International Telecommunication Union

ITU-T G.8021.1/Y.1341.1

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TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

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 AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Transport

Types and characteristics of Ethernet transport network equipment

Recommendation ITU-T G.8021.1/Y.1341.1

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Recommendation ITU-T G.8021.1/Y.1341.1

Types and characteristics of Ethernet transport network equipment

Summary

Recommendation ITU-T G.8021.1/Y.1341.1 describes examples of Ethernet equipment types derived from IEEE 802.1Q bridge types.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.8021.1/Y.1341.1	2012-10-29	15

Keywords

Bridge, Ethernet equipment.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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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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Types and characteristics of Ethernet transport network equipment

1 Scope

This Recommendation provides an overview of the functions of Ethernet equipment and gives examples of various Ethernet equipment types. The Recommendation is based on the Ethernet transport network architecture specified in [ITU-T G.8010], the bridge types specified in [IEEE 802.1Q], and equipment functional blocks specified in [ITU-T G.8021]. It is by no means intended to lay down restrictions on the way in which equipment may be built.

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 G.800] Recommendation ITU-T G.800 (2012), *Unified functional architecture of transport networks.*

[ITU-T G.8010] Recommendation ITU-T G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks.*

[ITU-T G.8011] Recommendation ITU-T G.8011/Y.1307 (2009), *Ethernet service characteristics.*

[ITU-T G.8012] Recommendation ITU-T G.8012/Y.1308 (2004), *Ethernet UNI and Ethernet NNI.*

[ITU-T G.8012.1] Recommendation ITU-T G.8012.1/Y.1308.1 (2012), *Interfaces for the Ethernet transport network.*

[ITU-T G.8013] Recommendation ITU-T G.8013/Y.1731 (2011), *OAM functions and mechanisms for Ethernet based networks.*

[ITU-T G.8021] Recommendation ITU-T G.8021/Y.1341 (2012), *Characteristics of Ethernet transport network equipment functional blocks.*

[ITU-T G.8031] Recommendation ITU-T G.8031/Y.1342 (2011), *Ethernet linear protection switching.*

[ITU-T G.8032] Recommendation ITU-T G.8032/Y.1344 (2012), *Ethernet ring protection switching.*

[IEEE 802.1aq] IEEE Std. 802.1aq-2012, *Shortest Path Bridging.*

[IEEE 802.1Q] IEEE Std. 802.1Q-2011, *Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks.*

[IEEE 802.1Qbc] IEEE Std. 802.1Qbc-2011, *Provider Bridging – Remote Customer Service Interface.*

[IEEE 802.3] IEEE Std. 802.3-2008, Part 3: *Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.*

[IETF RFC 6060] IETF RFC 6060 (2011), *Generalized Multiprotocol Label Switching (GMPLS) Control of Ethernet Provider Backbone Traffic Engineering (PBB-TE).*

[MEF 6.1] Metro Ethernet Forum (MEF) (2008), *Technical Specification 6.1 – Ethernet Services Definitions – Phase 2.*

[MEF 26.1] Metro Ethernet Forum (MEF) (2012), *Technical Specification 26.1 – External Network Network Interface (ENNI) – Phase 2.*

[MEF 30] Metro Ethernet Forum (MEF) (2011), *Technical Specification* 30 – *Service OAM Fault Management Implementation Agreement.*

[MEF 35] Metro Ethernet Forum (MEF) (2012), *Technical* Specification *35 – Service OAM Performance Monitoring Implementation Agreement.*

3 Definitions

This Recommendation does not define any terms.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

B-BEB	B-type Backbone Edge Bridge
BCB	Backbone Core Bridge
B-MAC	Backbone MAC address
CBP	Customer Backbone Port
CE	Customer Equipment [IEEE 802.1], Customer Edge [MEF]
CEP	Customer Edge Port
CEP IB-BEB	IB-BEB with Customer Edge Port
CEP I-BEB	I-BEB with Customer Edge Port
CFM	Connectivity Fault Management
CNP	Customer Network Port
DSL	Digital Subscriber Line
EC	Ethernet Connection
ENNI	External Network to Network Interface
ESP	Ethernet Switched Path
ETH	Ethernet MAC layer network
EVC	Ethernet Virtual Connection
FD	Flow Domain
GMPLS	Generalized Multiprotocol Label Switching
IB-BEB	IB-type Backbone Edge Bridge
I-BEB	I-type Backbone Edge Bridge
I-SID	Backbone Service Identifier field in an I-TAG
MAC	Media Access Control
MD	Maintenance Domain

MEF	Metro Ethernet Forum
MEG	Maintenance Entity Group
MPLS	Multiprotocol Label Switching
MPLS-TP	MPLS Transport Profile
NNI	Network to Network Interface
OAM	Operations, Administration and Maintenance
OTN	Optical Transport Network
OVC	Operator Virtual Connection
PAP	Provider Access Port
PB	Provider Bridge
PBB	Provider Backbone Bridging
PBB-TE	Provider Backbone Bridging with Traffic Engineering
PDH	Plesiochronous Digital Hierarchy
PEB	Provider Edge Bridge
PHY	Physical layer
PIP	Provider Instance Port
PNP	Provider Network Port
PON	Passive Optical Network
RCAP	Remote Customer Access Port
RCSI IB-BEB	IB-type Backbone Edge Bridge with Remote Customer Service Interface
RCSI I-BEB	I-type Backbone Edge Bridge with Remote Customer Service Interface
RCSI PEB	Provider Edge Bridge with Remote Customer Service Interface
RCSI	Remote Customer Service Interface
SDH	Synchronous Digital Hierarchy
SPB	Shortest Path Bridging
TAG	The attributes of priority information, and optionally, VLAN identification information, associated with an Ethernet frame
TB-BEB	TB-type Backbone Edge Bridge
T-BEB	T-type Backbone Edge Bridge
UNI	User to Network Interface
VID	VLAN Identifier
VLAN	Virtual Local Area Network

5 Conventions

There are no special conventions in this Recommendation.

6 ETH layer hierarchy, domains, topology and connections

Figure 6-1 shows a much simplified view of an Ethernet network consisting of two domains (depicted by the cloud edges) and showing generic Ethernet bridge equipment within each domain.

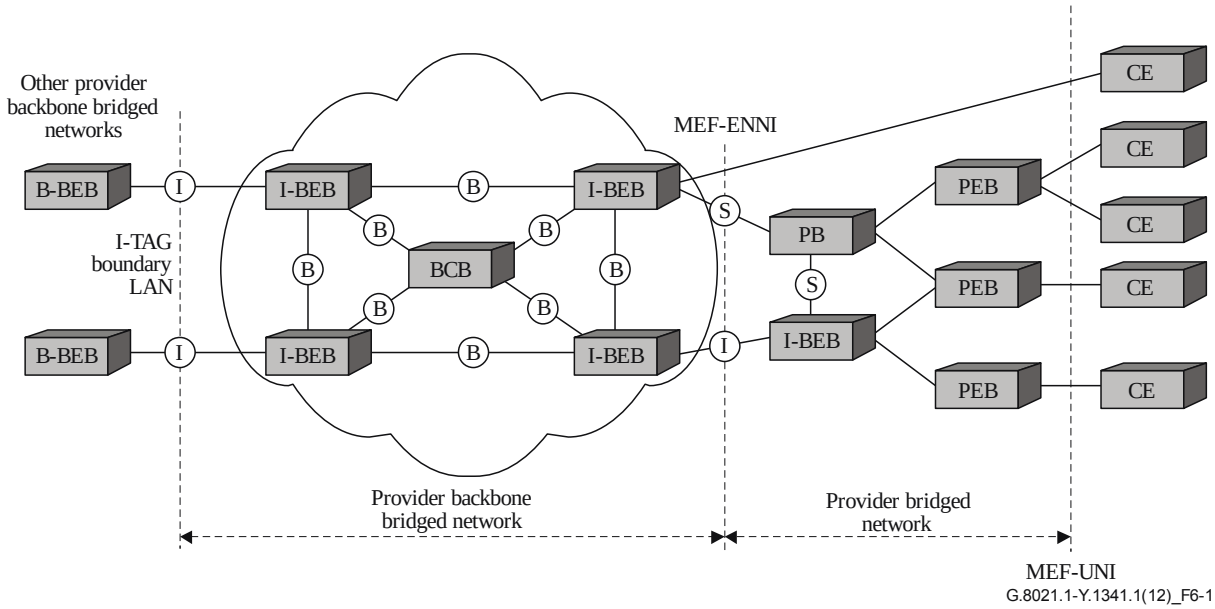


Figure 6-1 – Simplified Ethernet network

Ethernet is an extremely flexible technology and it is virtually impossible to illustrate in a diagram the many possible deployments. In Figure 6-1, the network is constructed from Ethernet provider bridges (PBs) interconnected by Ethernet links. See Appendix II for additional [IEEE 802.1Q] considerations on the provider network. A provider edge bridge (PEB) provides for connection to Ethernet customer equipment (CE) via an MEF user network interface (UNI).

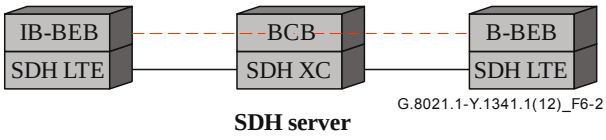


Figure 6-2 – Example of Ethernet over synchronous digital hierarchy (SDH)

The links between bridges are not necessarily optical fibres and may be provided by Ethernet over X technology networks. For example, a link could be provided by Ethernet over synchronous digital hierarchy (SDH) or by Ethernet over an optical transport network (OTN). The generic equipment would then also contain some SDH or OTN components, ranging from a simple termination to a complete cross-connect function.

6.1 MEF global interconnect

The Metro Ethernet Forum [MEF 6.1] defines three basic Ethernet service types – E-Line, E-LAN and E-Tree (Figure 6-3) – which can be offered by a single service provider in a single metro network or between multiple metro networks, or by multiple service providers. In the latter case, the UNI ports may be distributed globally.

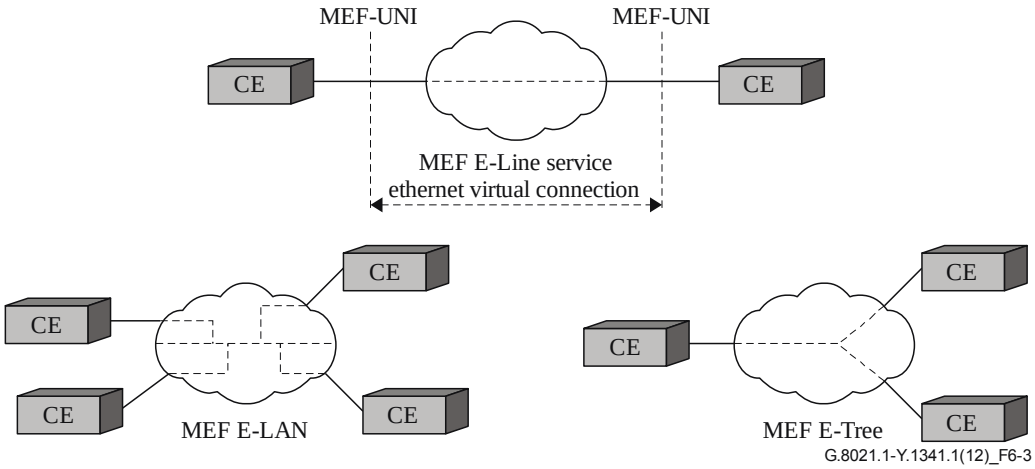


Figure 6-3 – Examples of MEF's E-Line, E-LAN and E-Tree service

The Ethernet service connectivity between UNIs is referred to as an Ethernet virtual connection (EVC). There are point-to-point EVCs, rooted multipoint EVCs and multipoint-to-multipoint EVCs.

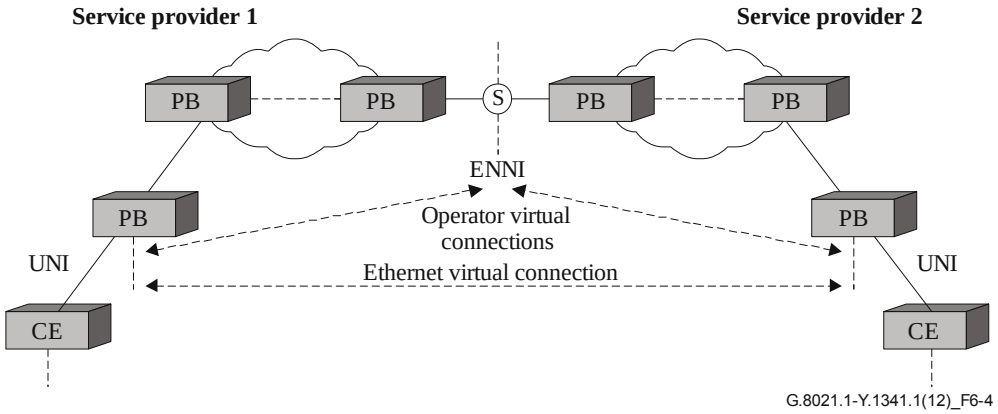


Figure 6-4 – Connections across multiple operators

An EVC starts and ends at midpoints of UNI links and spans one or more service provider/carrier networks. When an EVC spans multiple service provider/carrier networks, these carrier networks are interconnected via [MEF 26.1]-based Ethernet external network to network interface (ENNI) links. Interconnection may be direct or via a carrier Ethernet exchange. The segment of an EVC within one service provider/carrier network is referred to as an operator virtual connection (OVC). An OVC starts and ends at the midpoints of the user network interface (UNI) and ENNI links.

6.2 Ethernet maintenance entities

Ethernet virtual connections are supported by Ethernet connections (ECs) within an Ethernet services layer, which is providing an Ethernet bridge functionality. This Ethernet services layer is supported by a transport services layer. The connections in this transport services layer carry one or more ECs. The ECs pass the ENNIs, while the transport services layer connections terminate before those ENNIs.

The ECs are monitored by means of [ITU-T G.8013] or connectivity fault management (CFM) [IEEE 802.1Q] Ethernet OAM, allowing customers, service providers and network operators to monitor the EC segment within their domain via a maintenance entity group/maintenance association (MEG/MA) level (Figure 6-5).

