
- optionally translate the VID value (ETH_SV_L only);
- if no VLAN tag of the type recognized by the function is present, provide values for the VID, PCP, and DEI parameters for the frame;
- optionally discard frames whose VID is not in the port's VID member set;
- output each remaining frame on the output port corresponding to the frame's VID.

ETH OAM MEP or MIP functions as specified in [ITU-T G.8013]Y.1731 and/or [IEEE 802.1Q]ag may be provided at the input and/or output ports of ETH_xV_L functions.

The ETH_xV_L functions can multiplex, aggregate, or merge ETH SNTEs depending on how and where they are used in an ETH layer network.

- If ETH_xV_L functions of the same type are present at all the boundary points of a server access transport entity they can multiplex/demultiplex VLANs to/from the provided link or server subnetwork transport entity.
- If ETH_xV_L functions of the same type are present at all the boundary points of an ETH SNTE they can aggregate/disaggregate VLANs to/from that SNTE (Service VLAN).
- If an ETH_xV_L_So function uses the same label encoding (i.e., same VID value in the VLAN Tag or no VLAN Tag) for multiple VLANs, these VLANs are merged and cannot later be separated by a matching ETH_xV_L_Sk function.

9.3.2.4 ETH C-VLAN to S-VLAN layer processor function

The bidirectional ETH C-VLAN to S-VLAN layer processor function (ETH_CS_L) is performed by a co-located pair of ETH C-VLAN to S-VLAN layer processor source (ETH_CS_L_So) and ETH C-VLAN to S-VLAN layer processor sink (ETH_CS_L_Sk) functions. The ETH_CS_L has one C-VLAN aware port and one or more service VLAN ports.

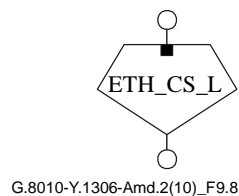


Figure 9-8 – ETH C-VLAN to S-VLAN layer processor function

The ETH_CS_L_So function performs the following processes:

- receive ETH_CI on the C-VLAN aware input port;
- if a C-VLAN Tag is present in the MSDU received at the input port, decode the VID, PCP, and DEI;
- if no C-VLAN tag is present, provide values for the VID, PCP, and DEI parameters for the frame;

- optionally discard either 1) frames whose VID is not 0 or 2) frames whose VID is 0 or have no VLAN Tag of the recognized type;
- optionally discard frames whose VID is not in the port's VID member set;
- if a C-VLAN tag is present in the MSDU received at the input port, optionally the C-VLAN tag may be removed;
- if a C-VLAN tag is not present in the MSDU received at the input port, optionally a C-VLAN tag may be added using the input port's default C-VID;
- forward the frame on an S-VLAN output port for the S-VLAN to which the frame's C-VID is assigned.

The ETH_CS_L_Sk function performs the following processes:

- receive ETH_CI on the S-VLAN input ports;
- if a C-VLAN tag is present in the MSDU received at the input port, optionally the C-VLAN tag may be removed;
- if a C-VLAN tag is not present in the MSDU received at the input port, optionally a C-VLAN tag may be added using the input port's default C-VID;
- forward frames to the C-VLAN aware output port.

9.3.2.5 ETH customer backbone inter-layer processor function

The bidirectional ETH customer backbone inter-layer processor function (ETH_CB_IL) is performed by a co-located pair of ETH customer backbone inter-layer processor source (ETH_CB_IL_So) and sink (ETH_CB_IL_Sk) functions. The ETH_CB_IL function performs backbone service instance grooming at the boundary of an ETH backbone domain. The function has one non-VLAN aware port and one or more backbone VLAN ports.

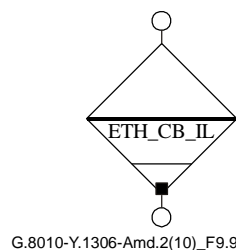


Figure 9-9 – ETH customer backbone inter-layer processor function

The ETH_CB_IL_So function accepts ETH_CI at its input port and performs the following processes:

- validates the presence of an I-Tag in the MSDU and the value of the I-SID in the I-Tag;
- assigns the frame to a backbone VLAN based on the backbone service instance identifier (I-SID);
- optionally translates the I-SID;
- optionally replaces the backbone destination address;
- sends the resulting ETH_CI on its output port associated with the assigned VLAN.

The ETH_CB_IL_Sk function accepts ETH_CI on input ports associated with backbone VLANs and performs the following processes:

- validates the presence of an I-Tag in the MSDU and the value of the I-SID in the I-Tag;
- optionally translates the I-SID;
- optionally replaces the backbone destination address;

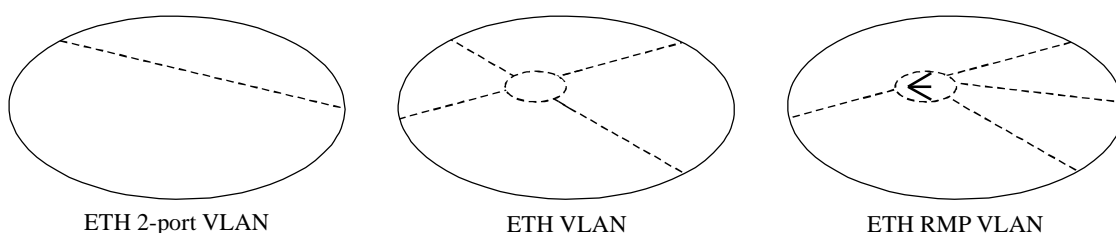
- sends the resulting ETH_CI on its output port.

9.3.3 ETH transport entities

The transport entities in an ETH layer network include:

- ETH access transport entity;
- ETH network transport entity;
- ETH subnetwork transport entity;
- ETH link connection;
- ETH server subnetwork transport entity.

All of these transport entities transfer ETH_CI traffic units (frames) from input to outputs and all except the link connection may have more than two ports. An ETH transport entity that has more than two ports may deliver an input frame to specific output ports as determined by forwarding rules selected based on the DA of the frame. If specific forwarding rules do not apply to the frame's DA then the frame is "flooded" and delivered to all output ports associated with the frame's VID with the possible exception of the output port paired with the input port on which the frame was received.



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Figure 9-10 – ETH transport entities

The general form of a multipoint ETH transport entity is the LAN or VLAN in which communication is supported between all port pairs. A useful restricted form of ETH transport entity is "rooted multipoint" which has a distinguished "root" port and multiple "leaf" ports. A rooted multipoint ETH transport entity supports communication from the root port to any leaf port and from any leaf port to the root port, but not between leaf ports. A rooted multipoint ETH TE (RMP VLAN) can be formed by pairing a unidirectional point-to-multipoint TE and a unidirectional multipoint-to-point TE.

A VLAN with only two ports behaves much like a connection with the caveat that frames using reserved destination addresses are not passed transparently.

9.4 Server/client associations

An ETH layer network can provide point-to-point, point-to-multipoint, multipoint, and rooted multipoint access transport entities for use by client layer networks. In turn an ETH layer network can make use of bidirectional point-to-point, multipoint, and rooted multipoint server access transport entities to provide interconnection between ETH transport processing functions.

9.4.1 ETH/client adaptation

An ETH/client adaptation function formats client CI for transport over an ETH layer network. An ETH layer network may provide services for a variety of clients and each ETH/client_A function will have both client specific and ETH specific processes. Only generic and ETH specific aspects are described here.

An ETH/client_A_So function processes client CI received at its client input forwarding port(s) to produce MAC service data units (MSDUs) to be carried transparently across the ETH layer network.

The first two octets of the MSDU contain an Ethertype value indicating the type of adapted client. The ETH/client_A_So which sends each MSDU on its output access port may also provide the following parameters:

- destination address;
- source address;
- priority;
- discard_eligible.

An ETH/client_A_Sk function receives ETH_AI (MSDU and parameters) at its input access port and reconstitutes client CI to be sent on output client forwarding ports. The parameters provided with the MSDU at the input access port may include:

- destination address;
- source address;
- priority;
- discard_eligible.

9.4.2 Server/ETH adaptation

A server/ETH adaptation function formats ETH_CI for transport over a server layer network. An ETH layer network may use services provided by a variety of servers and each server/ETH_A function will have both ETH specific and server specific processes. Only generic and ETH specific aspects are described here.

Ethernet bridging provides an extension of the service provided by an Ethernet LAN and that service is defined as a media access control (MAC) service. Therefore, an ETH layer network provides a MAC service to its clients and expects server layer networks that provide ETH links to provide a MAC service as well. Therefore, the general name used here for a server/ETH adaptation function is <MAC>/ETH_A.

The characteristics of a MAC service include the delivery of a MAC frame from an input port to either 1) the output port(s) identified with the DA in the frame (unicast or multicast behaviour) or 2) all output ports with the possible exception of the output port paired with the input port on which the frame is sent (broadcast behaviour).

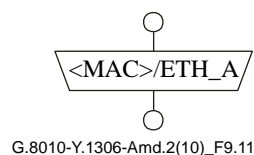


Figure 9-11 – Server/ETH adaptation function

A <MAC>/ETH_A_So function accepts ETH_CI (MSDU and parameters) at its ETH input forwarding port(s) and formats MAC frames for transmission over the server layer access transport entity. The parameters include:

- destination address;
- source address;

and may include:

- priority;
- discard_eligible;
- connection_identifier.

The `connection_identifier` may be used with a server subnetwork transport entity to indirectly identify a specific SSNTE output port. The CID for an address (SA) is provided by the `<MAC>/ETH_A_Sk` at an output `ETH_FwP` and may be provided to the `<MAC>/ETH_A_So` at an input `ETH_FwP` with a frame carrying a matching address (DA).

A `<MAC>/ETH_A_Sk` function accepts server AI at its server input AP and produces `ETH_CI` at its output `ETH_FwPt(s)`. The parameters provided may include:

- destination address;
- source address;

and may include:

- priority;
- `discard_eligible`;
- `connection_identifier`.

9.4.3 BMAC/ETH adaptation

The ETH backbone service provides server subnetwork transport entities (SSNTEs) to client ETH layer networks. Since it provides an instance of the MAC service, the adaptation function is called `BMAC/ETH_A`.

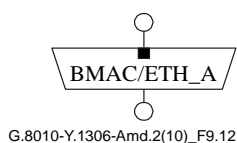


Figure 9-12 – BMAC/ETH adaptation function

The `BMAC/ETH_A_So` function accepts `ETH_CI` from an input `ETH_FwP` and forms the MSDU to be carried over the server (backbone) ETH network by adding to the client MSDU an I-Tag which encodes the following parameters:

- client destination address;
- client source address;
- priority;
- discard eligible;
- backbone service instance identifier.

The I-SID value is selected based on the input `ETH_FwP` (and represents a corresponding backbone service instance). To form the `ETH_AI` for the backbone ETH layer network, a backbone destination address parameter value is set, using the CID parameter as input.

The `BMAC/ETH_A_Sk` function accepts `ETH_AI` from the input `ETH_AP`, validates and removes the I-Tag from the MSDU and passes `ETH_CI` to the output `ETH_FwP` identified by the I-SID value. The `BMAC/ETH_A_Sk` function also provides a CID parameter value which can be mapped by the `BMAC/ETH_A_So` to the received source address parameter (B-SA).

9.5 Ethernet network topology

An ETH layer network is the set of ETH access groups (co-located `ETH_T` functions) that may be associated to exchange `ETH_CI`. An ETH layer network has a maximal subnetwork that provides connectivity between access groups. This maximal subnetwork may be partitioned into smaller ETH subnetworks interconnected by ETH links (point-to-point) and/or ETH server subnetworks (multipoint).

Figure 9-13 shows an ETH layer network with access groups connected to either customer bridges (supporting C-VLANs) or provider bridges (supporting S-VLANs). The customer bridges are connected to each other directly or via provider bridges that form a provider bridged (sub)network (PBN). The provider bridges are connected to each other either directly or via a server subnetwork supported by an ETH server layer network or provider backbone bridged network (PBBN).

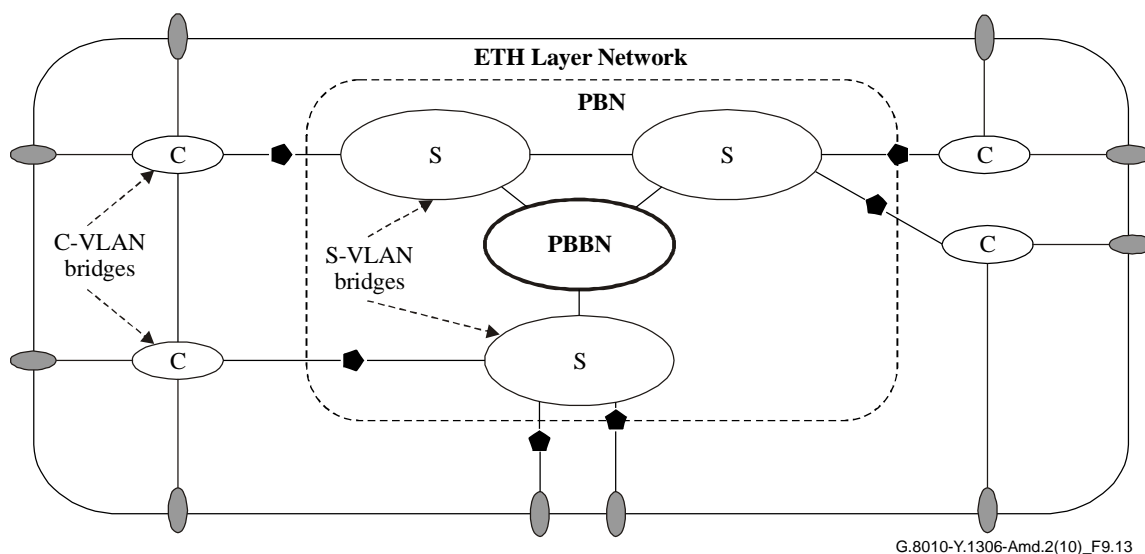


Figure 9-13 – ETH layer network topology example

While the topology shown could support transport entity topologies containing loops, the active topology of each ETH transport entity must be loop-free due to the specified ETH_F behaviour (specifically the default "flooding" rule). This property can be ensured either by management or dynamic control mechanisms.

Figure 9-13 shows a topology of an entire ETH layer network. In practice the topology of the ETH layer network may be partitioned into distinct views held by different administrations. For example, a customer (C-VLAN) network topology may show the C-VLAN bridges/subnetworks and links separately, but show the PBN as a single subnetwork (i.e., the customer has no visibility into the PBN topology). Similarly, the PBN administration may see a topology that ends at the PBN boundary (not showing any detail of C-VLAN bridges or links outside the PBN). In the PBN administration's view, the PBBN may be shown as a single server subnetwork (as in the figure), or it may be partitioned to show server layer detail if the administration has responsibility for both layers. Alternatively the PBBN may be under a separate administration which has its own view of the PBBN topology and limited visibility outside the PBBN layer network boundary.

9.5.1 Provider bridged networks

Provider bridged networks (PBNs) are constructed using service VLAN (S-VLAN)-aware bridges also called provider bridges (PBs). A provider edge bridge (PEB) includes additional functionality to map customer VLANs (C-VLANs) to service VLANs (S-VLANs) in the PBN. Figure 9-14 is a topology diagram for an example PBN.