The transport services layer may consist of Ethernet, MPLS, MPLS-TP, PDH, SDH, OTN, DSL and PON technologies. The UNI and external network to network interface (ENNI) links are supported by [IEEE 802.3] technologies. The ENNI links carry S-Tagged Ethernet connection (EC) signals.

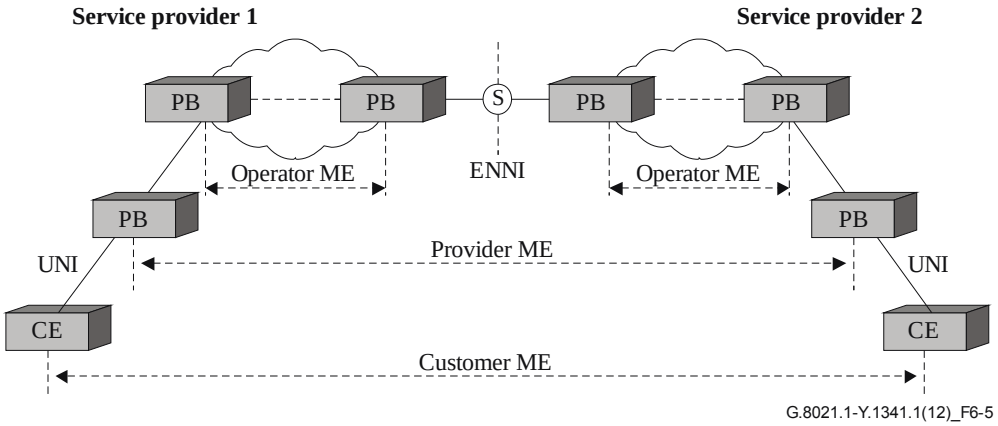


Figure 6-5 – Ethernet maintenance entities (MEs)

7 Interface ports on Ethernet transport network equipment

The figures in this clause illustrate examples of different types of ports that could be used in Ethernet MAC layer network (ETH) equipment. The term 'port' is used here in a logical context and does not imply any partitioning of functions to hardware modules. A hardware module may implement one port, many ports, or a portion of the functions for one or more ports.

These types of interfaces depend on the type of ETH equipment, as shown in the following table:

Table 7-1 – Bridge types and interfaces

Ethernet MAC layer network (ETH) equipment/ ITU-T 802.1Q bridge type	**User to network interface (UNI) service**	**Network to network interface (NNI) service**
Provider edge bridge (PEB)	C-tagged (Individual, Bundled)	S-tagged
Remote customer service interface (RCSI) PEB	C-tagged (Individual, Bundled)	S-tagged
	Port-based (Untagged, Priority C-tagged/ S-tagged)	
Provider bridge (PB)	Port-based (Untagged, Priority C-tagged/ S-tagged)	S-tagged
	S-tagged (Peering)	
I-type backbone edge bridge (I-BEB)	Port-based (Untagged, Priority C-tagged/ S-tagged)	I-tagged
	S-tagged (Individual, Bundled)	
B-type backbone edge bridge (B-BEB)	I-tagged	B-tagged
IB-type backbone edge bridge (IB-BEB)	Port-based (Untagged, Priority C-tagged/ S-tagged)	B-tagged
	S-tagged (Individual, Bundled)	

Table 7-1 – Bridge types and interfaces

Ethernet MAC layer network (ETH) equipment/ ITU-T 802.1Q bridge type	User to network interface (UNI) service	Network to network interface (NNI) service
IB-BEB with Customer edge port (CEP)	C-tagged (Individual, Bundled)	B-tagged
I-BEB with CEP	C-tagged (Individual, Bundled)	I-tagged
RCSI IB-BEB	C-tagged (Individual, Bundled)	B-tagged
	Port-based (Untagged, Priority C-tagged/ S-tagged)	
RCSI I-BEB	C-tagged (Individual, Bundled)	I-tagged
	Port-based (Untagged, Priority C-tagged/ S-tagged)	
T-type backbone edge bridge (T-BEB)	Transparent (Individual)	I-tagged
TB-type backbone edge bridge (TB-BEB)	Transparent (Individual)	B-tagged
Backbone core bridge (BCB)	N/A	B-tagged
NOTE 1 – "Peering" here means that any operations, administration and maintenance (OAM) flows associated with the client signal share the same maintenance domain (MD) level space as used by the operator's OAM flows because no tag is added by the UNI mapping. NOTE 2 – An S-TAG is identical to a B-TAG in all respects.		

7.1 User to network interface (UNI)

Table 7-1 above provides a summary of the twelve [IEEE 802.1Q] edge bridge types and their supported user to network interfaces (UNIs). Those UNIs include the following five types: C-Tagged, S-Tagged, I-Tagged, Port Based and Transparent.

In general, when an interface is referred to as "X-Tagged", it means that the interface is configured to accept a client signal which carries a tag type of "X" following the destination address and source address fields (DA/SA). Note that other addresses and tags may follow that outer X-tag.

A port-based interface can be thought of as the opposite of X-Tagged; it is configured to accept client signals which are untagged (i.e., no tag follows the destination and source address fields), or priority tagged (i.e., only a priority value is carried in the tag, the VLAN identifier is zero).

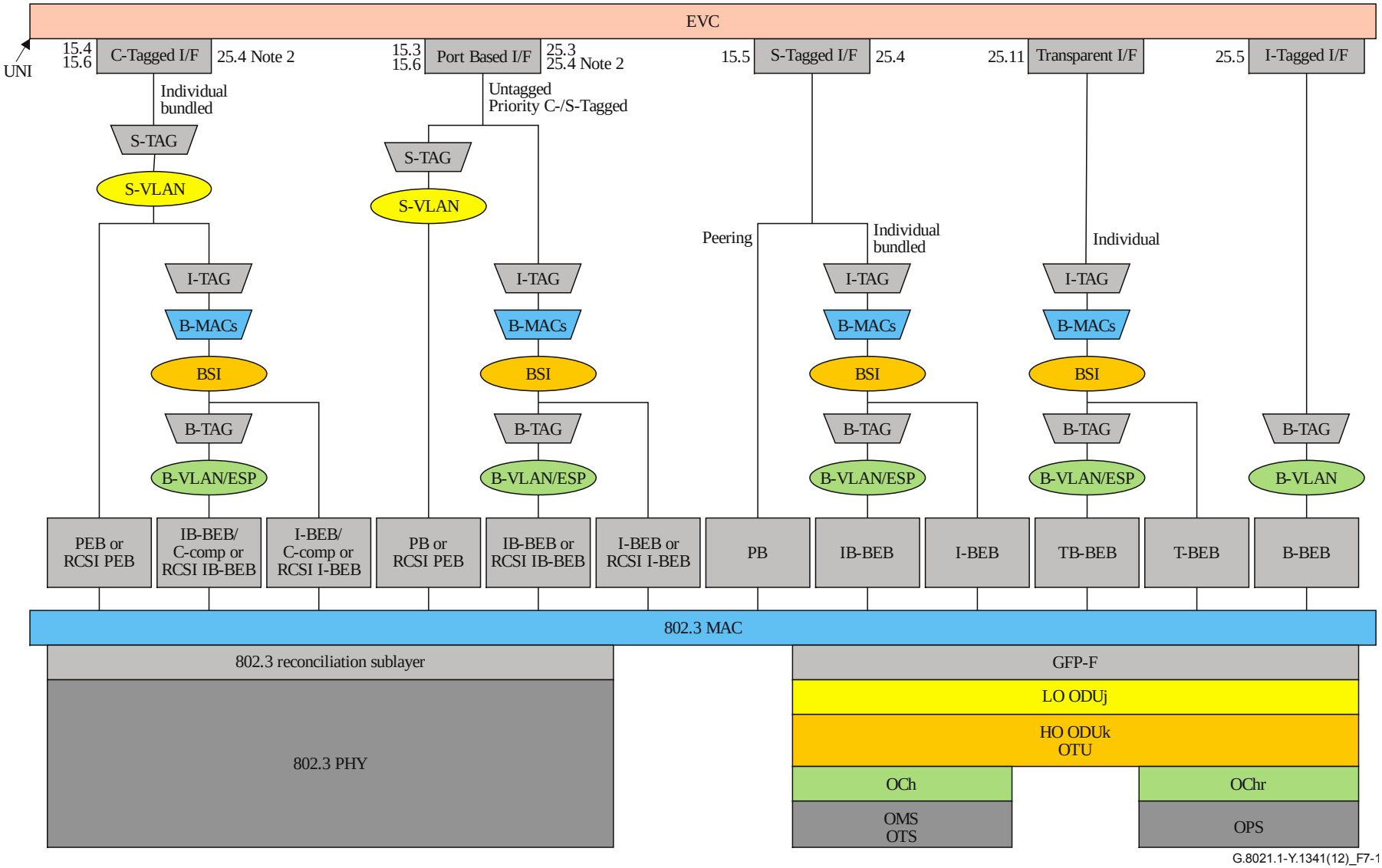
A Transparent interface is configured to accept any client with properly formed destination and source address fields and frame format, regardless of the tag type.

Figure 7-1 below illustrates how an Ethernet virtual connection can be mapped by the five types of user to network interfaces (UNIs). The numbers beside each interface refer to the clauses in [IEEE 802.1Q] and [IEEE 802.1Qbc] where they are defined. For each interface, a pictorial representation shows the sequence of tag processing (e.g., S-TAG) and backbone MAC addresses (B-MACs) processing. The ovals in-between the processing elements provide labels typically used to refer to the signals formed at those points (e.g., a backbone service instance). Note that the figure is not intended to depict [ITU-T G.800] or [ITU-T G.8010] (sub)layers.

The row of blocks below the various processing elements shows the [IEEE 802.1Q] edge bridge types (e.g., a provider edge bridge (PEB)) supporting the connected UNIs.

This representation provides a simple means to identify which type of [IEEE 802.1Q] edge bridge supports a certain UNI type.

For illustration purposes, an [IEEE 802.3] Ethernet media access control (MAC) is shown mapped into either an [IEEE 802.3] physical layer (PHY) or an optical transport network (OTN) PHY. The full set of Ethernet mappings is described in [ITU-T G.8012].



The numbers beside the five types of UNI service interfaces are the corresponding clause numbers in[IEEE 802.1Q] and [IEEE 802.1Qbc] (RCSI)

Figure 7-1 – EVC over provider bridge (PB), provider backbone bridging (PBB) and provider backbone bridging with traffic engineering (PBB-TE) (grouped by user to network interface (UNI))

7.2 Network to network interface (NNI)

Figure 7-2 below illustrates the same mappings of an EVC into the five UNI types, except that they are shown from an NNI perspective, grouped into the three NNI types: S-Tagged, B-Tagged, I-Tagged. Note that since a B-TAG is identical to an S-TAG in all respects, there are actually only two NNI types.

This representation provides a simple means to identify which type of [IEEE 802.1Q] edge bridge supports a certain NNI type.

Again, for illustration purposes, an [IEEE 802.3] Ethernet media access control (MAC) is shown mapped into either an [IEEE 802.3] physical layer (PHY) or an OTN PHY.

The only other type of [IEEE 802.1Q] provider bridge is the backbone core bridge (BCB), which supports an S-/B-Tagged NNI service interface (see Appendix I). Since a BCB does not support a UNI service, it is not included in Figures 7-1 or 7-2. It can be viewed as a bridge fabric (i.e., an ETH flow domain (FD)) connected to a peering S-Tagged NNI service.

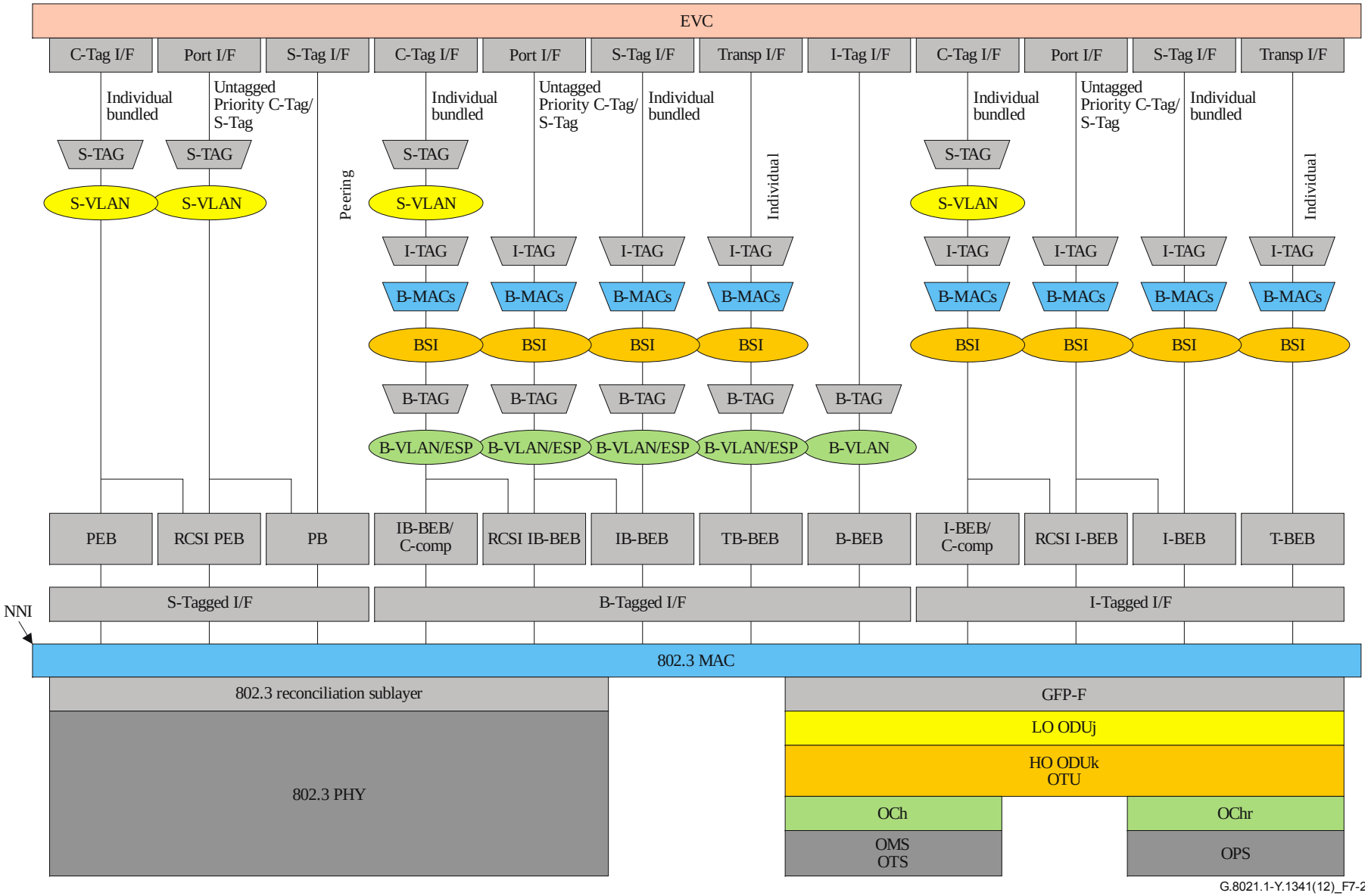


Figure 7-2 – EVC over PB, PBB, PBB-TE (grouped by NNI)

8 Basic Ethernet MAC layer network (ETH) equipment types

Several examples of Ethernet MAC layer network (ETH) equipment are described in this clause, illustrating different ways to combine the atomic functions defined in [ITU-T G.8021]. These particular combinations are aligned with the set of IEEE 802.1Q bridge types. This set is defined in [IEEE 802.1Q] and is summarized in Appendix I.