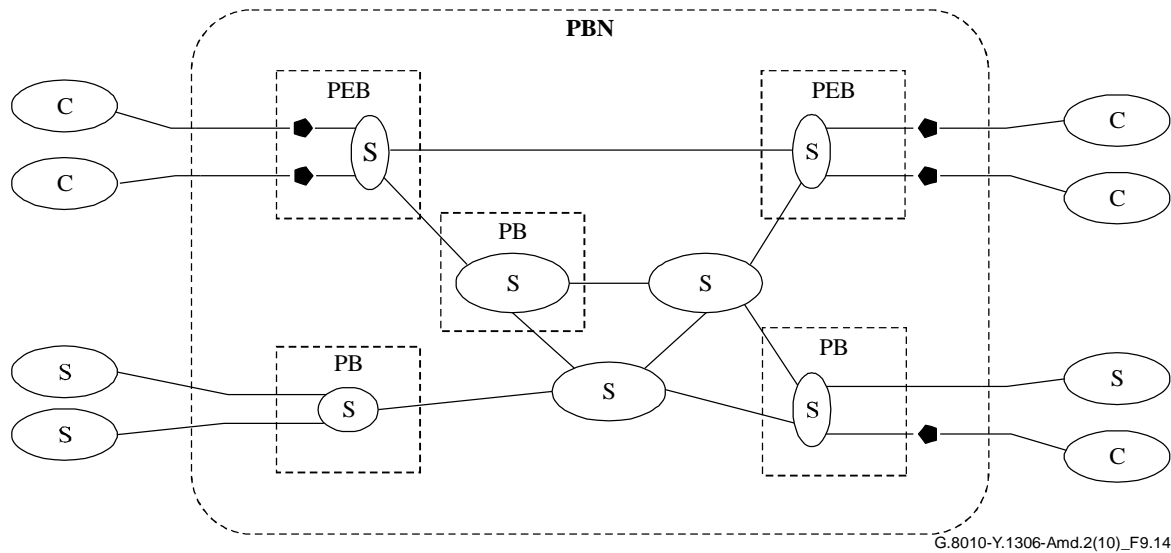


Figure 9-14 – ETH PBN topology example

The links connecting C-VLAN aware subnetworks to S-VLAN aware subnetworks are shown as transitional links because the relationship between C-VLAN forwarding points and S-VLAN forwarding points is not 1:1. In particular, multiple C-VLANs may be aggregated into a single S-VLAN. In addition, the bridge port (link port) relationship is not always 1:1. For example, a single C-VLAN link port may be related to multiple S-VLAN link ports as sets of C-VLANs are mapped to different S-VLANs in the PBN.

Figure 9-15 shows the topology of an example VLAN supported by the PBN shown in Figure 9-14. Link ports are shown as grey circles with forwarding points shown within. Two C-VLANs are shown (long-dashed blue and short-dashed red ovals) mapped to a single S-VLAN (black oval). It is not necessary that the extent of the S-VLAN exactly match the extent of the C-VLANs that are mapped into it. C-VLAN frames delivered to S-VLAN ports where the C-VLAN is not provisioned are discarded.

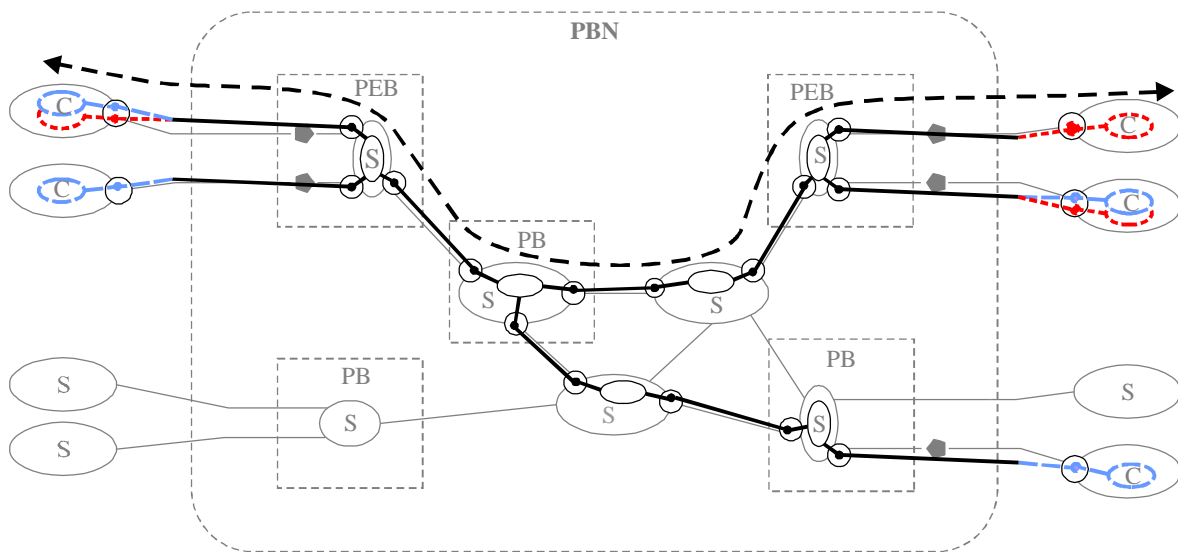


Figure 9-15 – ETH PBN VLAN topology example

Figure 9-16 shows the functional structure of the path indicated in Figure 9-15 by the thick dashed line. On the left, both C-VLANs are mapped to the S-VLAN by a PEB using the ETH_CS_L function. On the right, the (short-dashed red line) C-VLAN is mapped to the S-VLAN using a port-based service interface (no C-VLAN aware mapping).

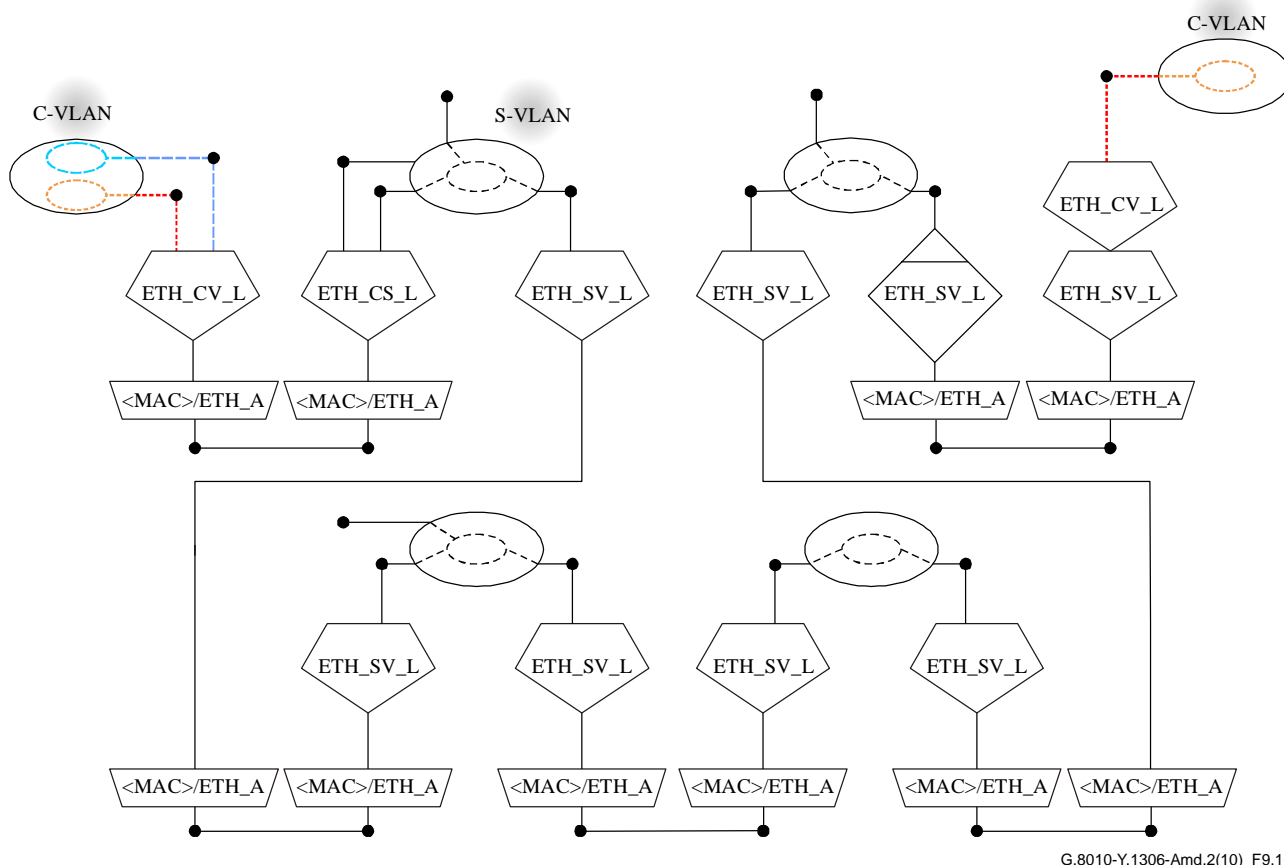


Figure 9-16 – ETH PBN functional path example

The provider bridges in the middle of the path have no C-VLAN awareness at all.

9.5.2 Provider backbone bridged networks

Figure 9-17 shows the topology of an example provider backbone bridged network (PBBN). The PBBN topology has client layer provider bridges at its boundary connected to server layer provider bridges by transitional links indicating the adaptation from the ETH client layer to the ETH server layer network. These transitional links are within network elements designated as either IB-BEB or I-BEB. The provider bridges within the PBBN that have no edge function (BCB) are identical in function to the provider bridges in the PBN that provide no edge function (PB).

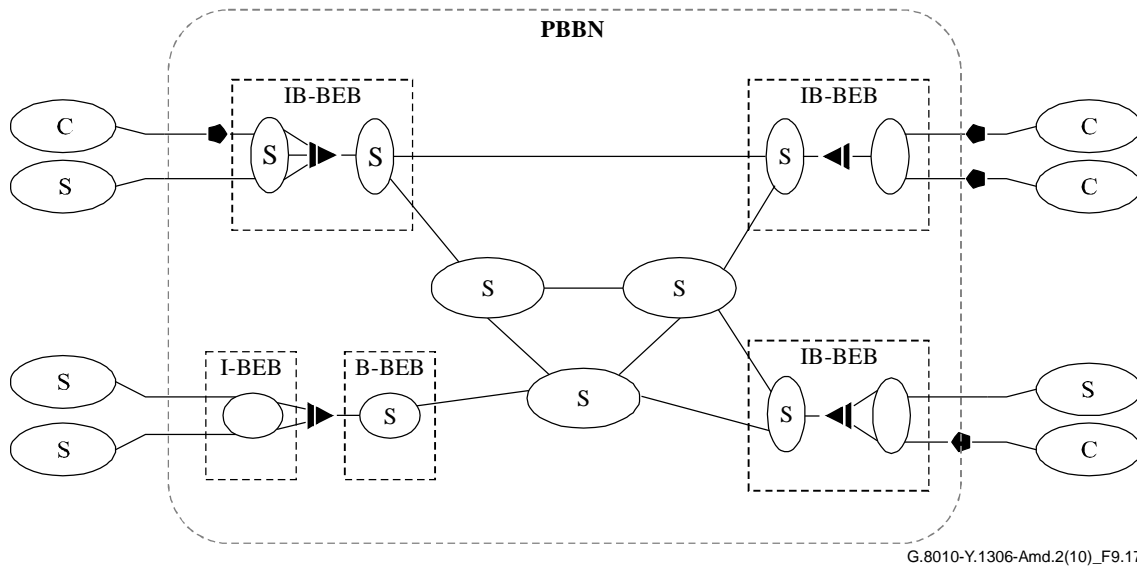


Figure 9-17 – ETH backbone topology example

The provider backbone bridges providing edge functions support either BMAC/ETH_A (I-BEB), ETH_CB_IL (B-BEB), or both (IB-BEB). External links that map C-VLANs to S-VLANs are shown as transitional links as in the PBN example above.

Figure 9-18 presents the topology of an example B-VLAN in the PBBN. The B-VLAN provides transport between backbone edge bridges (BEBs) for one or more backbone service instances (BSIs).

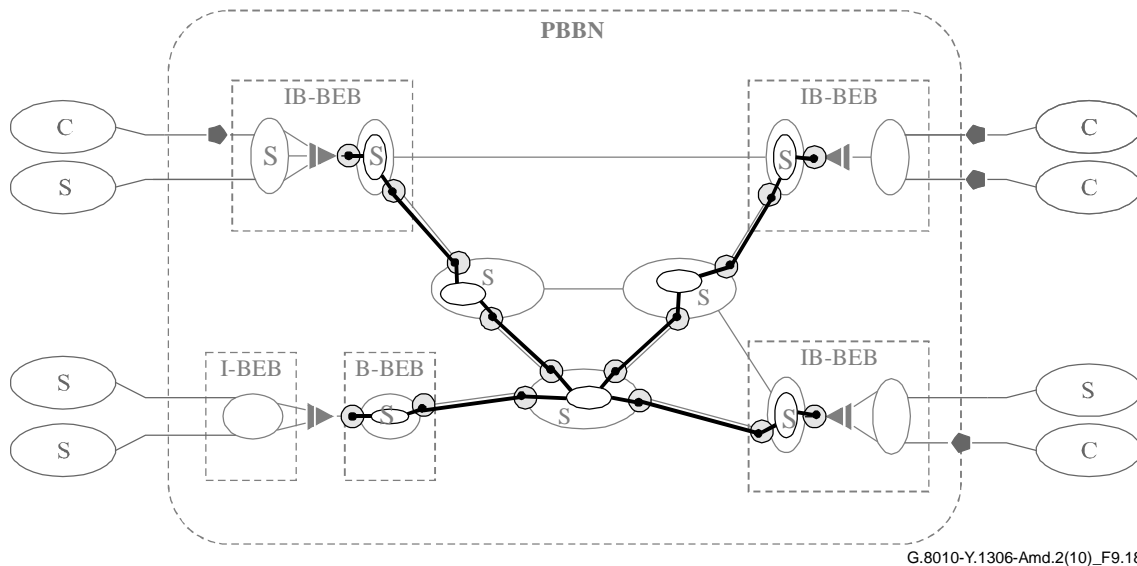


Figure 9-18 – ETH PBBN B-VLAN topology example

Figure 9-19 shows two example BSIs that are supported by the B-VLAN shown in Figure 9-18. Each BSI provides a server subnetwork to the client ETH S-VLAN-aware network. These BSI-supported SSNs are essentially in parallel but may include different sets of BEB endpoints.

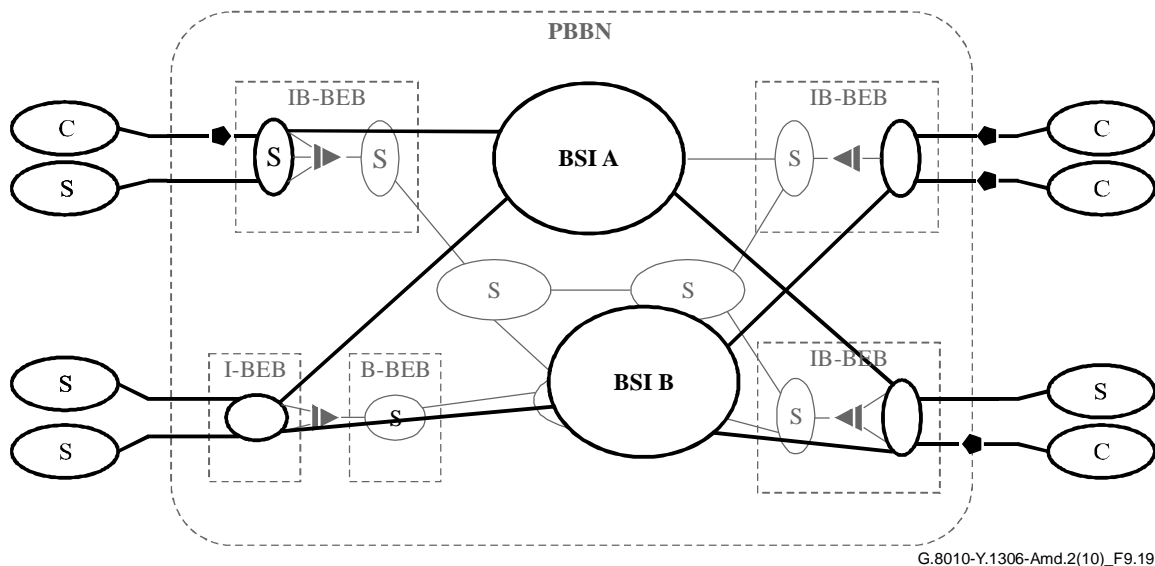


Figure 9-19 – ETH PBBN BSI topology example

Client S-VLANs can use the BSI SSNs to provide interconnection between client subnetworks.