The full set of basic ETH equipment types is presented together in Figure 8-0 using layer processor and edge processor functions. Each equipment type is then shown individually in the remainder of this clause, first comprised of layer processor and edge processor functions, followed by an expansion into ITU-T G.8021 atomic functions as outlined in Appendix III.

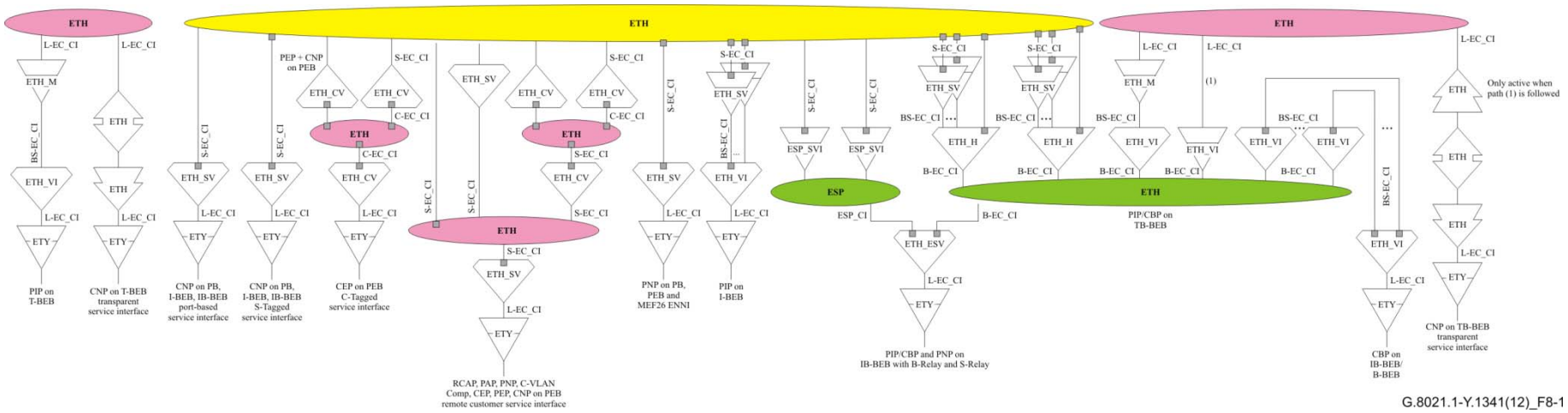


Figure 8-0 – Layer processor and edge processor based model for basic ETH equipment types

8.1 Provider edge bridge (PEB)

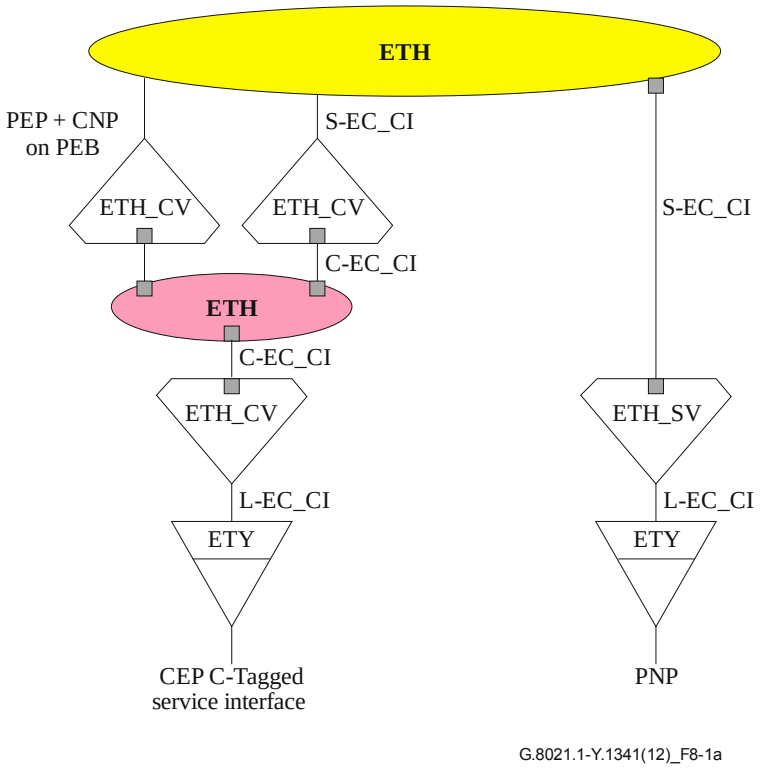


Figure 8-1a – PEB – layer processor and edge processor functions

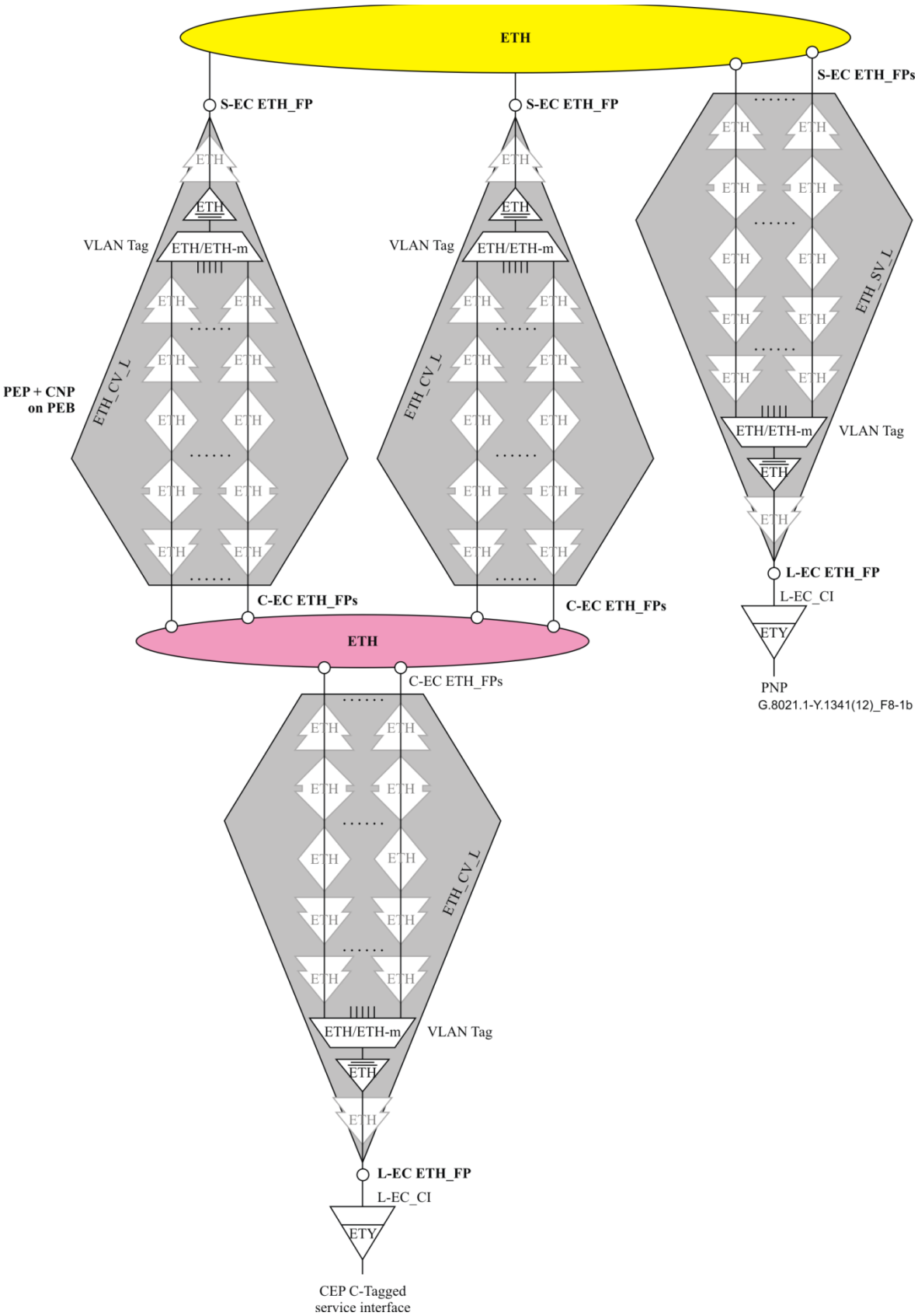


Figure 8-1b – PEB – ITU-T G.8021 atomic functions

8.2 Provider edge bridge with remote customer service interface (RCSI PEB)

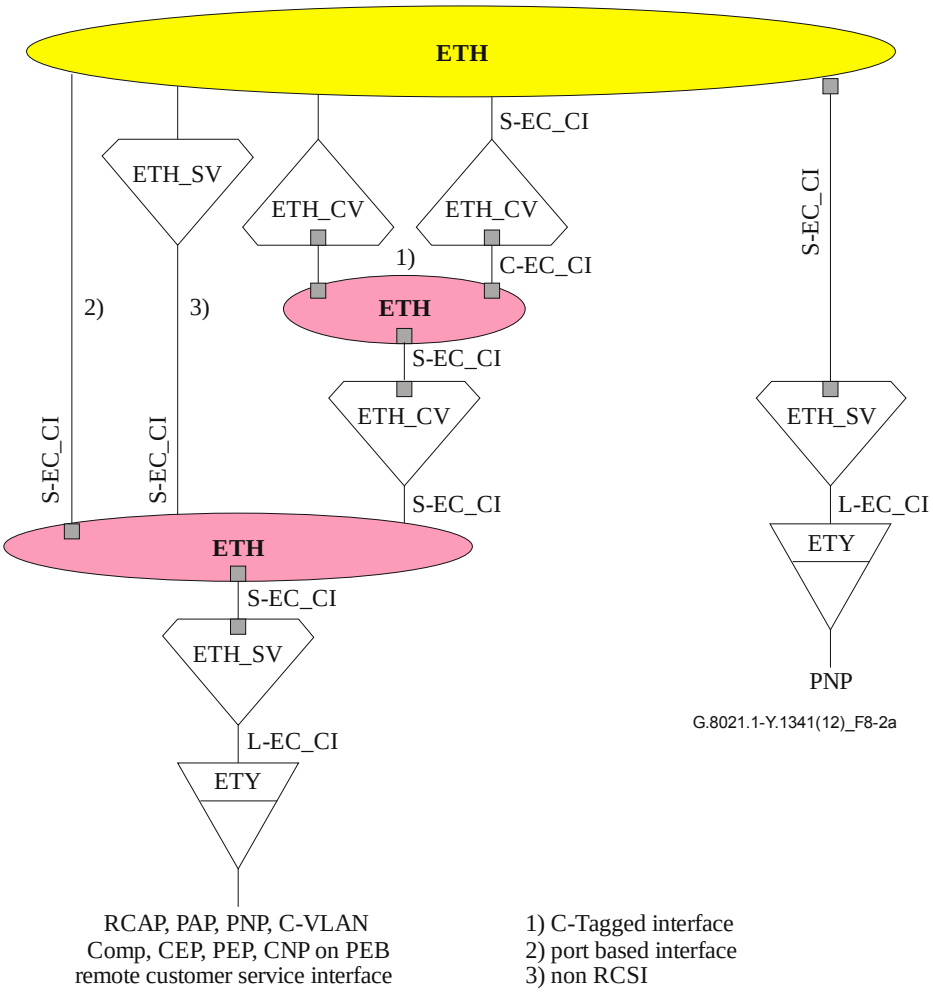


Figure 8-2a – RCSI PEB – layer processor and edge processor functions

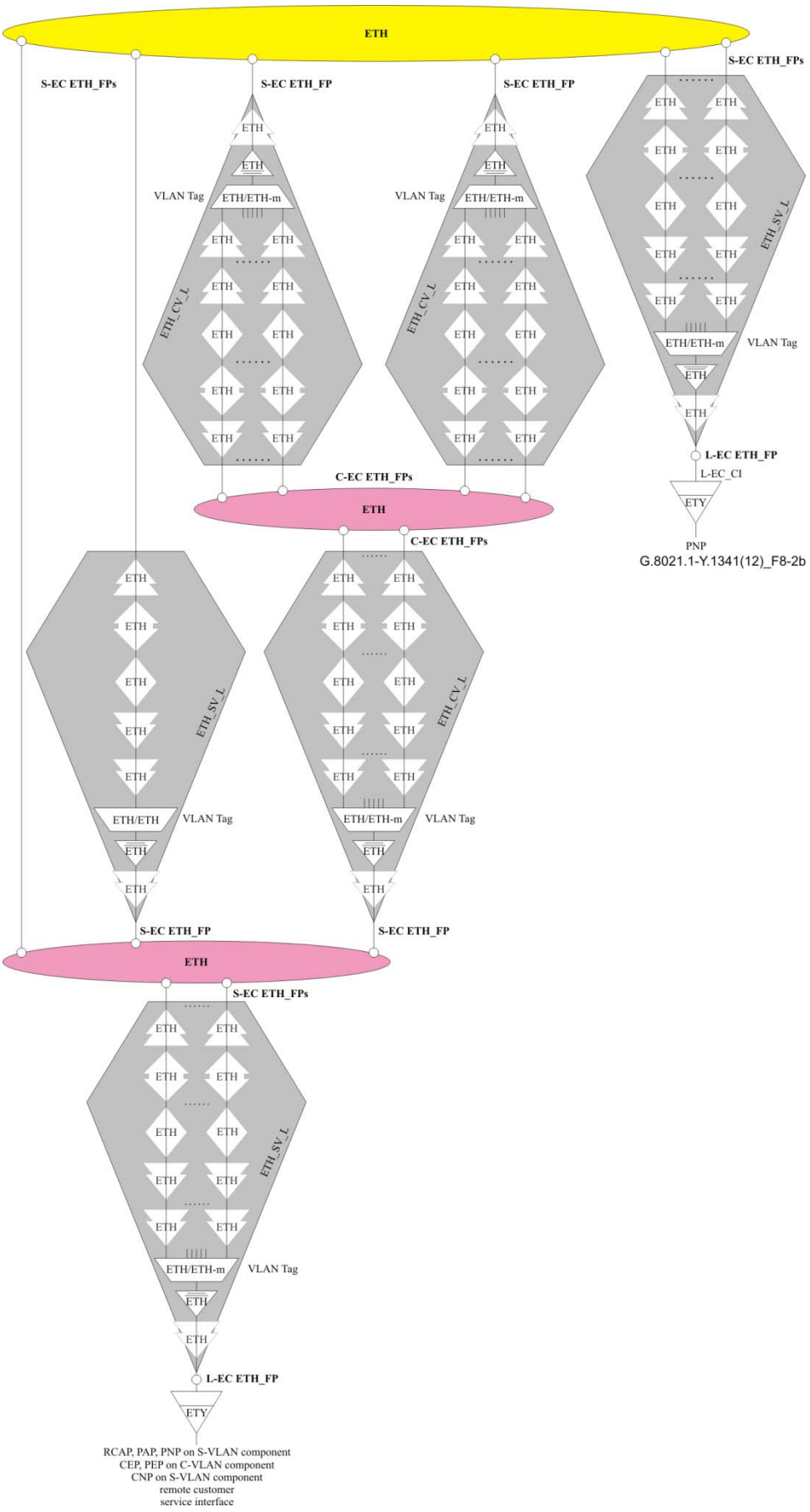


Figure 8-2b – RCSI PEB – ITU-T G.8021 atomic functions

8.3 Provider bridge (PB)

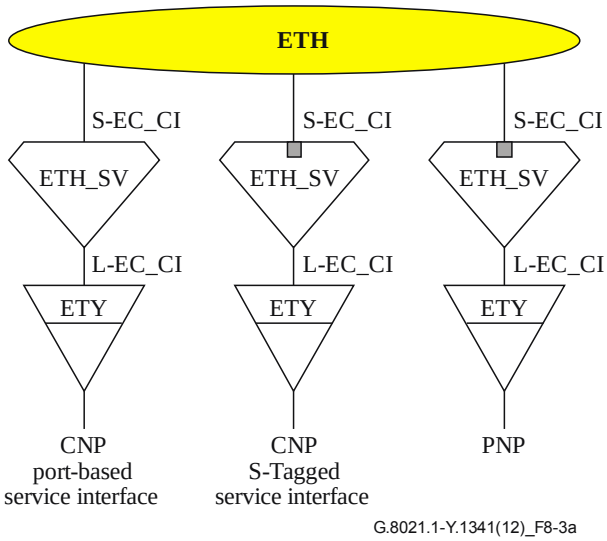


Figure 8-3a – PB – layer processor and edge processor functions

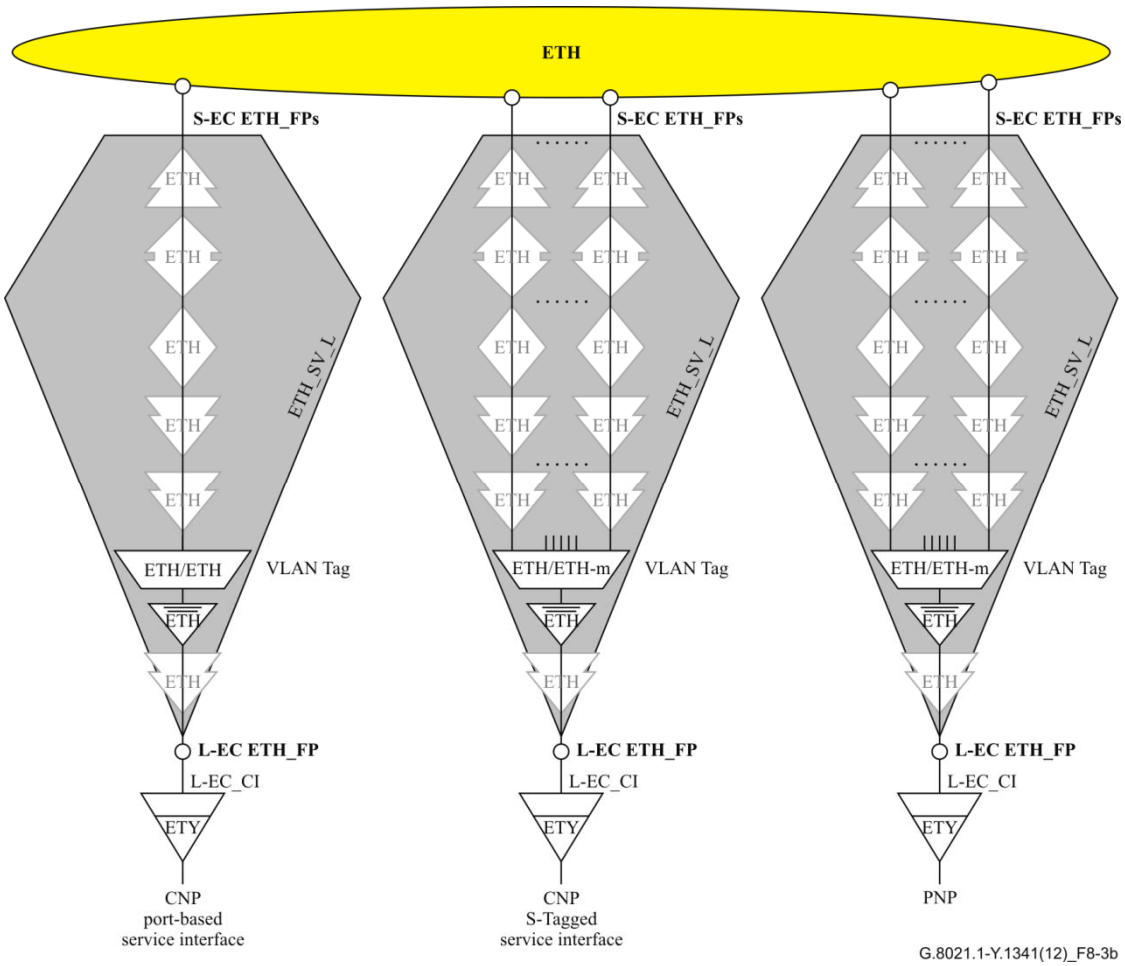


Figure 8-3b – PB – ITU-T G.8021 atomic functions

8.4 I-type backbone edge bridge (I-BEB)

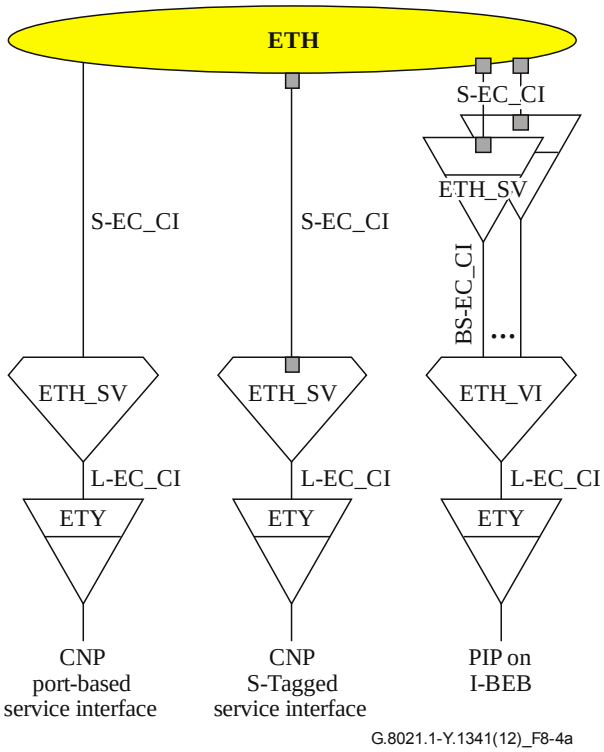


Figure 8-4a – I-BEB – layer processor and edge processor functions