Figure 9-20 shows the topology of a PBBN client S-VLAN (black). BSI B's SSN is used to provide an SSNTE for the S-VLAN.

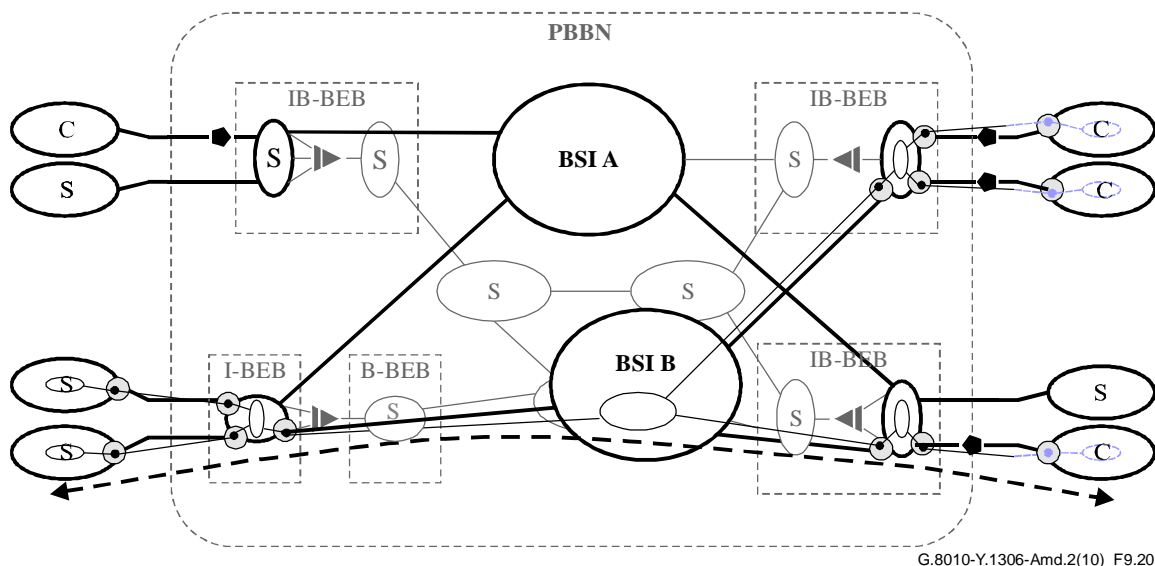


Figure 9-20 – ETH PBBN S-VLAN topology example

Figure 9-21 shows the functional structure of the path indicated in Figure 9-20 by the thick dashed line. On the left side the structure of a separate I-BEB and B-BEB is shown in which the provider instance port and customer backbone port functions reside in different bridges. On the right side the structure of an I-BEB is shown as well as a port-based service interface for a C-VLAN (long-dashed line) that is carried over the S-VLAN.

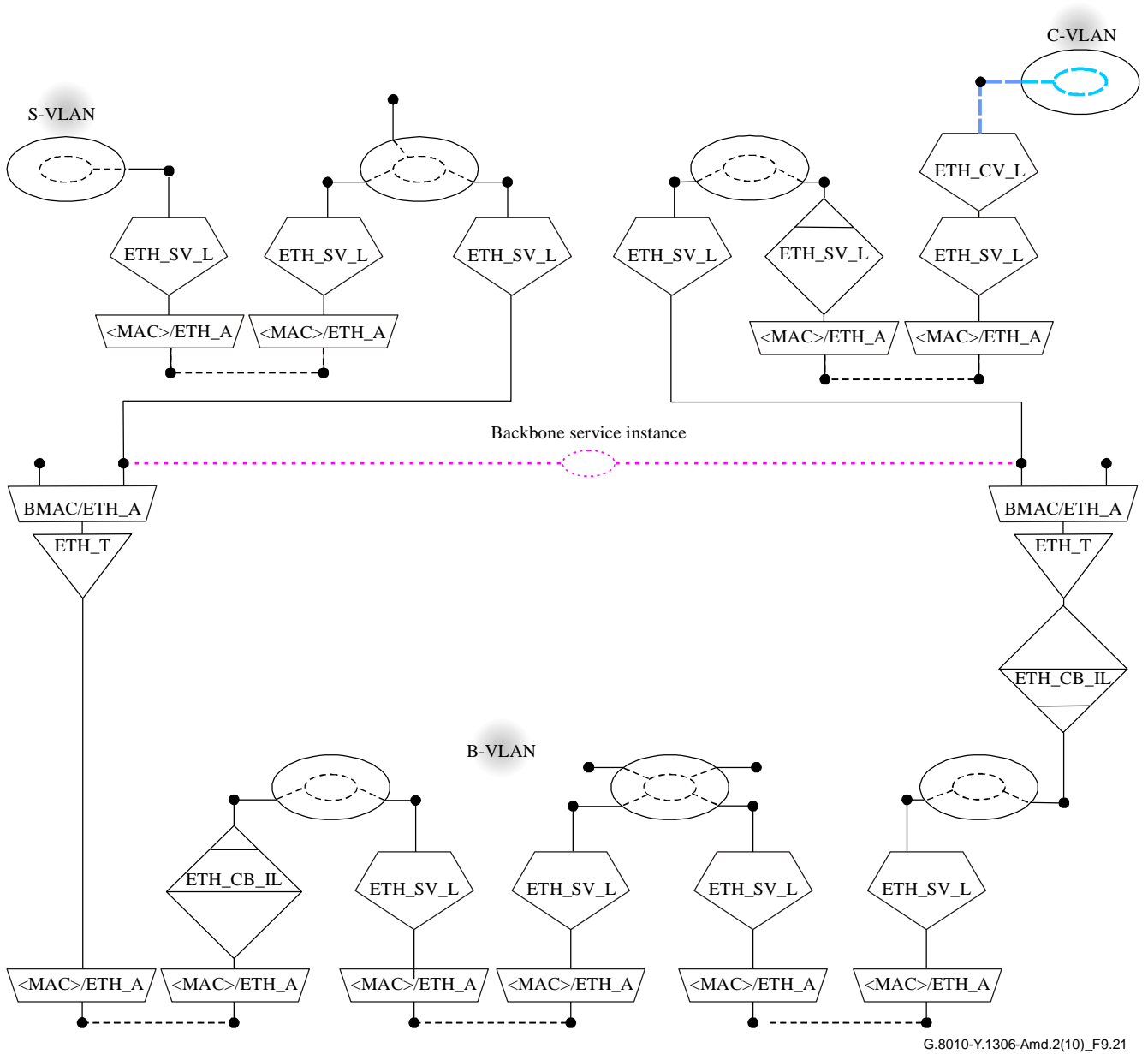


Figure 9-21 – ETH PBBN functional path example

Figure 9-22 shows two modes of interconnection between provider backbone networks. PBBN 1 is connected to PBBN 2 in a client-server relationship by interconnecting a backbone core bridge of PBBN 1 (BCB) to a backbone edge bridge of PBBN 2 (IB-BEB). PBBN 2 is connected as a peer to PBBN 3 by interconnecting backbone edge bridges providing only ETH_CB_IL functions (B-BEB).

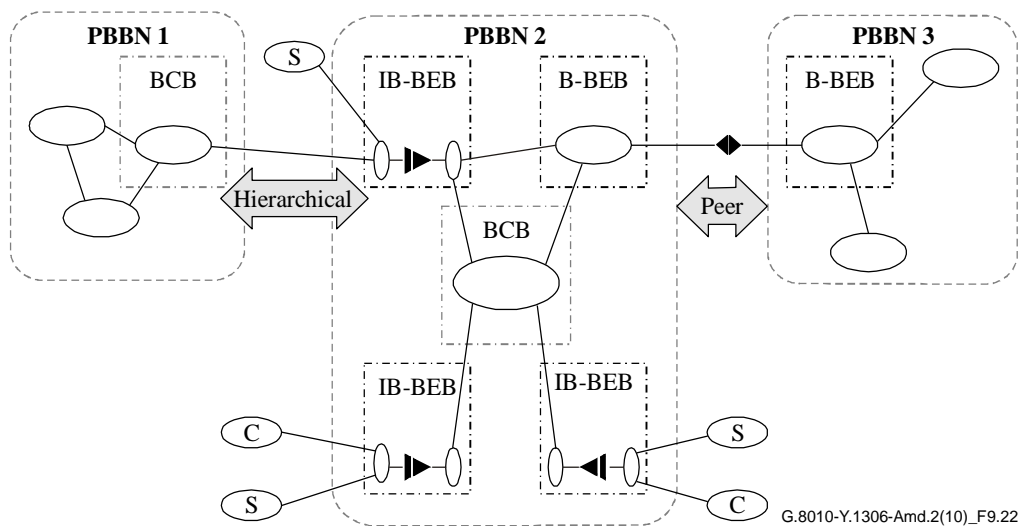


Figure 9-22 – ETH backbone interconnection

In this arrangement PBBN 1 will see PBBN 2 and PBBN 3 as a server subnetwork. PBBN 2 and PBBN 3 will see each other as peer domains in a larger provider backbone ETH layer network.

9.6 Ethernet network management

[[Recommendation ITU-T G.8013/Y.1731, IEEE 802.1ag](#) and [[IEEE 802.1Qaw](#)] specify functions for monitoring the performance of ETH transport entities and detecting, reporting, and diagnosing defects that affect this performance. The set of reference points belonging to the monitored ETH transport entity is called a maintenance entity group (MEG). OAM functions may be located at a boundary point or MEG end point (MEP) or at an intermediate point (MIP).

The OAM functions supported for monitoring and diagnosing ETH transport entities include:

- connectivity and continuity verification among MEPs;
- loopback from a MEP to a MEP or MIP;
- trace of forwarding rules for a specified unicast address;
- frame loss measurement between a pair of MEPs in a P-P transport entity;
- frame delay measurement between a pair of MEPs;
- insertion and detection of ETH maintenance signals;
- selection of specific traffic units at a reference point and redirection of (a copy of) these traffic units to an analysis function located elsewhere in the network;
- delivery of test traffic to a selected reference point and injection of the traffic at that point.

These OAM functions are provided for transport entities associated with the reference points shown in Figure 9-3 by inclusion of OAM transport processing functions in the atomic functions shown. In addition, the ETH_CB_IL function can provide backbone service instance MIPs and maintenance signal processing internally (these reference points are not shown in Figure 9-3). Detailed specification of the ETH transport processing functions, including the available OAM functions, is provided in [Recommendation \[ITU-T G.8021/Y.1341\]](#).

Annex A

Flow domain fragments

(This annex forms an integral part of this Recommendation.)

In general, any flow domain allows for any input flow point to be associated with any output flow point. In such a case the diagrammatic convention of showing a flow domain and its complete set of input and output flow points is sufficient to illustrate the allowable connectivity.

It is also possible to group flow points such that connectivity within the flow domain is limited to being between the members within each group. Each group represents a fragment of the flow domain connectivity and is referred to as a flow domain fragment (FDFr). This concept can be applied to any flow domain. When used in a matrix, the fragments are referred to as matrix fragments. The relationship between a flow domain and its fragments is illustrated in Figure A.1. A flow domain fragment may be labelled by its associated layer network name, fragment number or by the means of grouping flow points into a particular fragment, in the ETH layer network, for example, by VLAN identifier.

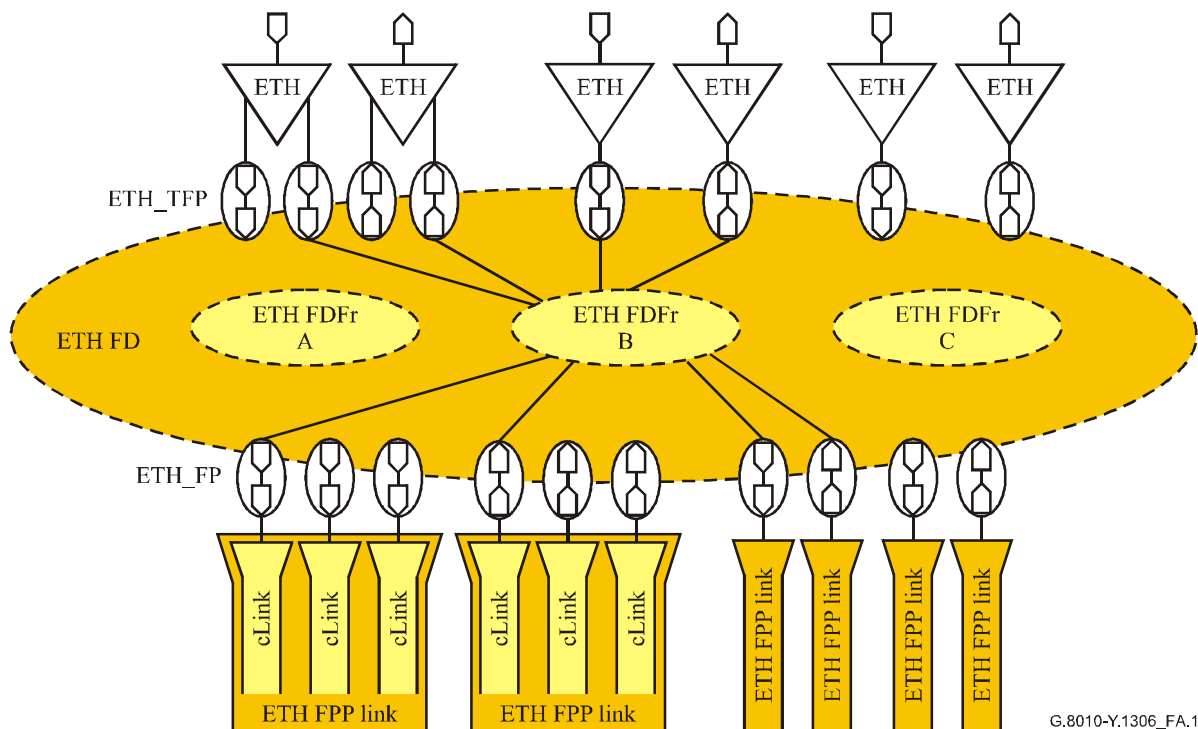


Figure A.1/G.8010/Y.1306 – Flow domain fragments and their relationship to a flow domain

A fragment of one flow domain is associated with a fragment in another flow domain by means of the interconnecting component link or FPP link.

Appendix I

Flows and their properties

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

In a circuit switched network, connections are bound to connection points and both the connection point and the connection are managed. The lifetime of the connection and its relationship to the connection point is reflected in the state of the related managed object.

This is very different to the case of connectionless networks. Here each packet is the "connection". The packet (frame) is bound to the flow point for the duration of the time it takes to traverse the flow point. The flow point is then available for the next "connection". There is no implied relationship between a previous packet and a future packet that traverses the flow point. The packet (frame) represents a flow from which aggregated flows can be constructed.

Examples of flows

In this appendix, different forms of flow are illustrated in Figure I.1. The examples given are for illustration and are not intended to be an exhaustive list.