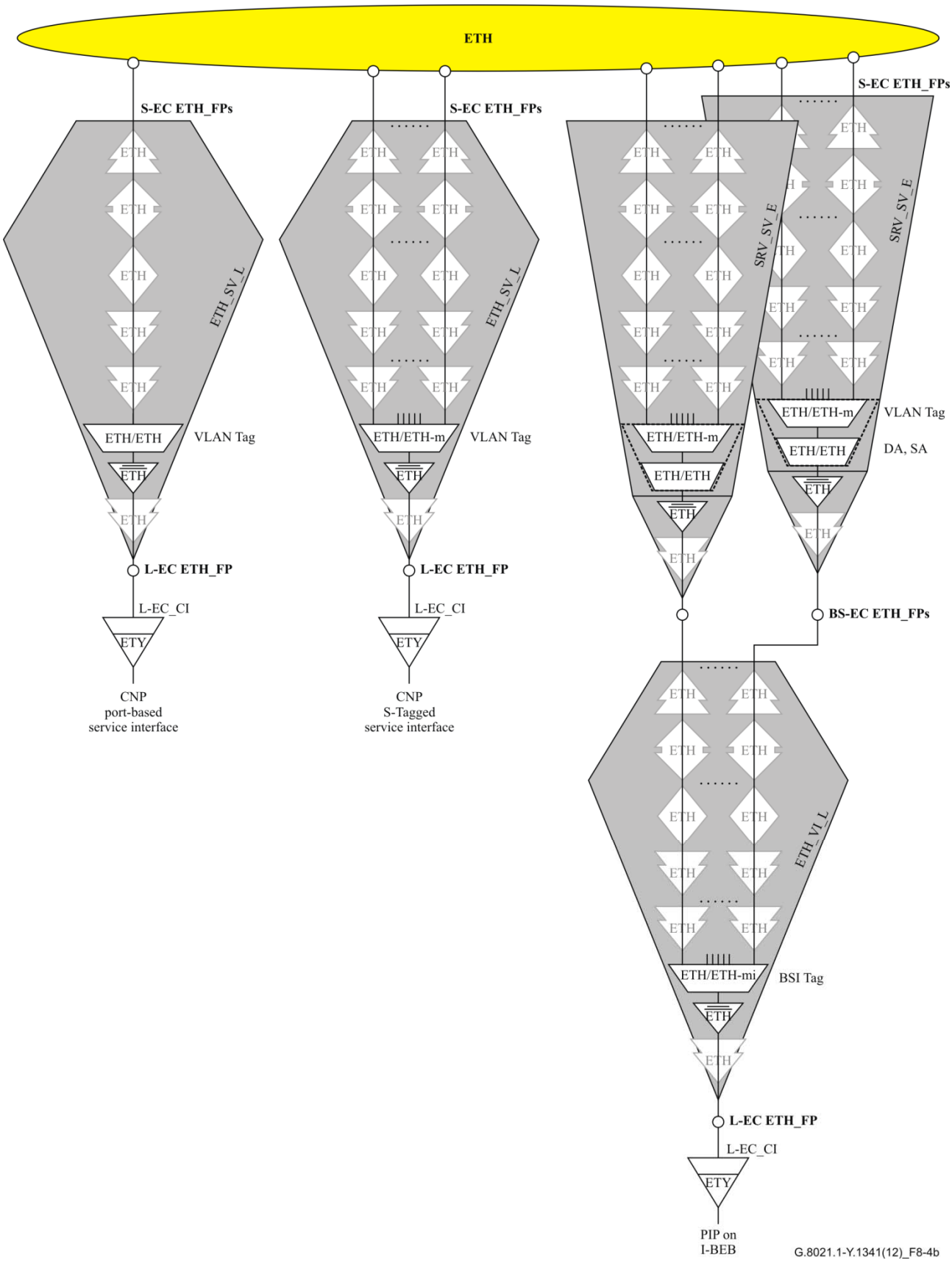


Figure 8-4b – I-BEB – ITU-T G.8021 atomic functions

8.5 B-type backbone edge bridge (B-BEB)

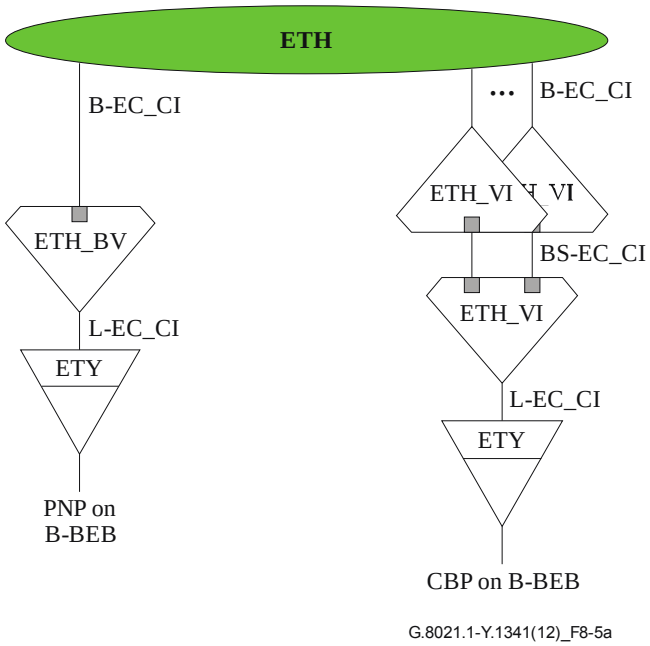


Figure 8-5a – B-BEB – layer processor and edge processor functions

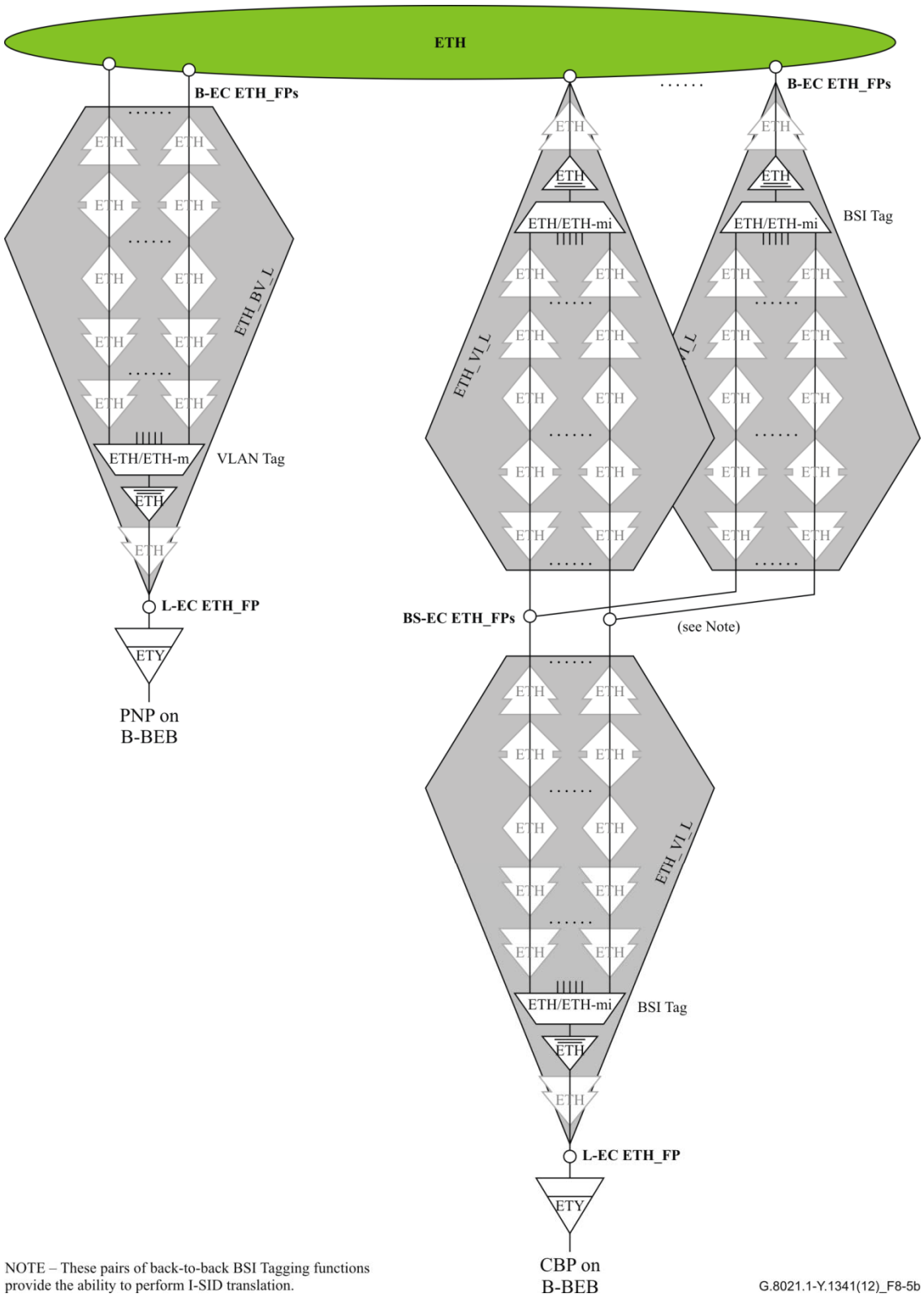


Figure 8-5b – B-BEB – ITU-T G.8021 atomic functions

8.6 IB-type backbone edge bridge (IB-BEB)

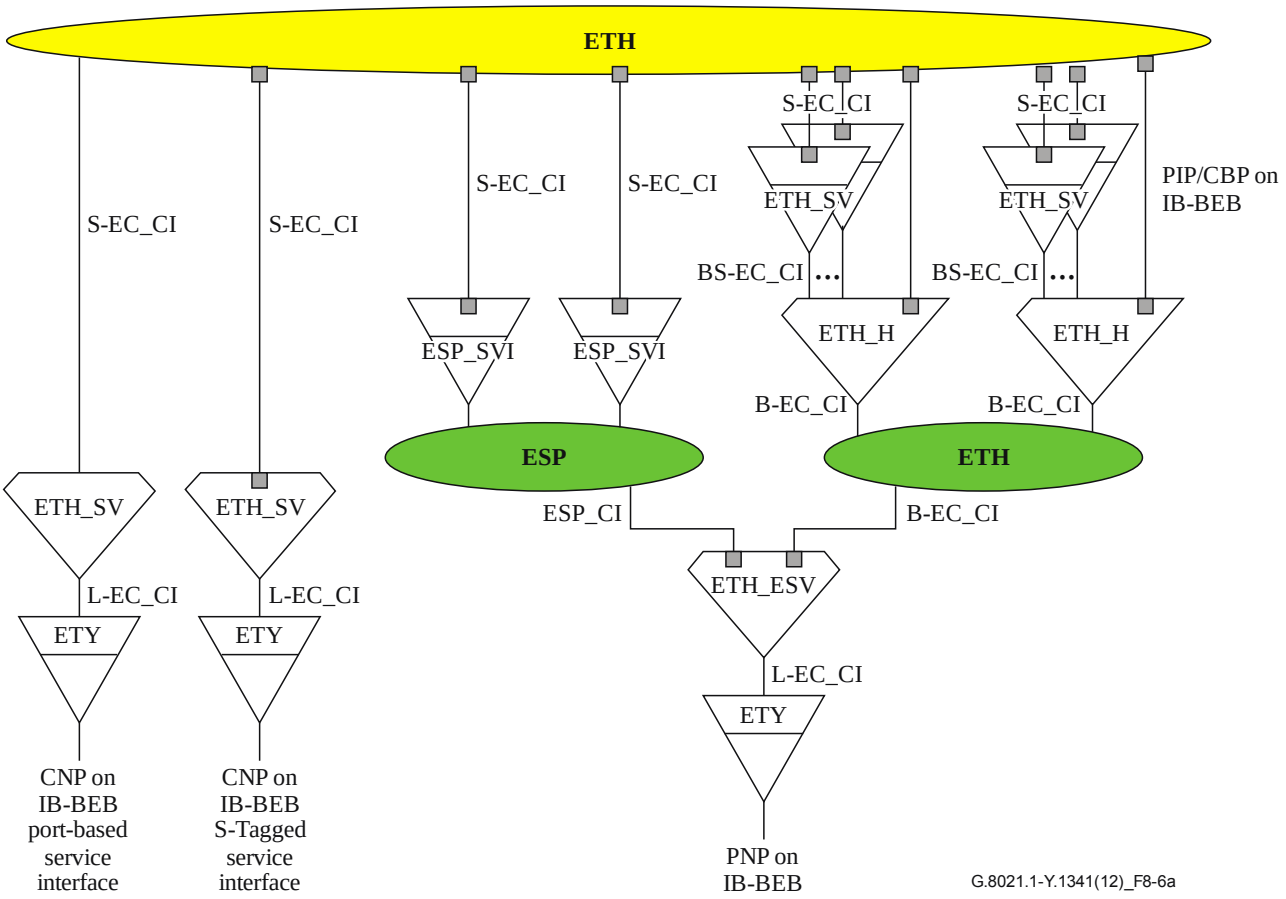


Figure 8-6a – IB-BEB – layer processor and edge processor functions

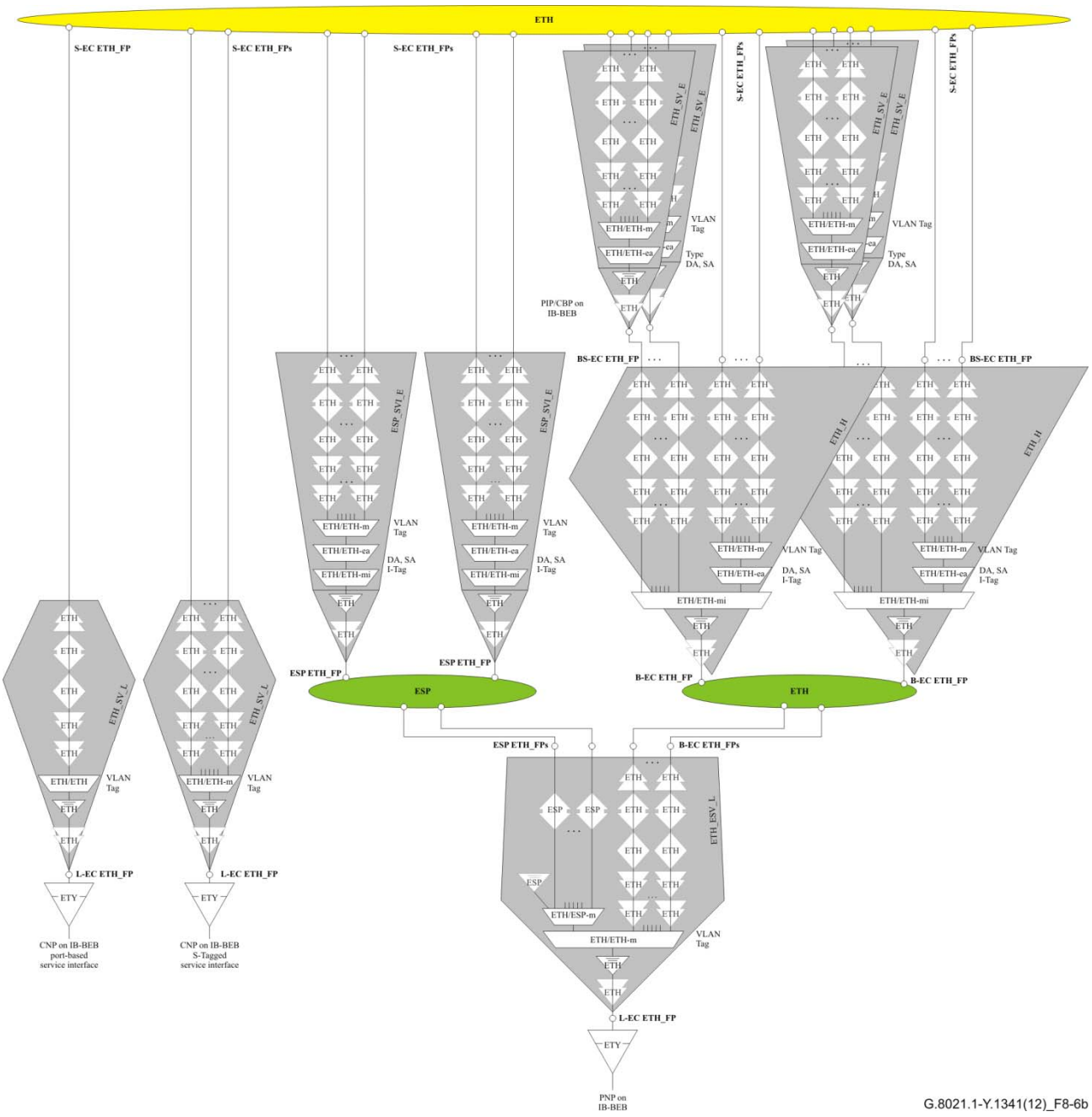


Figure 8-6b – IB-BEB – ITU-T G.8021 atomic functions

8.7 IB-BEB with customer edge port (CEP)

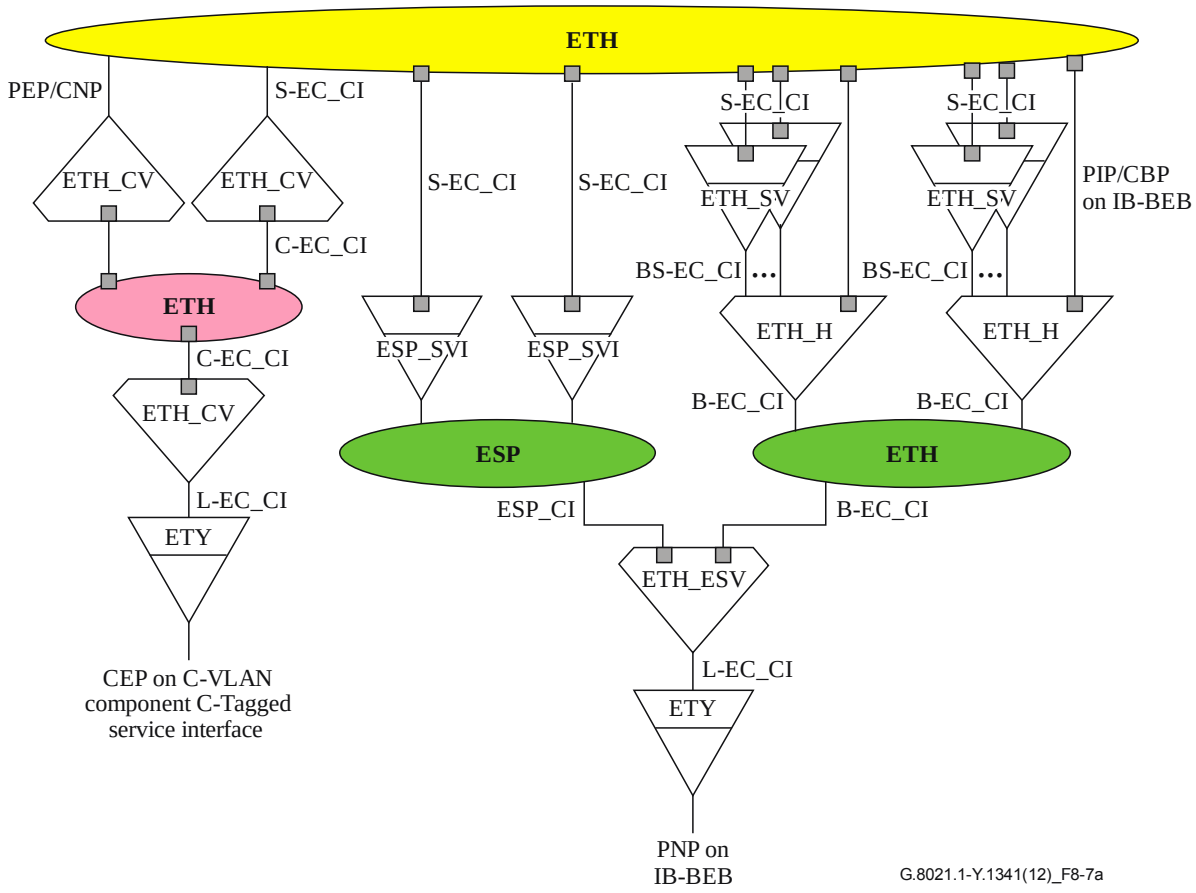


Figure 8-7a – IB-BEB with CEP – layer processor and edge processor functions

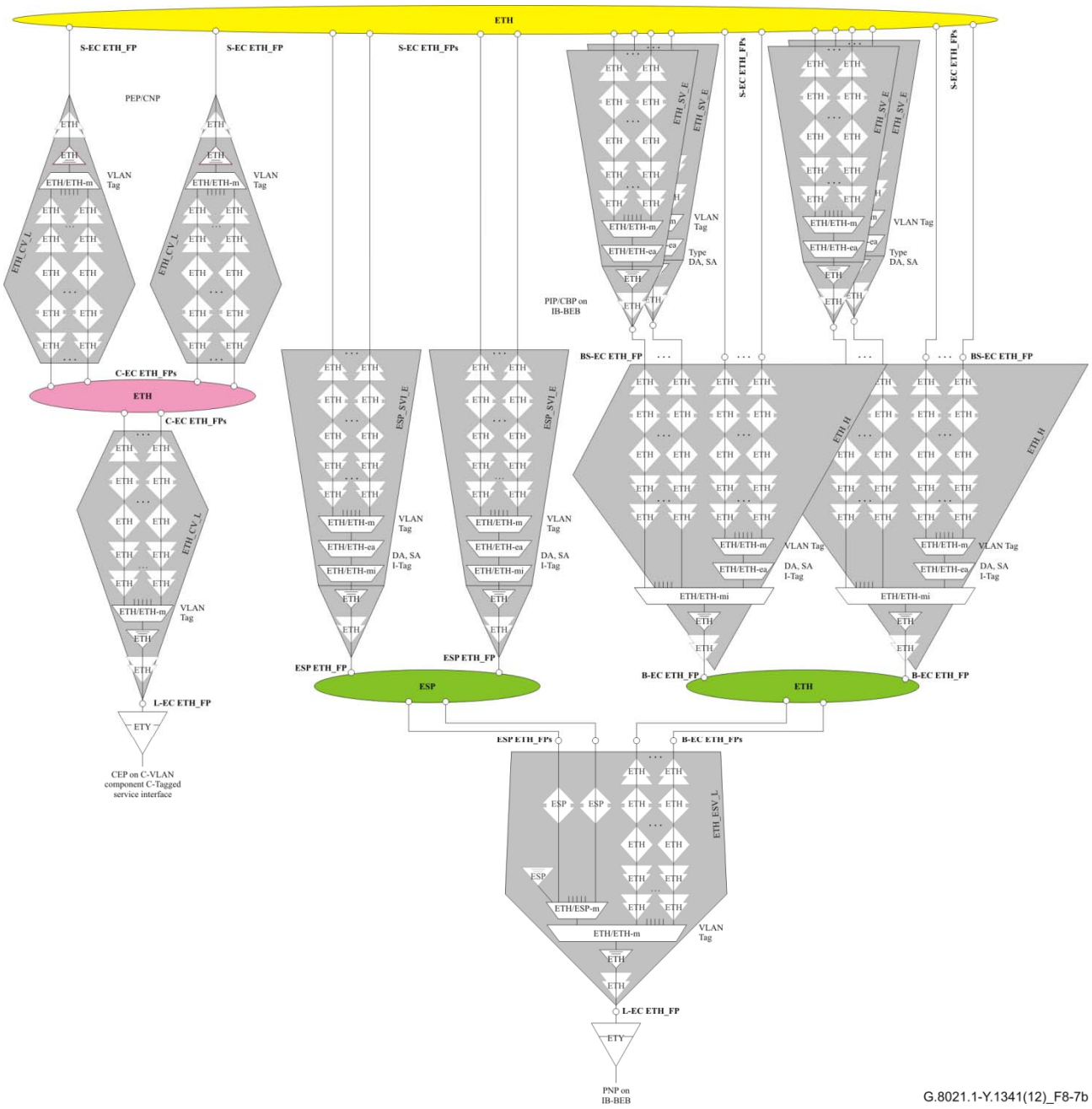


Figure 8-7b – IB-BEB with CEP – ITU-T G.8021 atomic functions

8.8 I-BEB with CEP

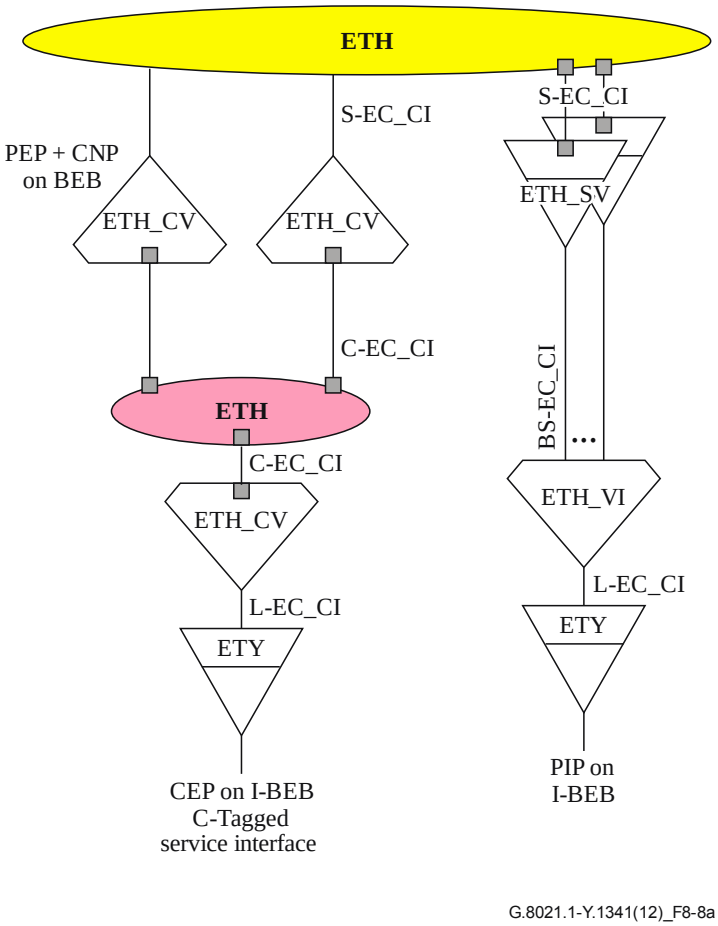


Figure 8-8a – I-BEB with CEP – layer processor and edge processor functions

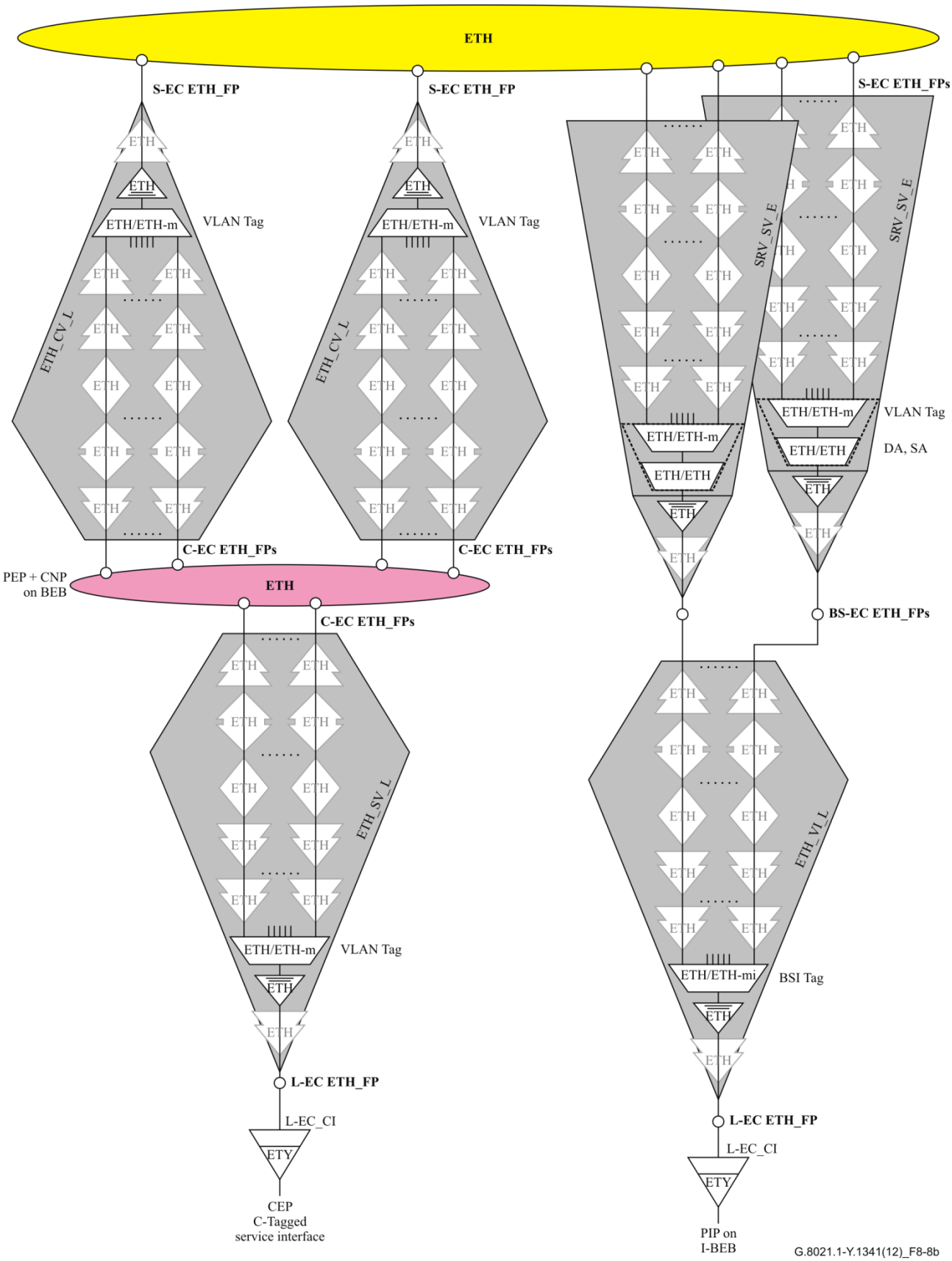


Figure 8-8b – I-BEB with CEP – ITU-T G.8021 atomic functions

8.9 RCSI IB-type backbone edge bridge (RCSI IB-BEB)

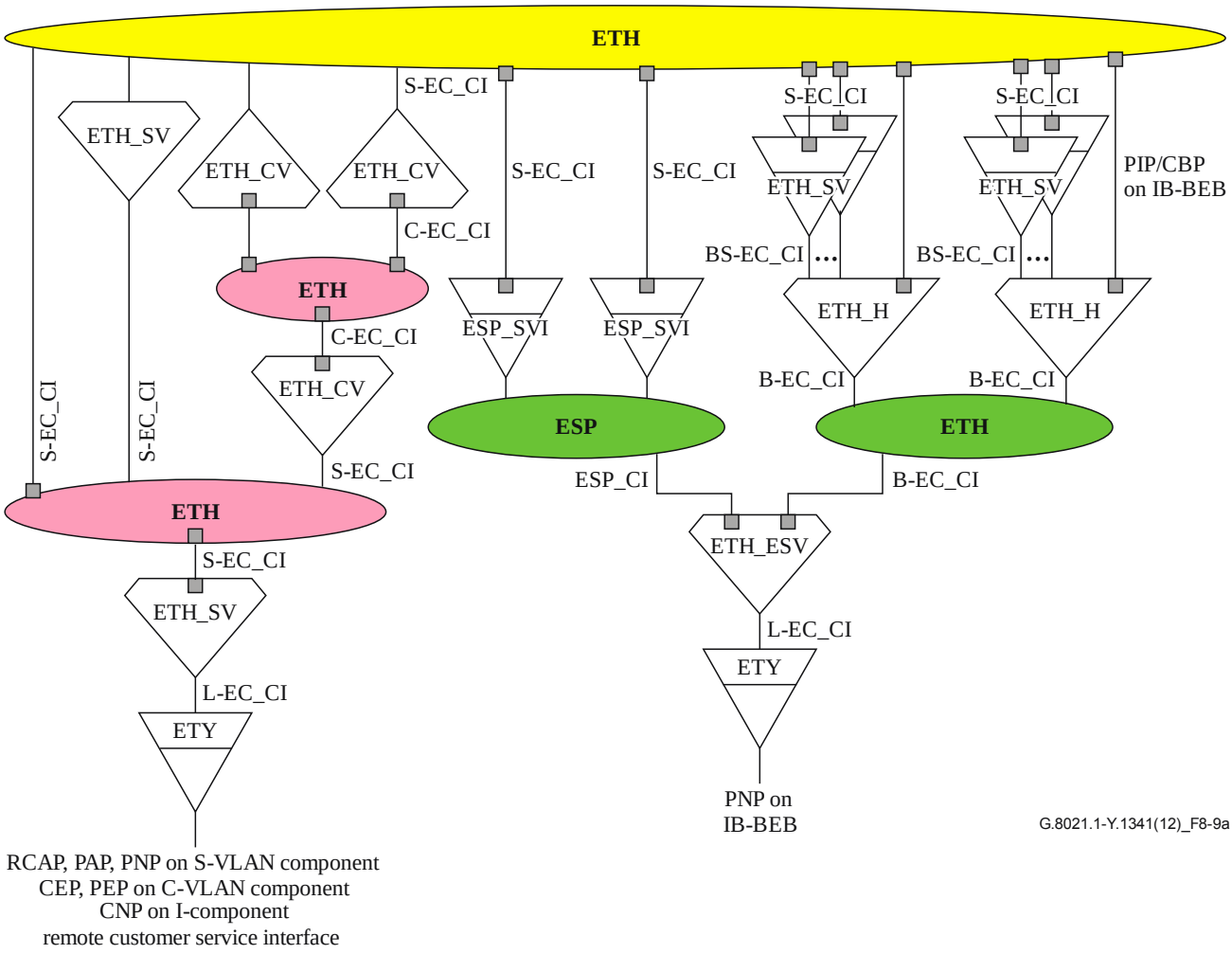


Figure 8-9a – RCSI IB-BEB – layer processor and edge processor functions

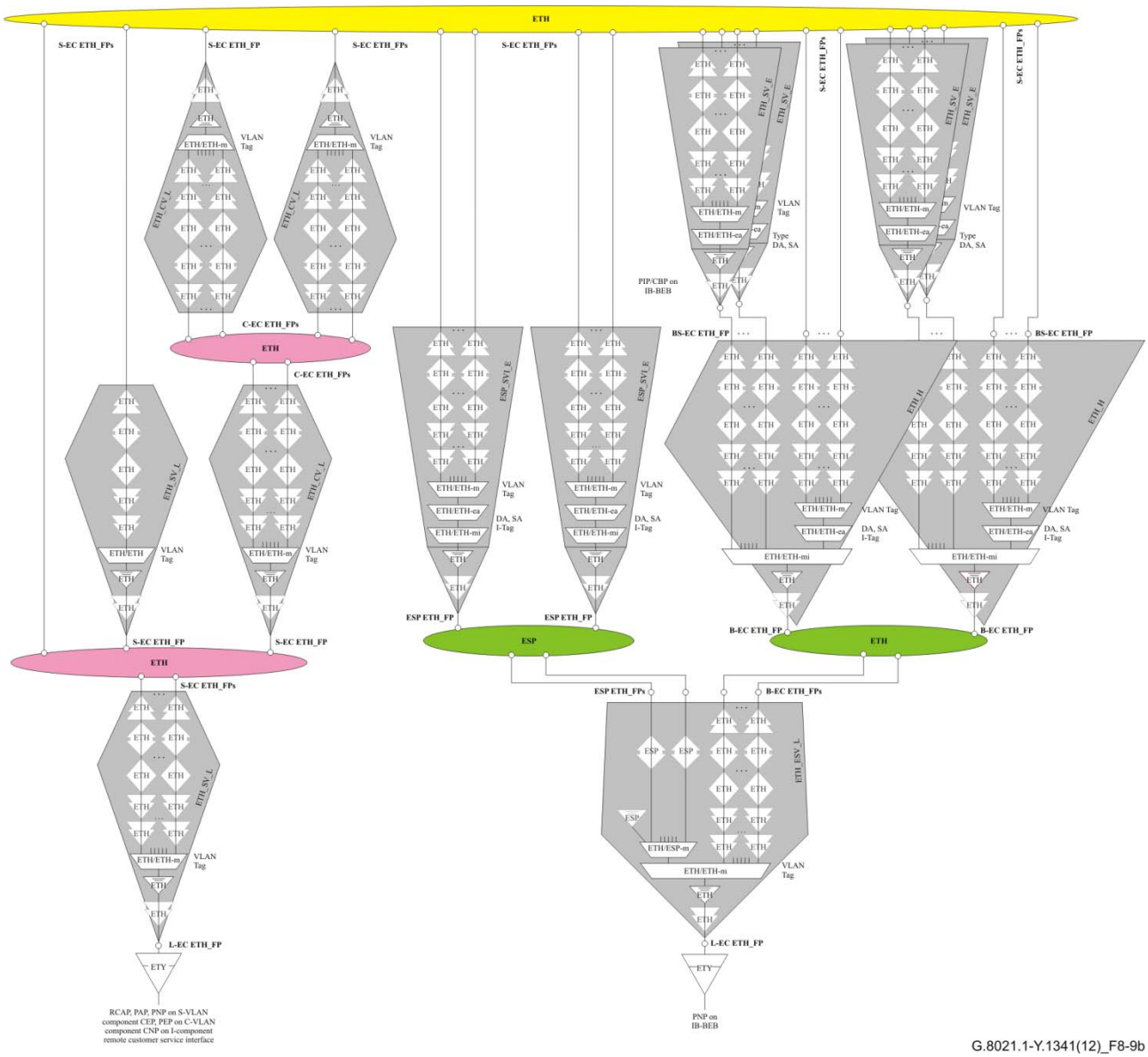


Figure 8-9b – RCSI IB-BEB– ITU-T G.8021 atomic functions

8.10 RCSI I-type backbone edge bridge (RCSI I-BEB)

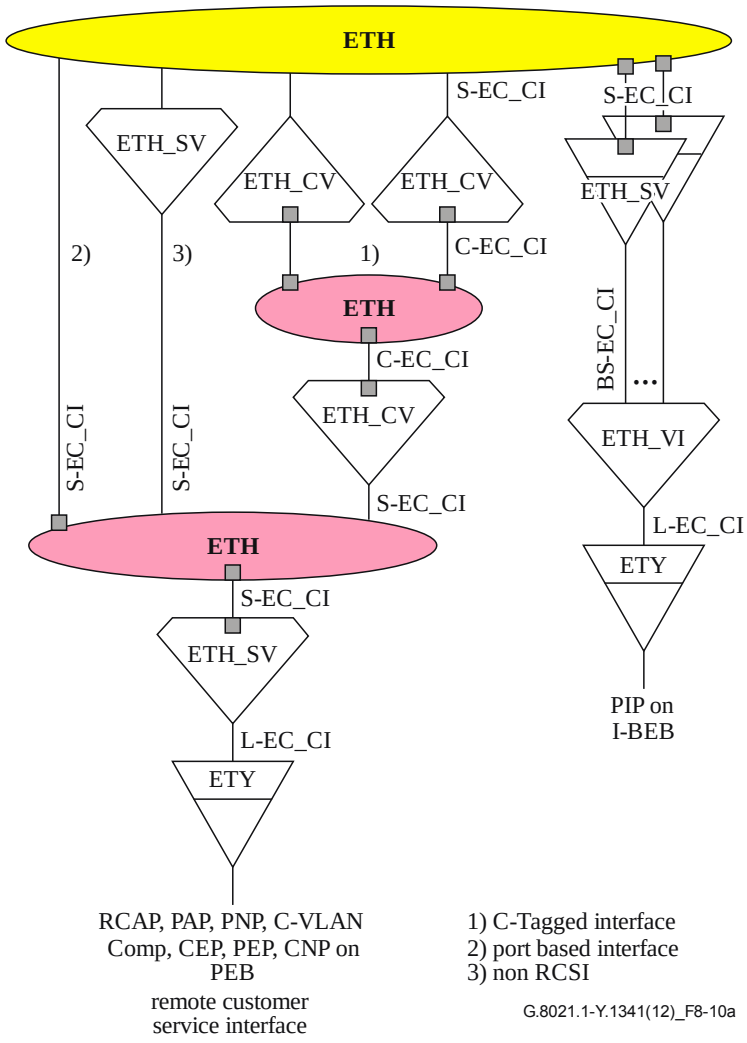


Figure 8-10a – RCSI I-BEB – layer processor and edge processor functions

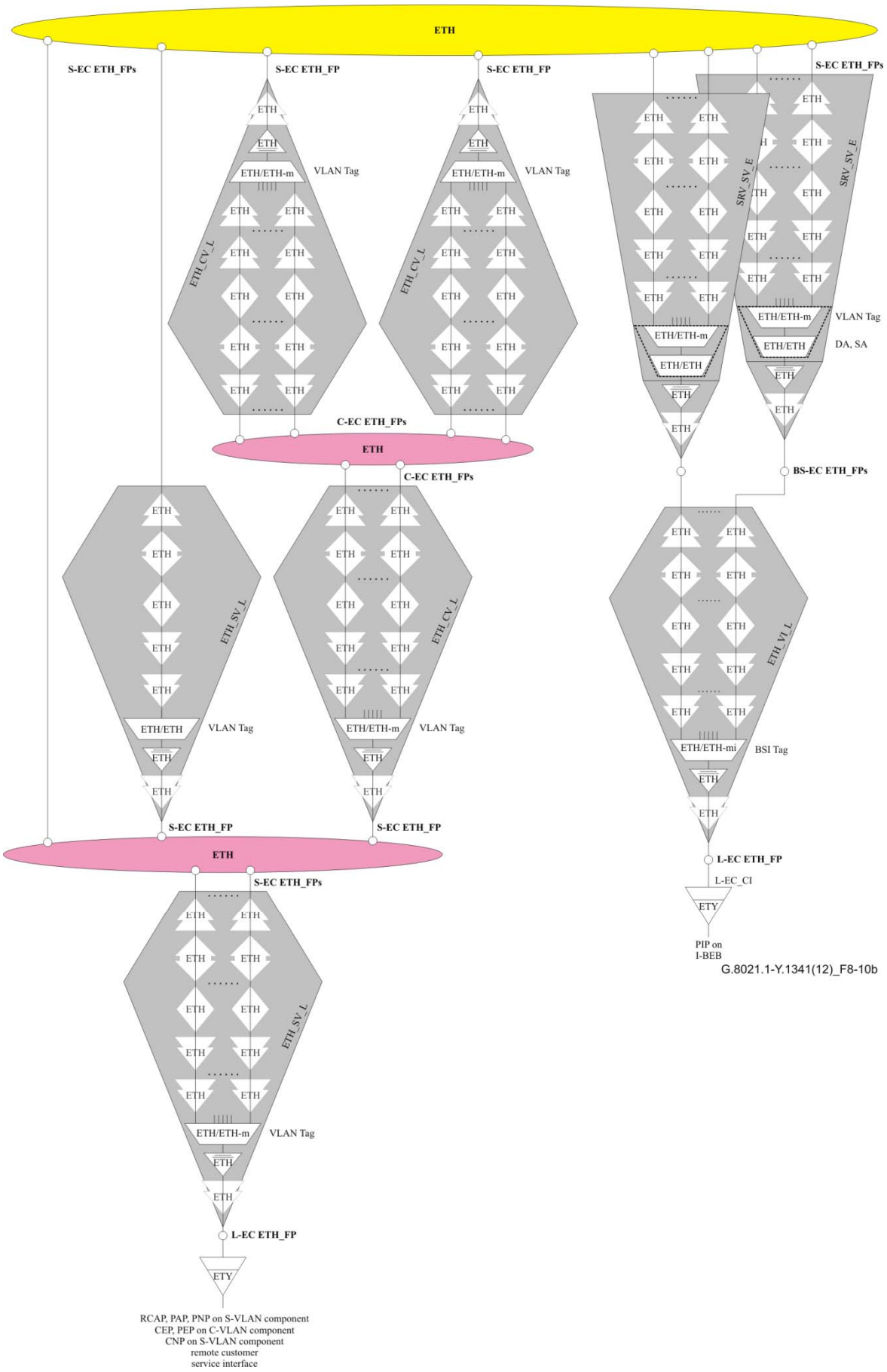


Figure 8-10b – RCSI I-BEB – ITU-T G.8021 atomic functions

8.11 T-type backbone edge bridge (T-BEB)

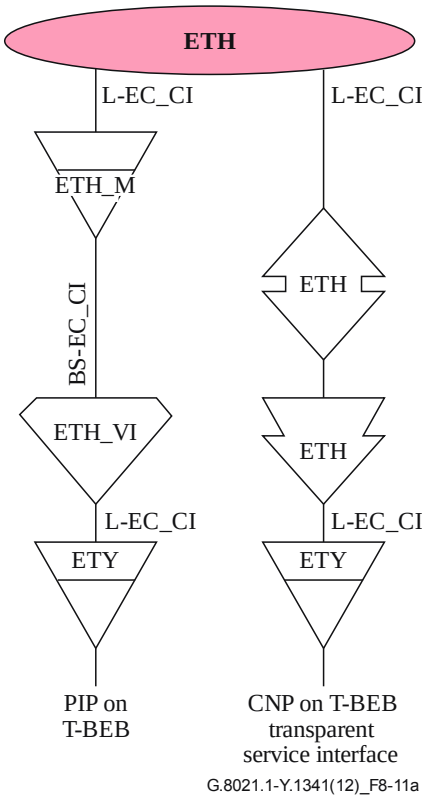


Figure 8-11a – T-BEB – layer processor and edge processor functions

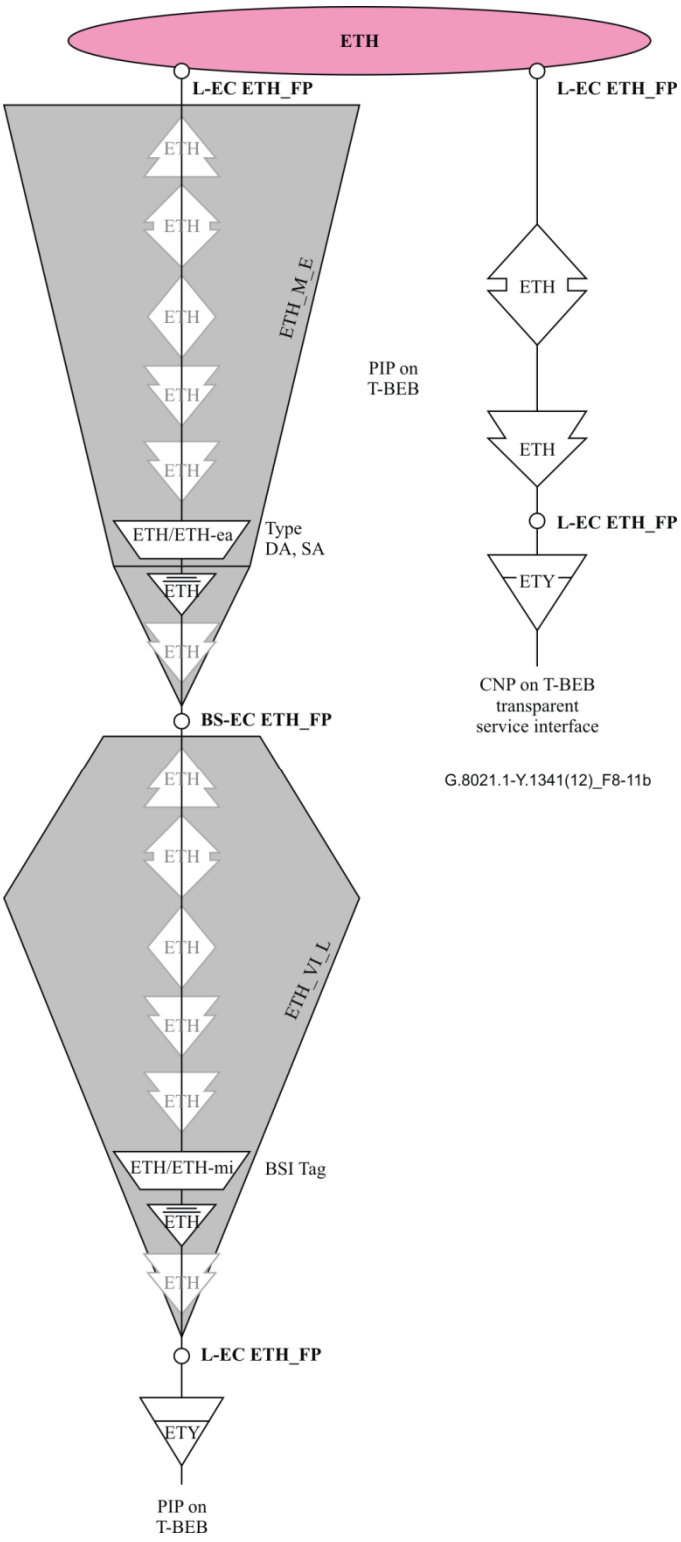