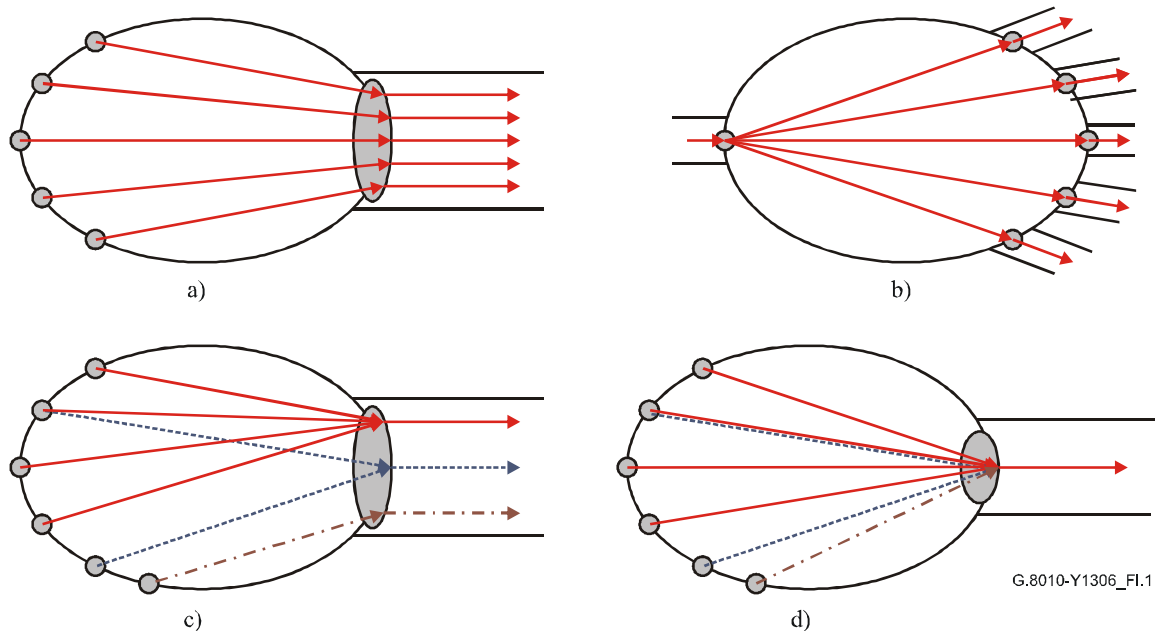


Figure I.1/G.8010/Y.1306 – Some examples of flows

Figure I.1 a) illustrates a flow domain with five input flow points and one output flow point (other output links are not shown for sake of simplicity). Each flow can be considered as corresponding to a source-destination, or network, flow. Each flow is characterized by frames with the same source and destination address. Downstream at the next flow domain, the flows may be separately routed to output flow points as necessary.

Figure I.1 b) illustrates a broadcast flow from a single input flow point to all output flow points. A flow that goes to multiple output flow points but not all is a multicast flow.

Figure I.1 c) illustrates a flow domain with six input flow points and one output flow point (other output flow points are not shown for the sake of simplicity). Each of the flows on the link represents a destination-based flow. Each of these flows is characterized by frames with the same destination address (multiple source addresses). Destination flows may contain multiple source-destination flows. Individual flows across the flow domain may represent a source-destination flow (so directly flowing into the flow domain from a source) that is aggregated at the output flow point, or a number of destination based flows that have already been aggregated from multiple sources (and have therefore arrived from an upstream flow domain). Further note that there are two multipoint-to-point flows and one point-to-point flow present in the figure. The flows are directed as appropriate at the next flow domain.

Finally, Figure I.1 d) represents a multipoint-to-point flow between six input flow points and one output flow point of a flow domain. The resultant flow may be directed toward a single destination (everything entering the link has the same destination address) or may be the aggregation of all incoming flows to create a link flow between flow points, in which case it is the aggregation of all the frames passing over the link.

The examples given above are intended to illustrate the concept of a flow as defined in [ITU-T G.809](#) ~~ITU-T Rec. G.809~~. It should be obvious that a packet (frame) can belong to many levels of flow at the same time.

Examples of flows

A flow can be defined in terms of a n-tuple $\langle A, \dots, N \rangle$, where each entry in the n-tuple represents a common property of each traffic unit in the flow. In the case of Ethernet, examples of forms of flow that can be defined in the ETH layer network are:

- $\langle \text{Source MAC Address, Destination MAC Address} \rangle$ 2-tuple where all frames have the same source address and destination address;
- $\langle \text{Destination MAC Address} \rangle$ 1-tuple where all frames have the same destination address, but need not have the same source address.

A flow may also be described in relation to a topological component. For example: a link flow, a flow domain flow or a network flow.

The network flow is between termination flow points, but there is no requirement for traffic units within the flow to follow the same route.

A link flow is the aggregation of all frames that traverse a link or it can be considered as the set of source-destination flows on the link, or the set of destination flows on the link (in this case they are equivalent in membership).

Flow point properties

A flow point, from the network viewpoint, is transparent to both the source address and destination address of any packet that traverses it. A flow point is a member of a flow point pool. For the ETH layer network, in the absence of logically separated VPNs, there is only one member of the flow point pool.

A flow point can be partitioned to generate new flow points. The new flow point may have the same properties as the original flow point. This mechanism is used to generate additional flow points in the ETH layer network as a result of creating logically separated VPNs. This results from the partitioning of a flow domain, resulting in one flow point for each of the partitions attached to the link containing the flow points. Such new flow points are of interest to both the network view and network management view. The set of flow points that results from this partitioning is contained within a flow point pool.

The following n-tuples are examples of flows between ETH FPs (case of VLAN being the VPN identifier):

- **<Source MAC Address, Destination MAC Address, VLAN ID, Priority>** quadruple where all frames in the flow have the same source and destination addresses and VLAN ID and Priority;
- **<Source MAC Address, Destination MAC Address, VLAN ID>** triple where all frames in the flow have the same source and destination addresses and VLAN ID;
- **<Destination MAC Address, VLAN ID>** 2-tuple where all frames in the flow have the same destination address and VPN ID but need not have the same source address;
- **<VLAN ID>** 1-tuple where all frames have the same VLAN ID but need not have the same source or destination address.

A flow point may also be partitioned such that the properties of each of the new flow points are not the same as the original flow point. However, the aggregated properties must be the same as that of the original flow point. Such partitioning may not be of general interest in either the network or management viewpoint.

A flow point pool can be partitioned to generate new flow point pools. This mechanism is used to generate additional flow point pools in the ETH layer network as a result of creating stacked VLANs. This results from the partitioning of the flow domain based on an additional level of VLANs. This results in one flow point pool for each of the partitions, created by the additional VLAN level, attached to the link. The set of resulting flow point pools is contained within a single higher level flow point pool. This process can be repeated as a result of further levels of partitioning to create higher level flow point pools.

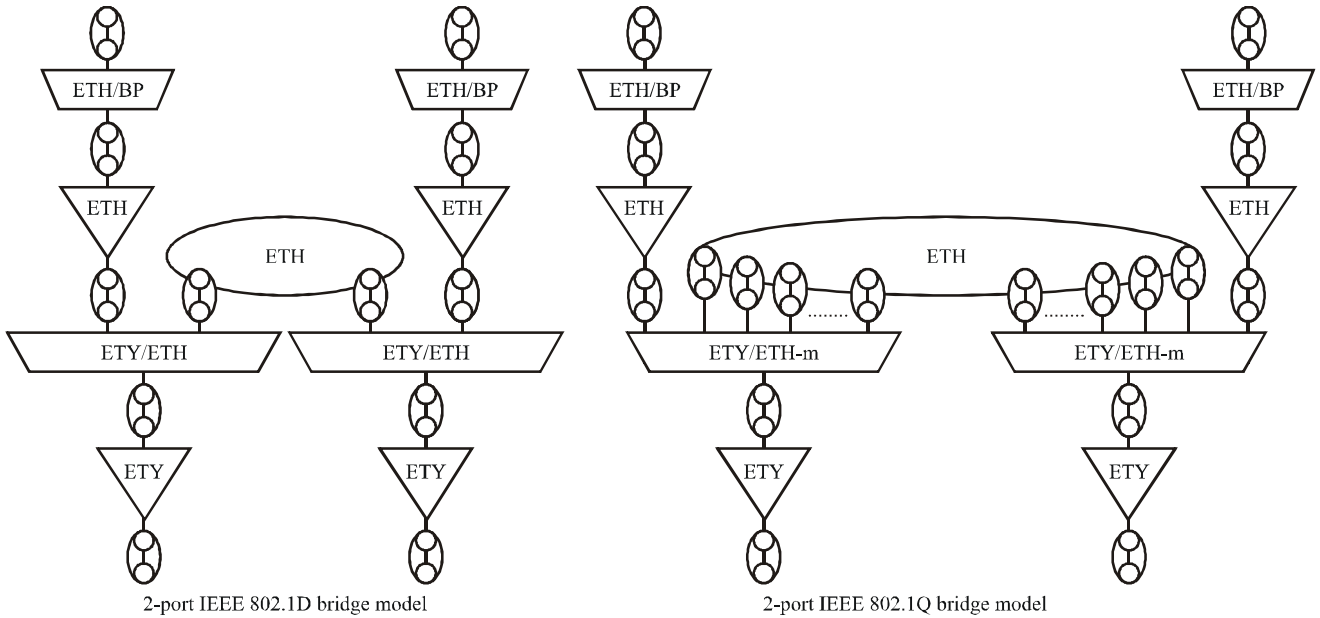
The generic rules for partitioning flow points are outside the scope of this Recommendation.

Appendix II

G.8010/Y.1306 model of 2-port bridge

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

Figure II.1 presents the G.8010/Y.1306-based models of 2-port ~~IEEE 802.1D~~ and ~~IEEE 802.1Q~~ bridges.



G.8010-Y.1306_FII.1

Figure II.1/G.8010/Y.1306 – 2-port bridge models

Appendix III

Overview of the VLAN ID in the MAC SDU and VLAN ID processing

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

As noted in 6.3.2.5.3, a VLAN ID may be used to identify the ETH VLAN a frame belongs to. The VLAN ID is part of an optional VLAN tag in the MAC SDU (described in [IEEE 802.3] and [IEEE 802.1Q]).

NOTE – This field includes also priority information.

All ETH links and ETH flow domains carry the MAC SDU (with or without the optional VLAN tag).

The VLAN ID is processed by the Srv/ETH-m_A function described in 6.5.2. The Srv/ETH-m_A function has N ($N = 1..4094$) ETH_FPs associated with it. When a VLAN ID is present in the MAC SDU, it is used to demultiplex the combined flow of MAC frames to individual ETH_FPs (one per VLAN). MAC frames without a VLAN ID are assigned to a default FP (default VLAN). This allows a link to carry MAC frames with or without a VLAN ID.

Depending on the network application, the Srv/ETH-m_A function may add and remove the VLAN ID or may use it and pass it on.

The Srv/ETH_A function, described in 6.5.2, has *only one* ETH_FP associated with it and therefore ignores the VLAN ID.

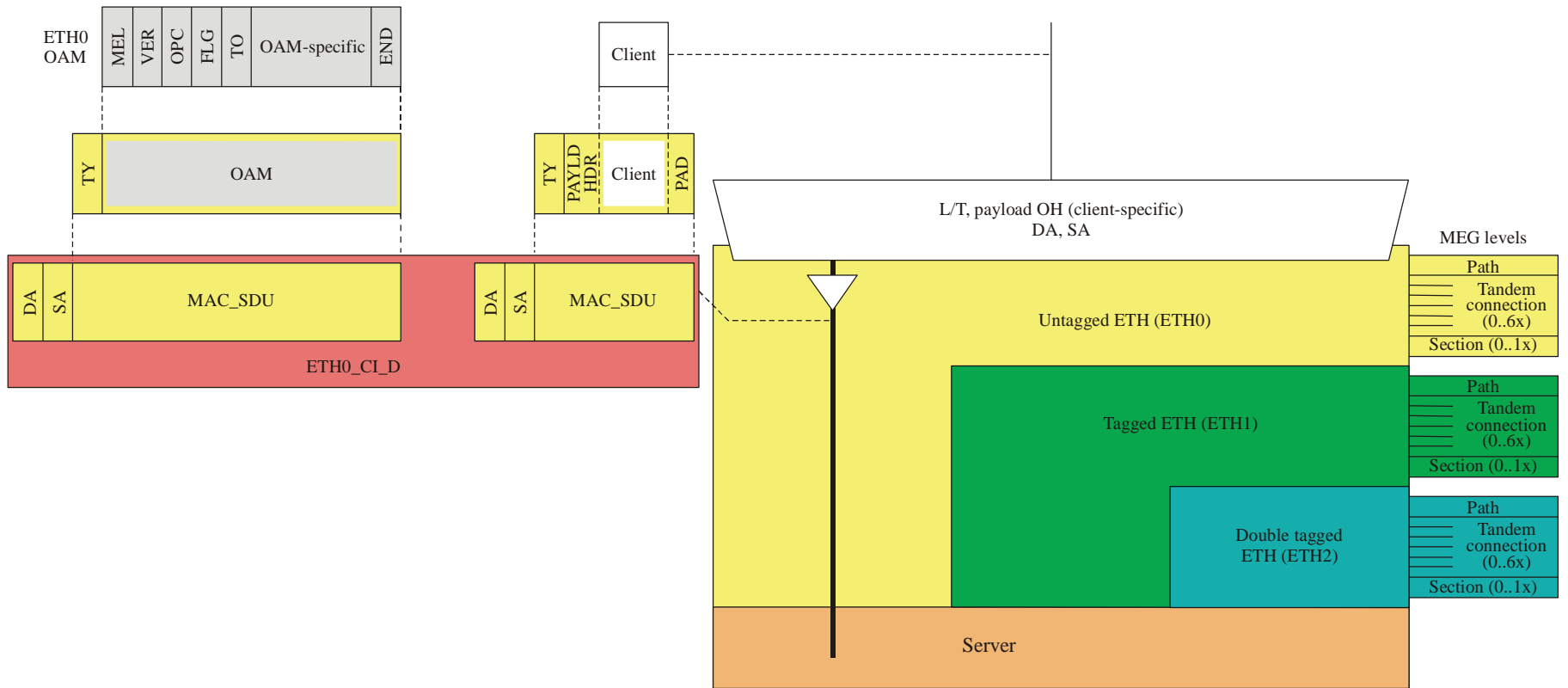
[IEEE P802.1Qad] will add a further optional field to the MAC SDU that is used to convey a second (service provider) VLAN ID. This may also be used by a Srv/ETH-m_A function (in service provider mode) to demultiplex the combined flow to individual ETH_FPs (one per service provider VLAN). The customer (802.1Q) VLAN IDs that may be part of the MAC SDU are ignored in this case and transparently forwarded. They may be used in downstream Srv/ETH-m_A functions to further demultiplex the flow (into customer VLANs).

Appendix IV

ETHn_CI (n = 0, 1, 2) traffic unit formats

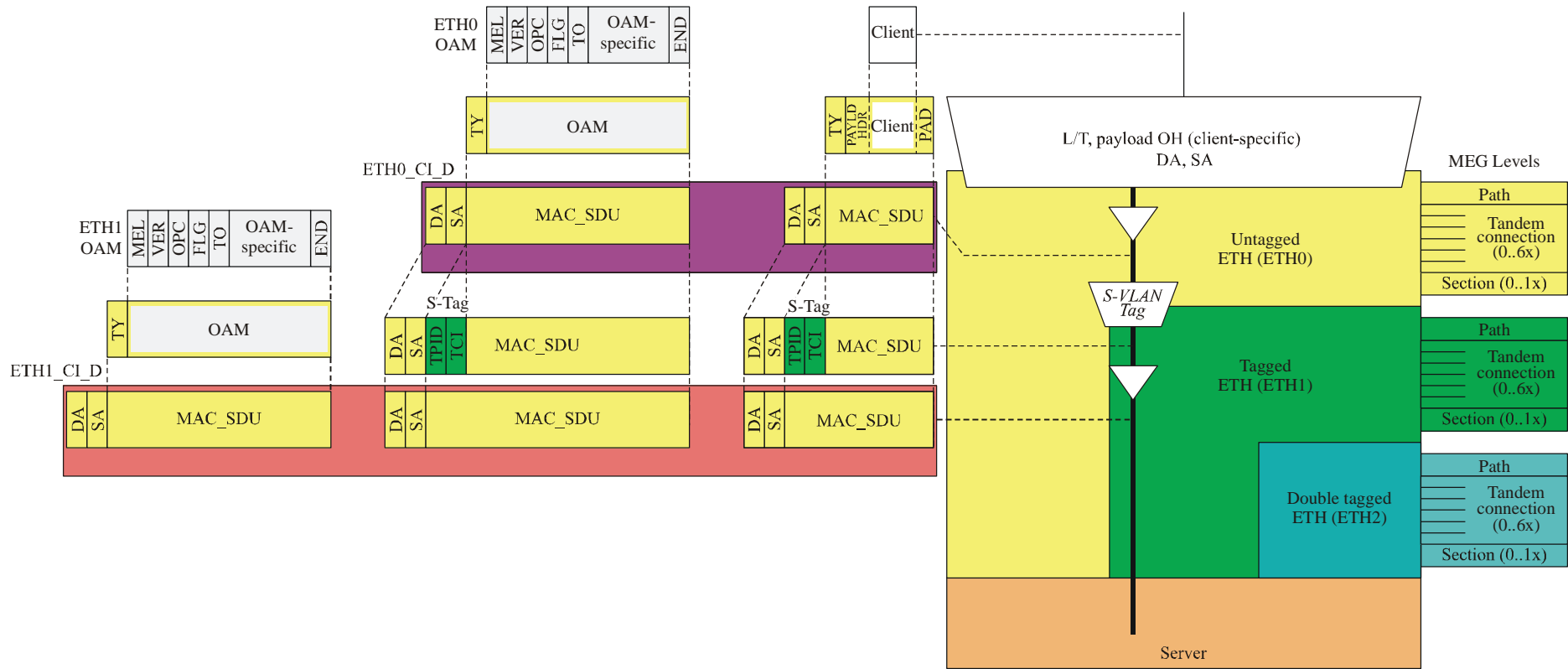
(This appendix does not form an integral part of this Recommendation.)