Figure 8-11b – T-BEB – ITU-T G.8021 atomic functions

8.12 TB-type backbone edge bridge (TB-BEB)

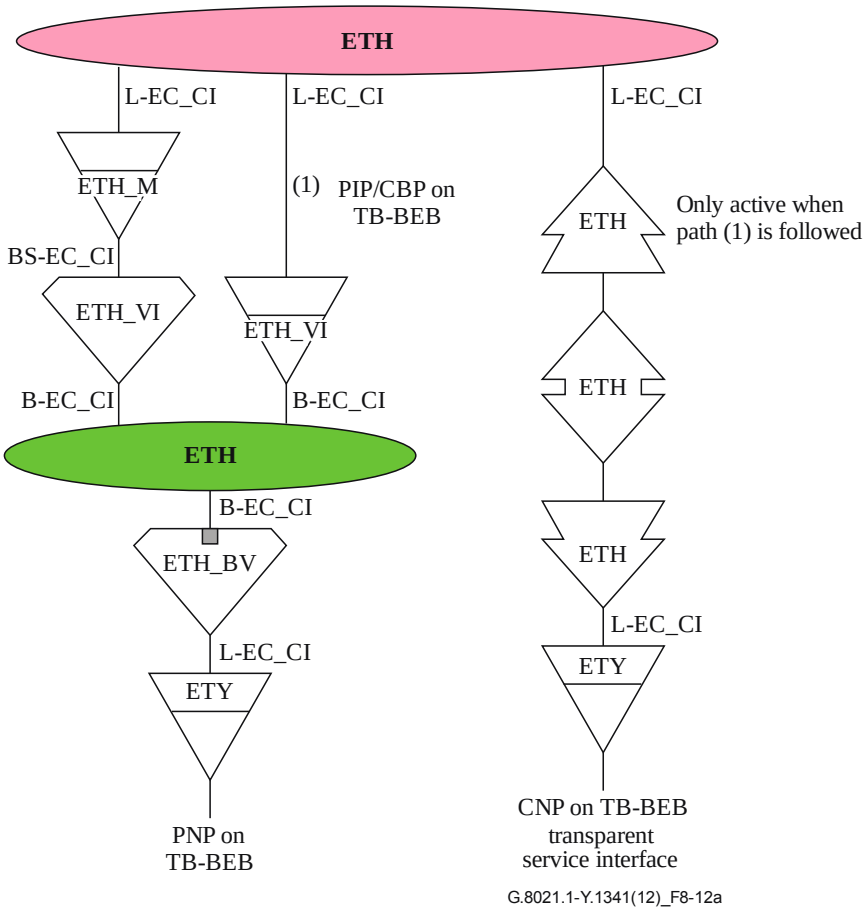


Figure 8-12a – TB-BEB – layer processor and edge processor functions

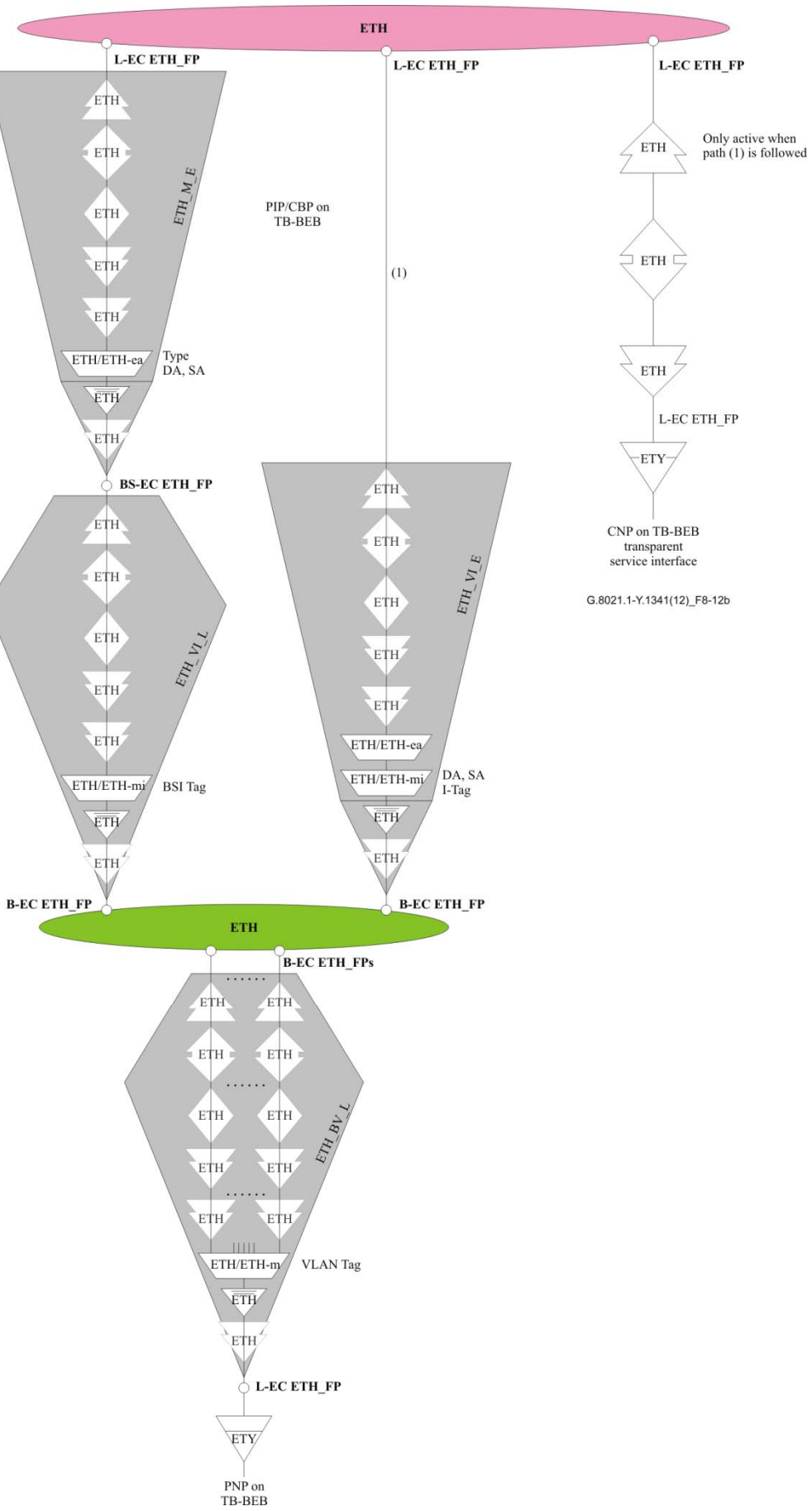


Figure 8-12b – TB-BEB – ITU-T G.8021 atomic functions

8.13 Backbone core bridge (BCB)

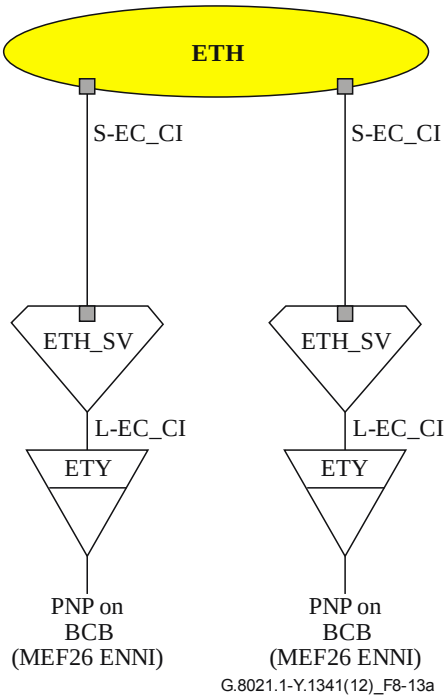


Figure 8-13a – BCB – layer processor and edge processor functions

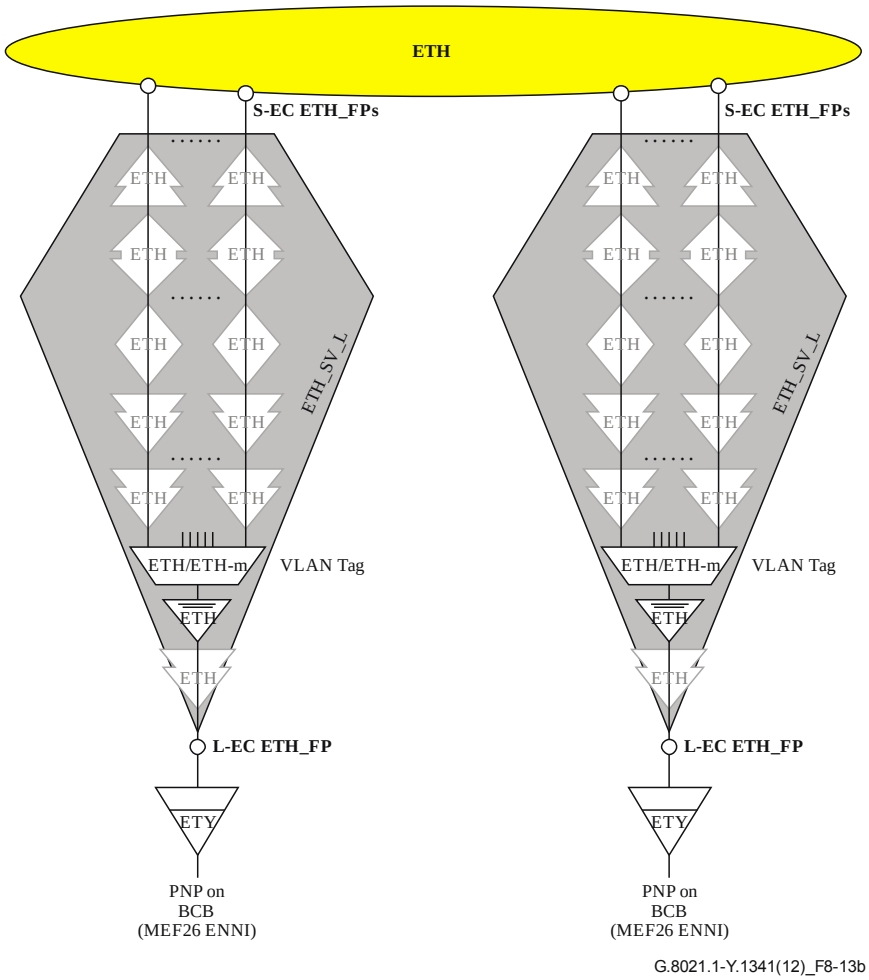


Figure 8-13b – BCB – ITU-T G.8021 atomic functions

9 Operations, administration, maintenance and provisioning

For detailed information on operations, administration and maintenance (OAM) processes for Ethernet layers, refer to [ITU-T G.8013], and for connectivity fault management (CFM) to [IEEE 802.1Q], [MEF 30] and [MEF 35].

10 Protection switching