The figures below show the relationship between the frame formats of the traffic units, the insertion of VLAN tags and the insertion of OAM frames. The corresponding sets of MEG levels are also shown. These figures do not describe the potential locations where a C-Priority tag or S-Priority tag may be inserted.



G.8010-Y.1306(04)AMD.1_FIV-1

Figure IV.1 – ETH0 over server with ETH0 OAM



G.8010-Y.1306(04)AMD.1_FIV-2

Figure IV.2 – ETH0 over ETH1 over Server with ETH0 and ETH1 OAM

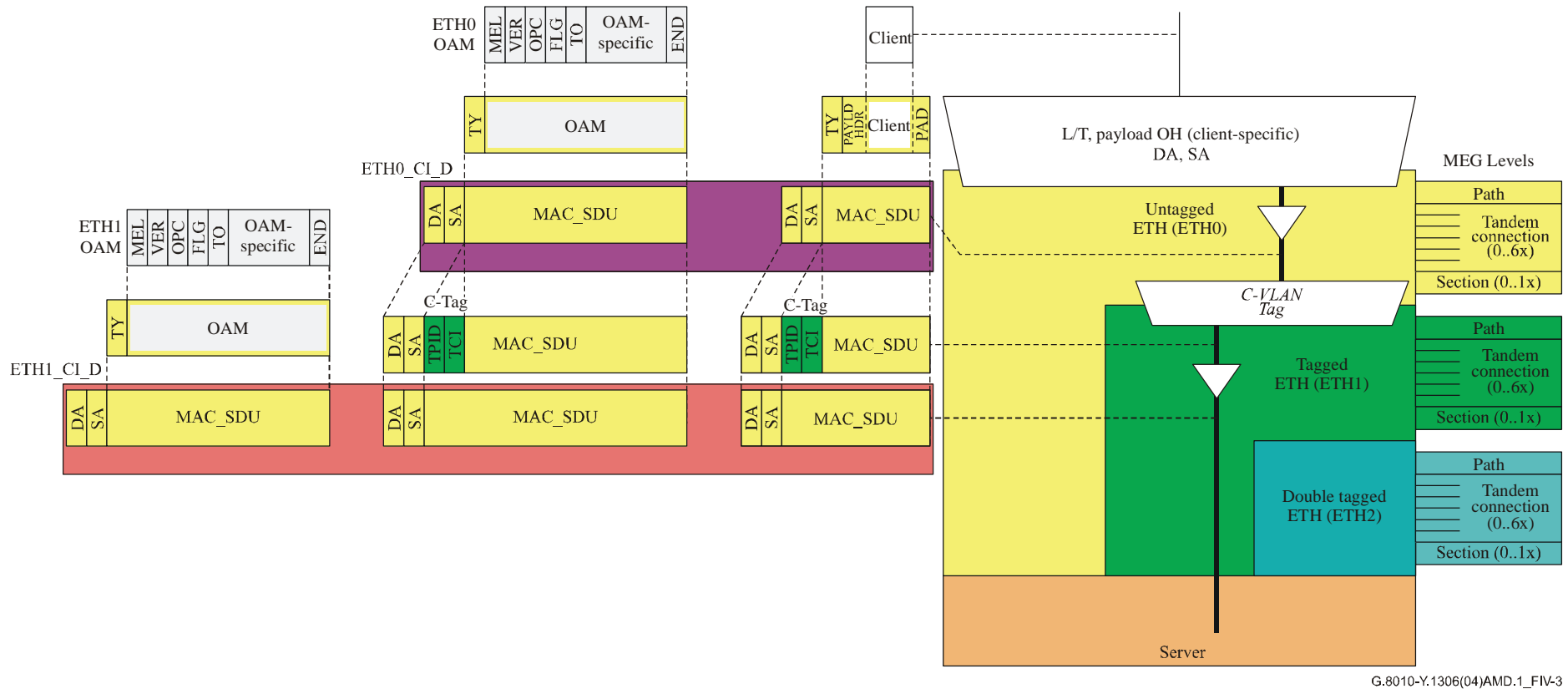
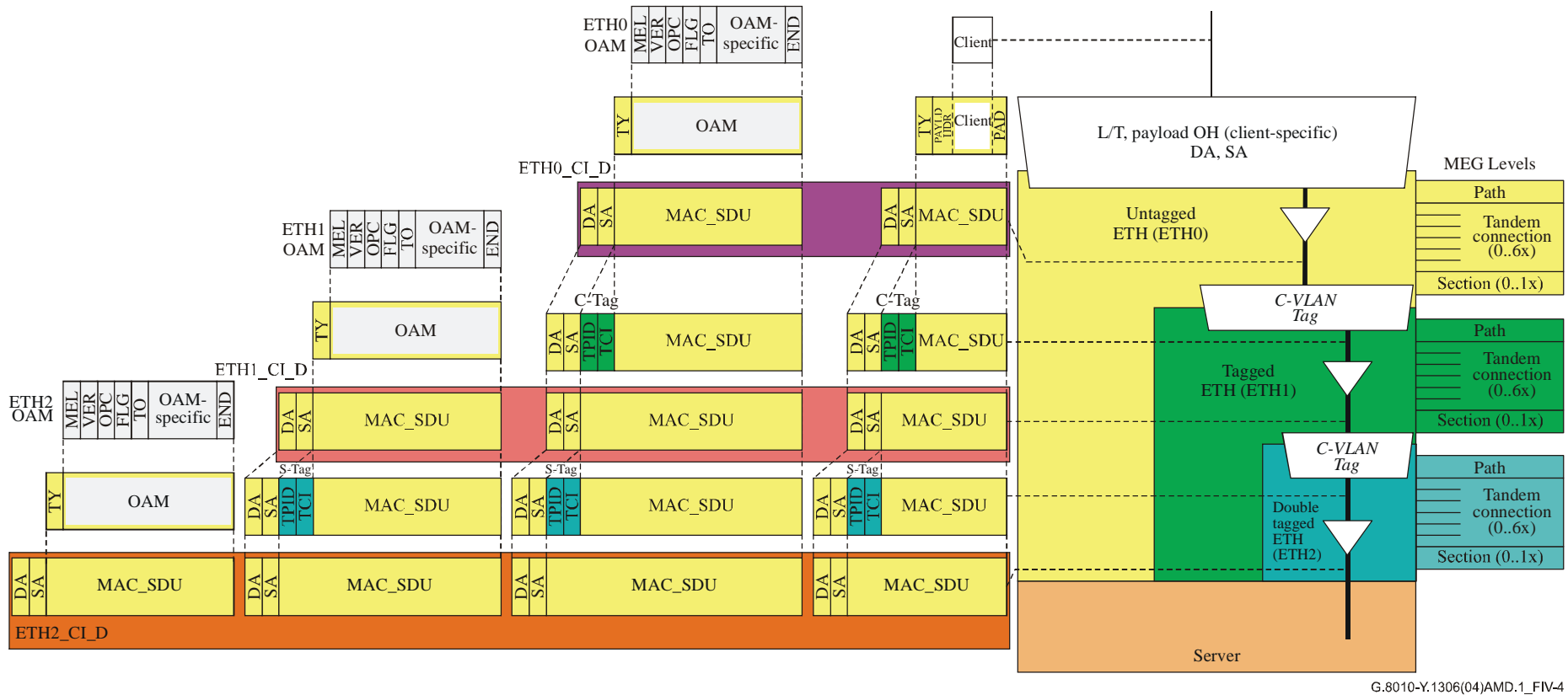


Figure IV.3 – ETH0 over ETH1 over Server with ETH0 and ETH1 OAM



G.8010-Y.1306(04)/AMD.1_FIV-4

Figure IV.4 – ETH0 over ETH1 over ETH2 over Server with ETH0, ETH1 and ETH2 OAM

Appendix V

Maintenance entity group level allocation examples

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

EC service with three owners

An EC service for which the customer, service provider and network operator are operating in "client/server" mode for customer/network and "peering" mode for service provider/network operator has the following default ETH MEG level allocation (Figure V.1):

| | |
|---|--|
| Customer-to-customer: | Path, tandem connections 6 to 1 |
| Within one customer network: | Path, tandem connections 6 to 1, section |
| Service provider: | Path, tandem connections 6 and 5 |
| Network operator: | Tandem connections 4 to 1, section |
| Customer-to-network: | Section |
| Network operator A-to-network operator B: | Section |

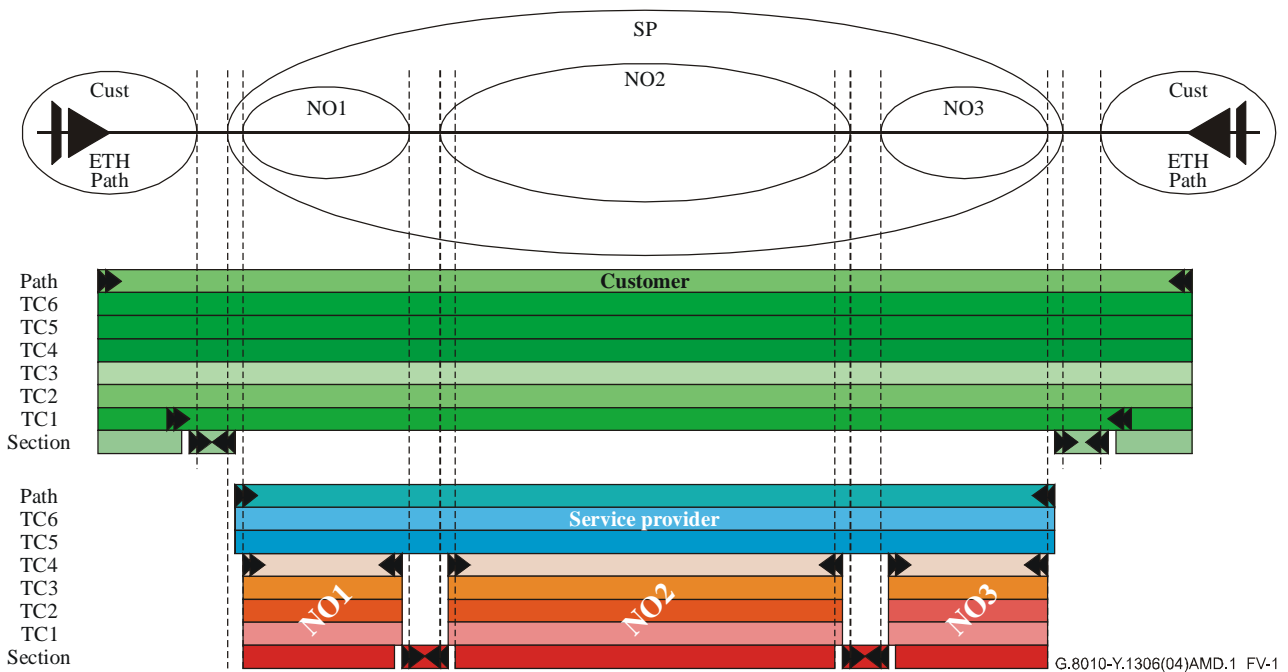


Figure V.1 – Example of default allocation of ETH MEG levels in hybrid client/server and peering modes

For the case where the customer and network are not able to operate in client/server mode, customer, service provider and network operator(s) all operate in "peering" mode. The default ETH MEG level allocation is listed below and illustrated in Figure V.2:

| | |
|---|--|
| Customer-to-customer: | Path, tandem connections 6 and 5 |
| Within one customer network: | Path, tandem connections 6 to 1, section |
| Service provider: | Tandem connections 4 and 3 |
| Network operator: | Tandem connections 2 and 1, section |
| Customer-to-network: | Section |
| Network operator A-to-network operator B: | Section |

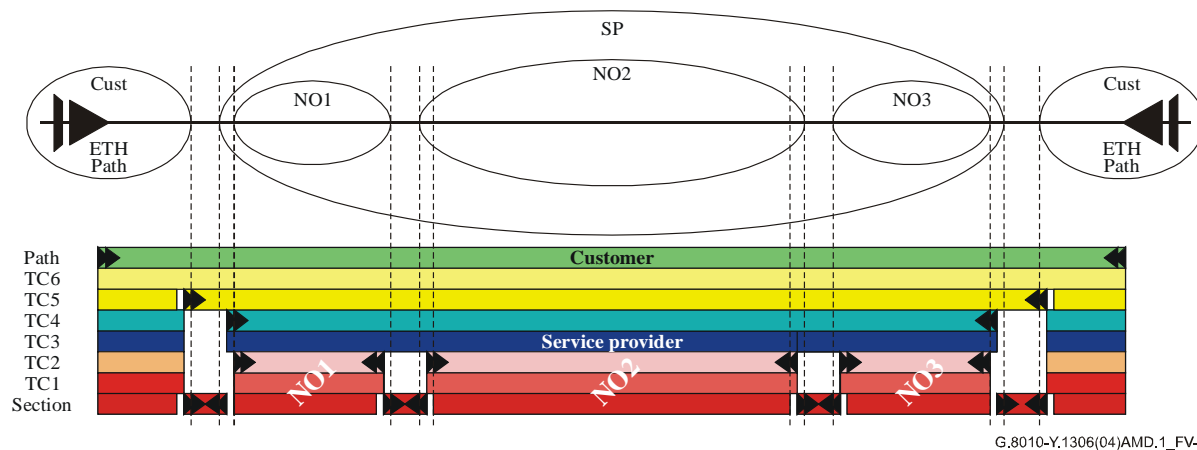
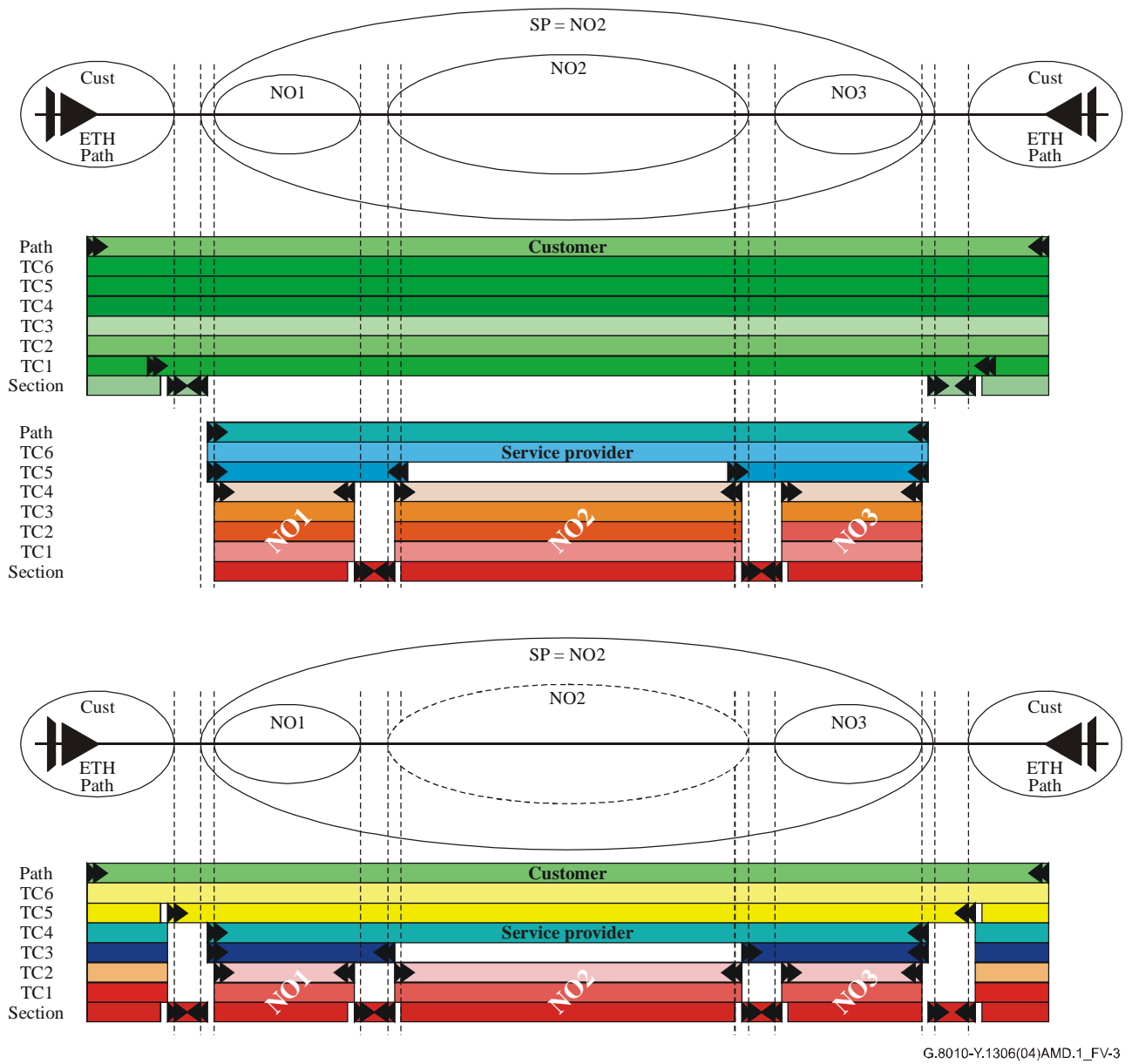


Figure V.2 – Example of default allocation of ETH MEG levels in peering mode

The deployment of the ETH MEG levels may depend on the relationship between the service provider and the network operators providing the EC service. When NO2 also performs the SP role, it may wish to monitor the status/performance of the EC segment between the edge of the network and the edge of the NO2 domain. Tandem connection level 5 could be activated at those interface ports to provide the SP/NO2 with this information (Figure V.3).



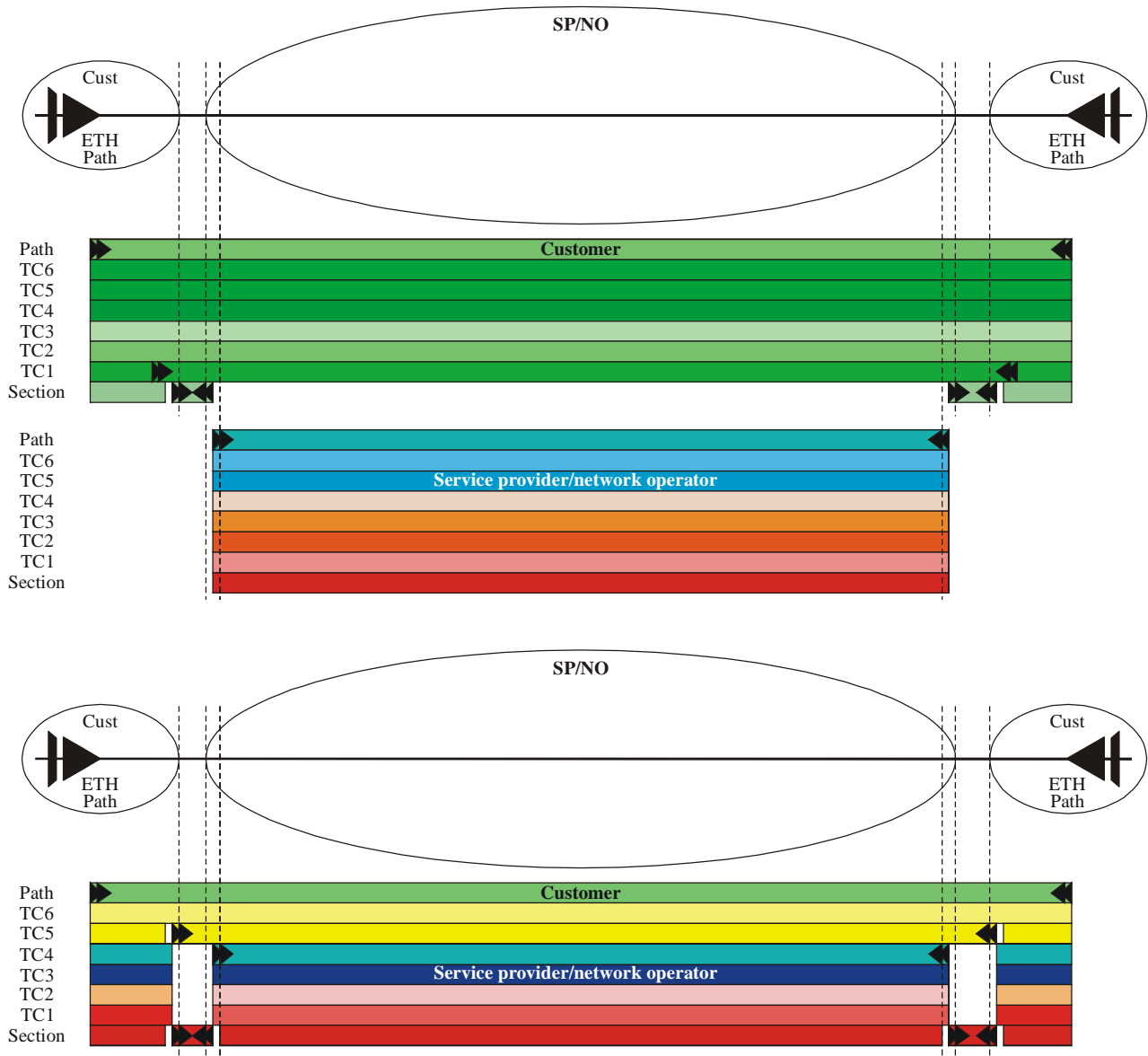
G.8010-Y.1306(04)AMD.1_FV-3

Figure V.3 – Example of allocation of ETH MEG levels in which an SP monitors service received from regional NOs

EC service with two owners

When a single administration provides the EC service, the service provider and network operator roles are merged. The default MEG level allocation is as shown in Figure V.4:

| | |
|------------------------------------|--|
| Customer-to-customer: | Path, tandem connections 6 to 1 |
| Within one customer network: | Path, tandem connections 6 to 1, section |
| Service provider/network operator: | Path, tandem connections 6 to 1, section |
| Customer-to-network: | Section |



G.8010-Y.1306(04)AMD.1_FV-4

Figure V.4 – Example of allocation of ETH MEG levels in EC service with two owners

Non-EC service with three owners

When the network provides a non-EC service over ETH (e.g., circuit emulation service, MPLS) the EC MEG levels can be allocated to Service Provider and Network Operator as follows as a default:

- Service provider: Path, tandem connection 6 and 5
- Network operator: Tandem connection 4 to 1, section
- Network operator A-to-network operator B: Section

NOTE – The customer has a non-EC signal for which ETH MEG levels are not applicable.

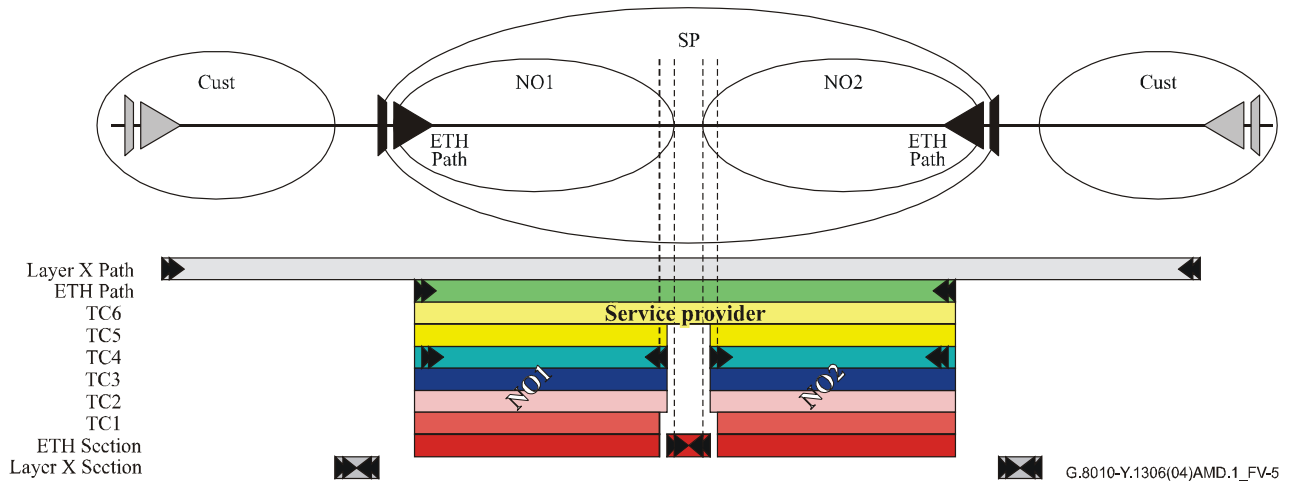


Figure V.5 – Example of allocation of ETH MEG levels in ETH client service (e.g., TDM, MPLS-TP)

Appendix VI

Allocation of [ITU-T ~~Y.1731~~G.8013](#) ETH OAM messages onto G.8010/Y.1306 atomic functions

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

This appendix summarizes the allocation of [ITU-T ~~Y.1731~~G.8013](#) ETH OAM messages to [ITU-T G.8010/Y.1306](#) atomic functions.

Table VI.1 – Allocation of [ITU-T G.8013](#)~~Y.1731~~ ETH OAM messages onto [ITU-T G.8010/Y.1306](#) atomic functions

| G.8013 Y.1731 OAM | ETHx MEP (x: P(ath), T(andem connection), S(ection)) | | | | ETHx MIP | SRV MEP |
|---|--|---------------------|------------------|-------------------|-------------------|--------------------|
| | ETHx/Client adaptation | ETHx/ETH adaptation | ETHx termination | ETHDe termination | ETHDi termination | SRV/ETH adaptation |
| ETH-CCM | | | X | | | |
| ETH-AIS | | X | X | | | X |
| ETH-LCK | | X | X | | | |
| ETH-LBM | | | | X | X | |
| ETH-LBR | | | | X | X | |
| ETH-TST | | | | X | | |
| ETH-LTM | | | | X | X | |
| ETH-LTR | | | | X | X | |
| ETH-LMM | | | | X | | |
| ETH-LMR | | | | X | | |
| ETH-DMM | | | | X | | |
| ETH-DMR | | | | X | | |
| ETH-IDM | | | | X | | |
| ETH-APS | | X | | | | |
| ETH-MCC (Note 1) | | | | | | |

NOTE 1 – The allocation of ETH-MCC to a G.8010 atomic function is for further study.

NOTE 2 – The [ITU-T G.8013](#)~~Y.1731~~-defined ETH-VSM, ETH-VSR, ETH-EXM and ETH-EXR OAM frames are provisions for future vendor-specific and experimental OAM messages. Mapping is outside the scope of this Recommendation.

NOTE 3 – "X" indicates that the OAM message is either: inserted, or extracted, or generated and inserted, or extracted and processed; or generated and inserted and extracted and processed in the atomic function. Note that the on-demand OAM in the ETHDe and ETHDi termination functions is inserted and extracted, while generation and processing is performed in the equipment management function (EMF). Refer to 7.5 for a description and refer to [ITU-T G.8021](#)~~ITU-T Rec. G.8021/Y.1341~~ for the specification.

Appendix VII

Deployment scenario for the ETH group

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

One of the scenarios in which the ETH group construct is deployed is illustrated in Figure VII.1. Two network elements are interconnected via a UNI or NNI interface. The right-hand network element provides a bundled EVC service ingress point to the left-hand network element. This left-hand network element is incapable of multiplexing its bundle of EVC signals. The multiplexing is therefore performed by the right-hand network element. To monitor the status and performance of the service from the left-hand network element, this network element establishes an ETH Group MEG. One of the EVC signals in the group is configured to carry ETH OAM to monitor this MEG.

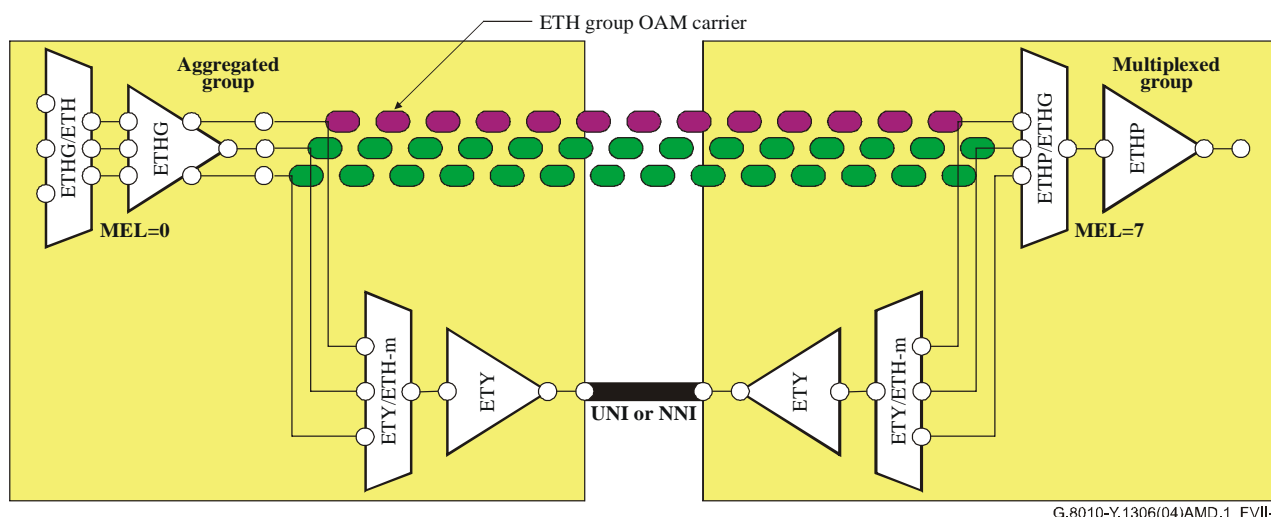


Figure VII.1 – ETH group deployment example

Appendix VIII

ITU-T G.800 ~~M~~odelling ~~C~~onventions

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

Clause 9 uses ~~ITU-T G.805~~ and ~~ITU-T G.800~~ functional modelling terminology and diagrammatic conventions to describe the Ethernet layer network architecture with the additions described in this appendix.

VIII.1 Terminology

The following terms are used in this Recommendation:

aggregation: Combining instances of characteristic information, with sufficient labelling to distinguish and later separate them, into a single transport entity without providing full client/server layer network independence (i.e., without full information independence).

multiplexing: Combining instances of characteristic information, with sufficient labelling to distinguish and later separate them, into a server layer access transport entity providing full client/server layer network independence (i.e., full information independence).

server subnetwork transport entity: A transport entity with multiple (more than two) forwarding points supported by one or more server layer access transport entities.

ITU-T G.8010 (2004) uses [ITU-T G.809] terminology, while clause 9 uses [ITU-T G.800] terminology. The following general correspondence of terms is provided to clarify the relationship between terms used in clause 9 and other terms commonly used.

Table VIII.1 – Terminology correspondence

| ITU-T G.809 | ITU-T G.8010 (2004) | ITU-T G.800 Amendment 1 | ITU-T G.8010 Clause 9 | IEEE 802.1 |
|----------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------------|
| flow domain | flow domain | subnetwork | subnetwork | bridged network |
| | flow domain fragment (FDFr) | subnetwork transport entity | subnetwork transport entity | virtual LAN (VLAN) |
| flow domain flow | flow domain flow | forwarding rule | forwarding rule | FDB entry |
| link flow | link flow | link connection | link connection | |
| | | | server subnetwork | local area network (LAN) segment |
| flow point | flow point | forwarding point | forwarding point | |
| flow point pool | flow point pool | | | |
| flow point pool link | flow point pool link | link | link | point-to-point link/LAN |
| connectionless trail | connectionless trail | access transport entity | access transport entity | |

VIII.2 Diagrammatic conventions

A few diagrammatic conventions are used in the models in clause 9 that are not as yet described in another Recommendation. These conventions are:

- paired versus singleton layer processor symbols;
- inter-layer processor indication;

- transitional link.

VIII.2.1 Paired versus singleton layer processor symbols

Two symbols have been defined for layer processor functions, a pentagon and a diamond. So far the diamond symbol has been used for singleton layer processor functions (i.e., functions that do not require a paired function to deliver proper behaviour, e.g., traffic conditioning). The pentagon symbol has been used for layer processor functions that must be paired, e.g., VLAN tagging functions. In this Recommendation, this convention is followed in that layer processor functions that must be paired are shown as pentagons and those that do not require pairing (even if this is commonly done) are shown using the diamond symbol.

For example, the VLAN tagging functions ETH_CV_L and ETH_SV_L are shown as pentagons:

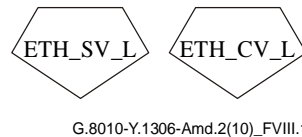


Figure VIII.1 – Symbol examples for paired layer processor

and the customer backbone port function ETH_CB_IL and S-VLAN port based service interface version of ETH_SV_L are shown as diamonds:

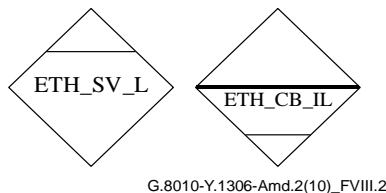


Figure VIII.2 – Symbol examples for singleton layer processor

VIII.2.2 Inter-layer processor indication

When a layer processor function depends on information that is not considered layer information but instead is adaptation information (belonging to an inter-layer adaptation function) or client characteristic information, this is indicated by a line through the middle of the layer processor symbol. This indicates there is an inter-layer information dependency. The strength of the dependency is indicated by the type of line. A dashed line indicates the inter-layer information is not mandatory and a solid line indicates that the inter-layer information is mandatory (that is, traffic units that do not include the inter-layer information are blocked).

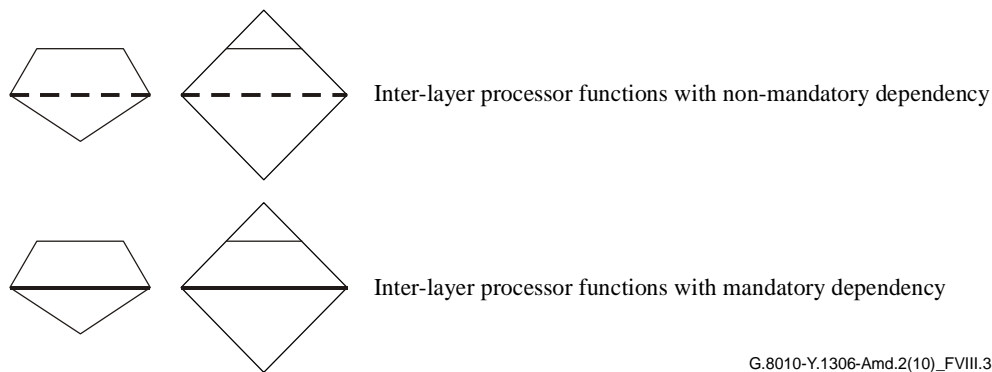


Figure VIII.3 – Symbol examples for interlayer processors

This convention is used for the ETH_CB_IL function that has a mandatory dependency on the presence of an I-Tag provided by the BMAC/ETH_A inter-layer adaptation function.

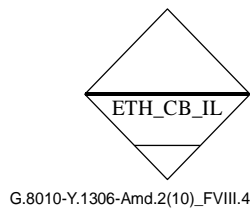


Figure VIII.4 – Symbol for ETH_CB_IL interlayer processor

VIII.2.3 Transitional link

A link whose endpoints contain forwarding points in different layer networks is called a transitional link. Such a link is indicated in topology diagrams by adding a triangle icon to the line representing the link. The triangle icon indicates the presence of client/server (adaptation/termination) functions within the link.

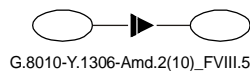


Figure VIII.5 – Symbol for layer transitional link

This is used, for example, to show a link between a client S-VLAN aware subnetwork and a server B-VLAN aware subnetwork at the boundary of a PBBN.

There are cases in which the structure (number) of link points is different for the two subnetworks connected by a transitional link. This can be shown by the number of link ends included as part of the link.

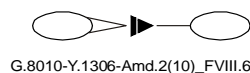


Figure VIII.6 – Layer transitional link with two client link points and one server link point

Note that this is not a generalized multipoint structure (i.e., server subnetwork) but a point-to-point structure in which multiple link points at one end are related to one link point at the other. The relationship is governed by the server/client adaptation function.

VIII.2.4 Sublayer transitional link

A link whose endpoints contain forwarding points in the same layer network but within which a transformation occurs so that the relationship between forwarding points is not fully transparent is called a sublayer transitional link. This type of link is shown in topology diagrams by adding a pentagon or diamond icon to the line representing the link. The icon indicates the presence of a layer processor function within the link that governs the relationship between the forwarding points at the link endpoints.

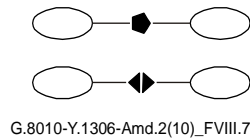


Figure VIII.7 – Symbols for sublayer transitional links

This convention is used, for example, to show the relationship between C-VLAN link points and S-VLAN link points at the boundary of a PBN or to show a link containing a customer backbone port at the boundary of a PBBN domain. The relationship between the link points and forwarding points at each end of the link is governed by the layer processor function(s) within the link.

Appendix IX

Mapping between clause 9 and clause 6/7 architectural components

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

The architectural components described in ITU-T G.8010 (2004) correspond to architectural components described in clause 9 as follows:

Table IX.1 – Relationship between ITU-T G.8010 (2004) and clause 9 architectural components

| ITU-T G.8010 (2004) | Clause 9 |
|--|--|
| ETH flow termination (ETH_FT) | ETH termination (ETH_T) |
| ETH traffic conditioning (ETH_TC) | within <MAC>/ETH_A (not specifically described) |
| ETH/BP adaptation (ETH/BP_A) | within <MAC>/ETH_A (not specifically described) |
| ETH/IP adaptation (ETH/IP_A) | form of ETH/client adaptation (not specifically described) |
| Srv/ETH adaptation (Srv/ETH_A) | <MAC>/ETH_A |
| Srv/ETH-m adaptation (Srv/ETH-m_A) | ETH_CV_L or ETH_SV_L + <MAC>/ETH_A |
| ETYn/ETH adaptation (ETYn/ETH_A, ETYn/ETH-m_A) | part of <MAC>/ETH_A (not specifically described) |
| SDH Path/ETH adaptation (S/ETH_A, S/ETH-m_A) | form of <MAC>/ETH_A (not specifically described) |
| OTN path/ETH adaptation (ODU/ETH_A, ODU/ETH-m) | form of <MAC>/ETH_A (not specifically described) |
| MPLS/ETH adaptation (MPLS/ETH_A) | form of <MAC>/ETH_A (not specifically described) |
| ATM VC/ETH adaptation (VC/ETH_A) | form of <MAC>/ETH_A (not specifically described) |
| Not described | ETH forwarding function (ETH_F) |
| Not described | ETH C-VLAN to S-VLAN layer processor function (ETH_CS_L) |
| Not described | ETH customer backbone inter-layer processor function (ETH_CB_IL) |
| Not described | BMAC/ETH adaptation (BMAC/ETH_A) |

The additional architectural components described in ITU-T G.8010 Amendment 1 (2006) correspond to architectural components described in clause 9 as follows:

Table IX.2 – Relationship between Amendment 1 and clause 9 architectural components

| ITU-T G.8010 Amendment 1 (2006) | Clause 9 |
|--|--|
| ETH flow termination (ETH _x _FT, <i>x</i> = P, T, S) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH group flow termination (ETHG) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH diagnostic flow termination (ETHD) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH traffic conditioning and shaping (ETH_TCS) | within <MAC>/ETH_A (not specifically described) |
| ETH _x /ETH adaptation (ETH _x /ETH_A, <i>x</i> = P, T, S) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH _x /ETH-m adaptation (ETH _x /ETH-m_A) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH _x /ETH adaptation (ETH _x /ETH_A) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH _x /ETHG adaptation | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETHG/ETH adaptation (ETHG/ETH_A) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETHD/ETH adaptation (ETHD/ETH_A) | OAM function that may be placed at appropriate reference points (not specifically described) |
| ETH/MPLS adaptation (ETHP/MPLS_A) | form of ETH/client adaptation (not specifically described) |
| MPLS path/ETH adaptation (MPLS/ETH_A) | form of <MAC>/ETH_A (not specifically described) |

Appendix X

Mapping between clause 9 and IEEE 802.1 architectural components

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

Table X.1 shows the relationship between various architectural or functional elements specified by [IEEE 802] and corresponding architectural components defined in the [ITU-T G.800] model in clause 9. These relationships are presented in an effort to make the relationship between IEEE specified functions and the functional modelling components described in clause 9 clear to readers familiar with IEEE specifications and perhaps less familiar with functional modelling methodology.

Table X.1 – Relationship between IEEE 802 and clause 9 architectural entities

| IEEE 802 | Clause 9 |
|--|---|
| LLC | form of ETH/client adaptation (not specifically described, not normally used in transport applications) |
| MAC | corresponds to the ETH layer (a generalization of the Ethernet ([IEEE 802.3]) frame to provide transport service) |
| PHY | form of <MAC>/ETH_A and functions below (not specifically described) |
| IEEE 802.1Q | |
| MAC Relay | ETH_F |
| Support of the EISS | ETH_CV_L or ETH_SV_L |
| Support of the EISS by Provider Instance Ports | combination of ETH_SV_L, BMAC/ETH_A, and ETH_T |
| Support of the EISS by Customer Backbone Ports | ETH_CB_IL |
| Support of the EISS for attachment to a Provider Bridged Network | ETH_SV_L |
| Provider Edge Bridge C-VLAN component | ETH_CS_L |

The following examples of functional model diagrams are provided as an aid to understanding the correspondence between the architectural components in the functional model and elements specified in [IEEE 802.1Q] bridge specifications.

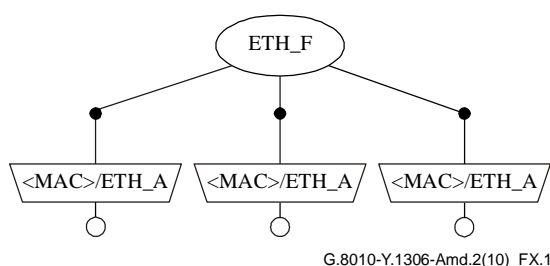
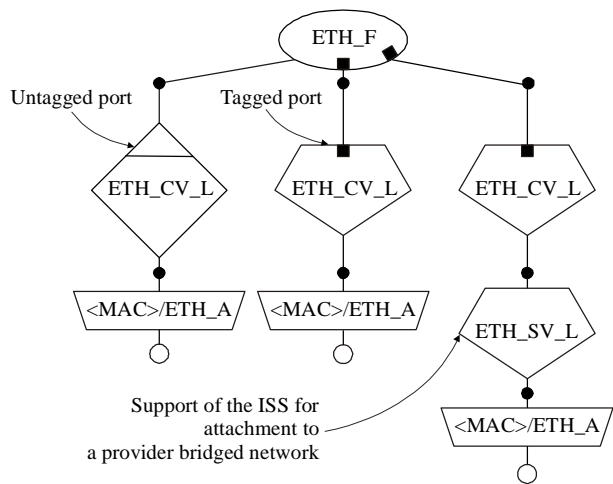
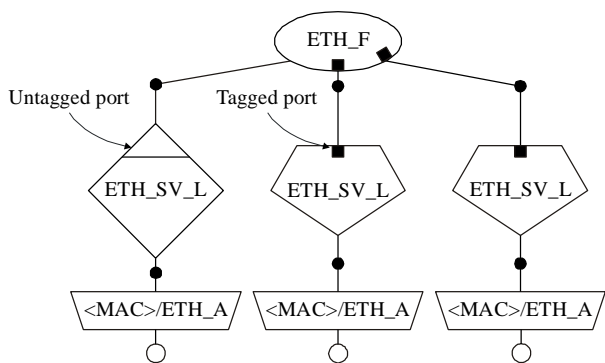


Figure X.1 – VLAN unaware bridge



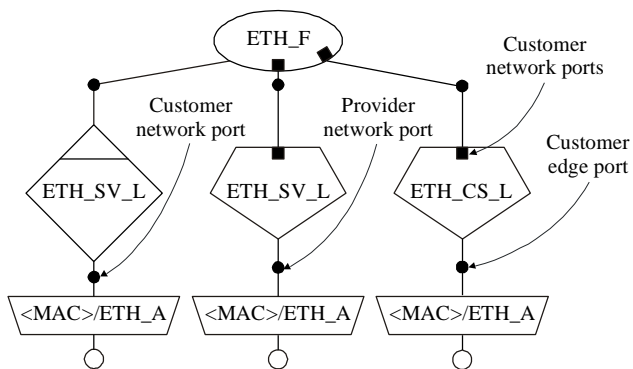
G.8010-Y.1306-Amd.2(10)_FX.2

Figure X.2 – C-VLAN aware bridge



G.8010-Y.1306-Amd.2(10)_FX.3

Figure X.3 – S-VLAN aware bridge, e.g., provider bridge (PB) or provider backbone core bridge (BCB)



G.8010-Y.1306-Amd.2(10)_FX.4

Figure X.4 – Provider edge bridge (PEB)

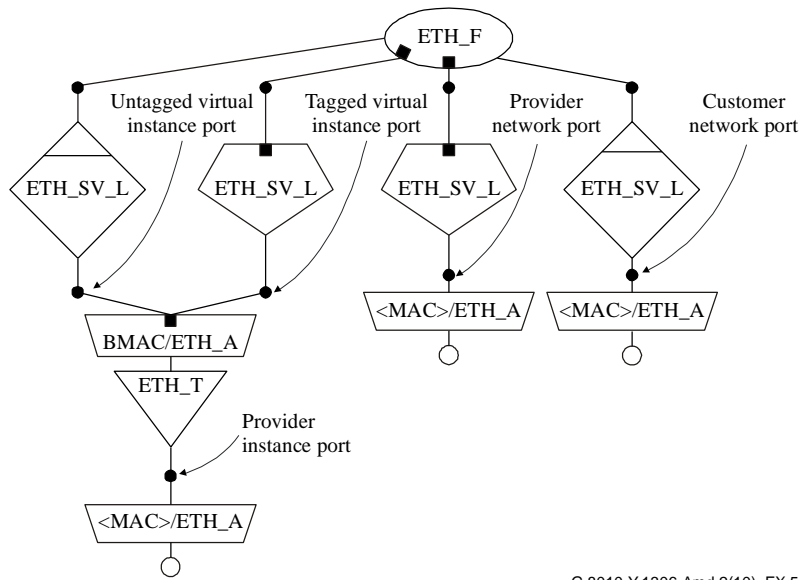


Figure X.5 – I type backbone edge bridge (I-BEB)

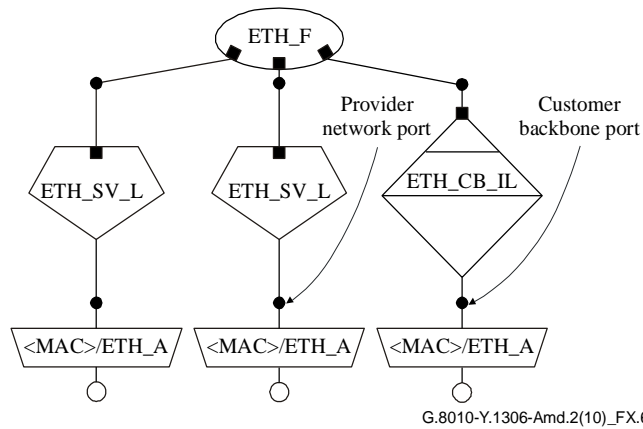


Figure X.6 – B type backbone edge bridge (B-BEB)

Appendix XI

Rooted multipoint using asymmetric VLANs

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

A form of rooted multipoint (RMP) ETH transport can be provided by configuration of an asymmetric VLAN. A bidirectional RMP VLAN is formed (as shown in Figure XI.1) by creating a unidirectional MP-P SNTE with leaf input ports and a root output port and pairing it with a unidirectional P-MP SNTE with the root input port and leaf output ports.

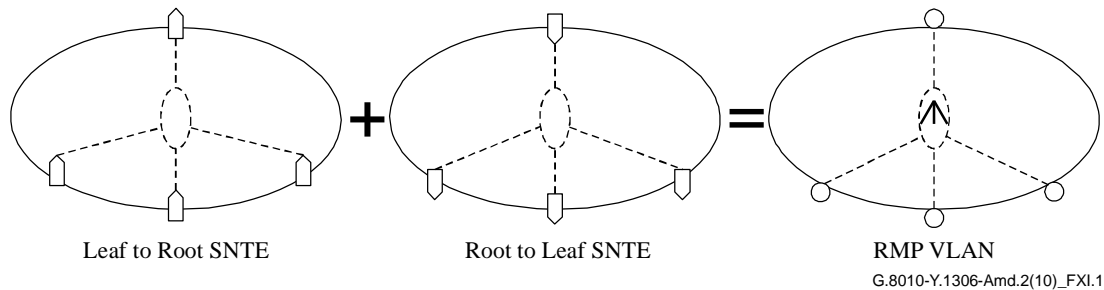
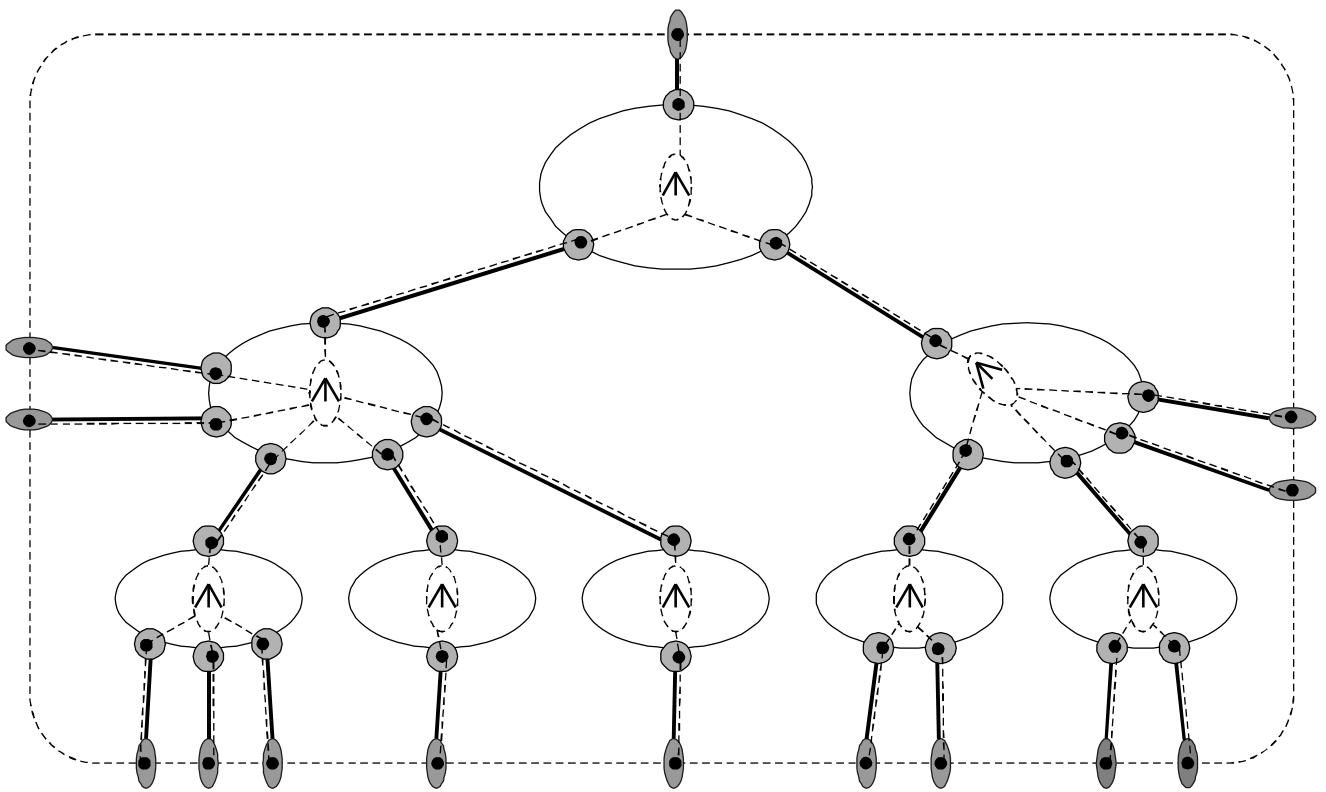


Figure XI.1 – RMP VLAN using asymmetric SNTEs

If the two SNTEs are configured for shared learning of MAC address forwarding information, the forwarding rules learned as frames are forwarded from a leaf port to the root in the MP-P SNTE and can be used to forward frames with corresponding addresses travelling from the root to that leaf port in the P-MP SNTE.

Figure XI.2 shows an example of an aggregation network that allows each leaf access point to communicate with the root access point, but does not allow direct communication between leaf access points.

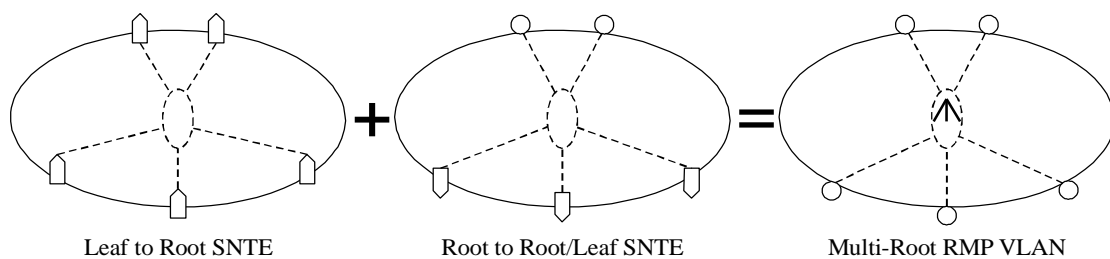


G.8010-Y.1306-Amd.2(10)_FXI.2

Figure XI.2 – Aggregation network using RMP VLAN

This aggregation architecture may be used in cases in which a number of customers require access to a service provider but must be protected from directly communicating with each other or observing other customer's communications with the service provider.

In scenarios requiring high availability for the RMP root, multiple root access points may be provided. This is supported by having multiple sinks (i.e., multiple roots) in the leaf-to-root SNTE and allowing root access points to be bidirectional in the root-to-leaf SNTE (allowing root access points to communicate directly with each other). This combination is illustrated in Figure XI.3.



G.8010-Y.1306-Amd.2(10)_FXI.3

Figure XI.3 – Multi-root RMP VLAN using asymmetric SNTEs

The root forwarding ports are shown at the top and leaf forwarding ports at the bottom of the figure. Both of the root forwarding ports shown are sinks in the leaf-to-root SNTE and are bidirectional ports in the root-to-root/leaf SNTE. The combination of these two SNTEs creates a multi-root RMP SNTE that allows root ports to communicate with other root ports and leaf ports and allows leaf ports to communicate only with root ports.

Appendix XII

Rooted multipoint use in MP-MP service (split horizon)

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

A form of rooted multipoint (RMP) ETH transport is used when a "split horizon" rule is applied to a group of ports belonging to an ETH SNTE. This approach may be used, for example, to provide ETH multipoint service over a P-P transport infrastructure. The "split horizon" rule provides that a frame received on a port belonging to a "split horizon group" may not be forwarded to another port belonging to the same group.

Figure XII.1 shows a four port ETH VLAN implemented in a network by multipoint ETH SNTEs interconnected by link connections. A tree topology must be provided to support ETH flooding behaviour. In this example, traffic between the two ports on the right side must traverse all four subnetworks.

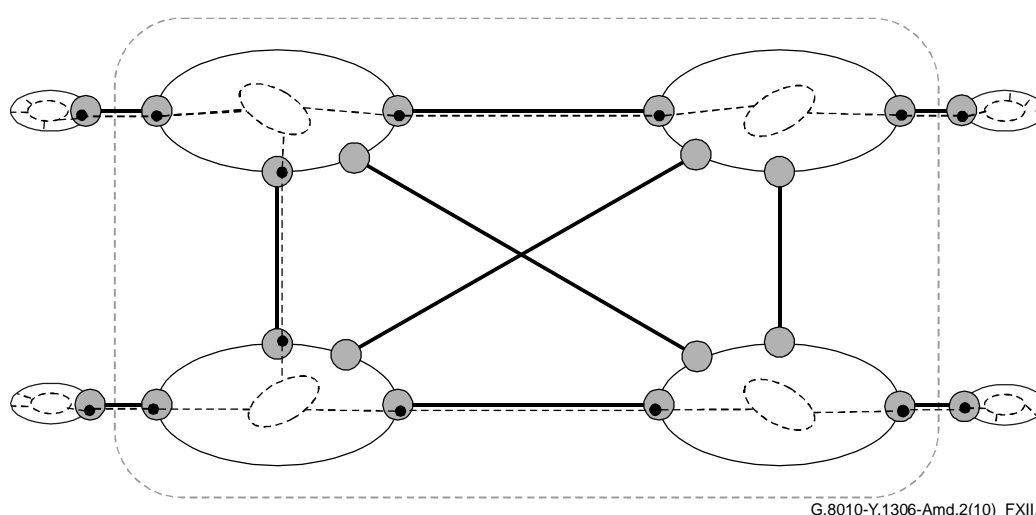
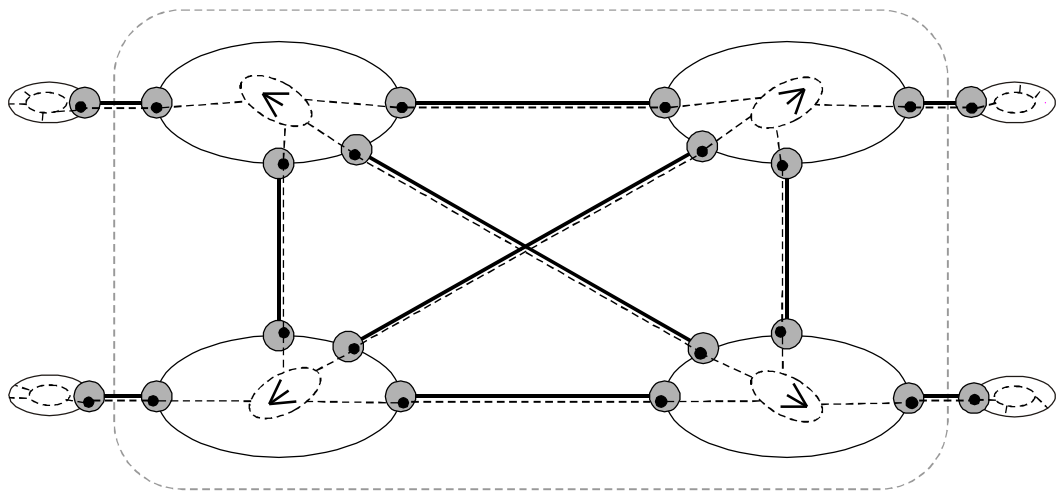


Figure XII.1 – VLAN using multipoint SNTEs

Figure XII.2 shows an example of a four port VLAN implemented in a network by four RMP SNTEs interconnected with a full mesh of ETH link connections. In this example an ETH RMP SNTE can be provided at each subnetwork by putting the ports providing ETH links to the other three ETH subnetworks into a split horizon group.



G.8010-Y.1306-Amd.2(10)_FXII.2

Figure XII.2 – VLAN using split horizon RMP SNTs

In this case, traffic between any two ports will traverse only two subnetworks.

Bibliography

- [1] — IEEE Standard 802.1ag-2007, *IEEE Standard for Local and metropolitan-area networks: Virtual Bridged Local Area Networks, Amendment 5: Connectivity Fault Management*.

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

| | |
|--|----------------------|
| GLOBAL INFORMATION INFRASTRUCTURE | |
| General | Y.100–Y.199 |
| Services, applications and middleware | Y.200–Y.299 |
| Network aspects | Y.300–Y.399 |
| Interfaces and protocols | Y.400–Y.499 |
| Numbering, addressing and naming | Y.500–Y.599 |
| Operation, administration and maintenance | Y.600–Y.699 |
| Security | Y.700–Y.799 |
| Performances | Y.800–Y.899 |
| INTERNET PROTOCOL ASPECTS | |
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| Transport | Y.1300–Y.1399 |
| Interworking | Y.1400–Y.1499 |
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| Signalling | Y.1600–Y.1699 |
| Operation, administration and maintenance | Y.1700–Y.1799 |
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| Service aspects: Interoperability of services and networks in NGN | Y.2250–Y.2299 |
| Enhancements to NGN | Y.2300–Y.2399 |
| Network management | Y.2400–Y.2499 |
| Network control architectures and protocols | Y.2500–Y.2599 |
| Packet-based Networks | Y.2600–Y.2699 |
| Security | Y.2700–Y.2799 |
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| Carrier grade open environment | Y.2900–Y.2999 |
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| BIG DATA | Y.3600–Y.3799 |
| QUANTUM KEY DISTRIBUTION NETWORKS | Y.3800–Y.3999 |
| INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES | |
| General | Y.4000–Y.4049 |
| Definitions and terminologies | Y.4050–Y.4099 |
| Requirements and use cases | Y.4100–Y.4249 |
| Infrastructure, connectivity and networks | Y.4250–Y.4399 |
| Frameworks, architectures and protocols | Y.4400–Y.4549 |
| Services, applications, computation and data processing | Y.4550–Y.4699 |
| Management, control and performance | Y.4700–Y.4799 |
| Identification and security | Y.4800–Y.4899 |
| Evaluation and assessment | Y.4900–Y.4999 |

For further details, please refer to the list of ITU-T Recommendations.

SERIES OF ITU-T RECOMMENDATIONS

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|-----------------|---|
| Series A | Organization of the work of ITU-T |
| Series D | Tariff and accounting principles and international telecommunication/ICT economic and policy issues |
| Series E | Overall network operation, telephone service, service operation and human factors |
| Series F | Non-telephone telecommunication services |
| Series G | Transmission systems and media, digital systems and networks |
| Series H | Audiovisual and multimedia systems |
| Series I | Integrated services digital network |
| Series J | Cable networks and transmission of television, sound programme and other multimedia signals |
| Series K | Protection against interference |
| Series L | Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant |
| Series M | Telecommunication management, including TMN and network maintenance |
| Series N | Maintenance: international sound programme and television transmission circuits |
| Series O | Specifications of measuring equipment |
| Series P | Telephone transmission quality, telephone installations, local line networks |
| Series Q | Switching and signalling, and associated measurements and tests |
| Series R | Telegraph transmission |
| Series S | Telegraph services terminal equipment |
| Series T | Terminals for telematic services |
| Series U | Telegraph switching |
| Series V | Data communication over the telephone network |
| Series X | Data networks, open system communications and security |
| Series Y | Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities |
| Series Z | Languages and general software aspects for telecommunication systems |