For detailed information on Ethernet protection switching, refer to [ITU-T G.8031] (linear protection), [ITU-T G.8032] (ring protection switching), and [b-ITU-T G-Sup.52] (ring protection switching).

11 Control plane

Typically transport Ethernet equipment does not implement xSTP from [IEEE 802.1Q]. Instead, each node is directly provisioned using the management plane.

However, it may be beneficial to implement the more advanced shortest path bridging (SPB) control plane defined in [IEEE 802.1aq], or use generalized multiprotocol label switching (GMPLS) specifically for provider backbone bridging with traffic engineering (PBB-TE) [IEEE 802.1Q] defined in [IETF RFC 6060].

Appendix I

Examples of IEEE 802.1Q equipment

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

The following figures provide diagrams showing the IEEE 802.1Q bridge types. These diagrams correspond to the set of figures in clause 8.

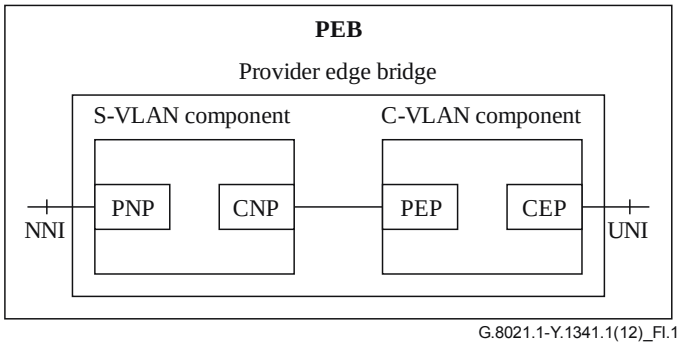


Figure I.1 – Provider edge bridge (PEB)

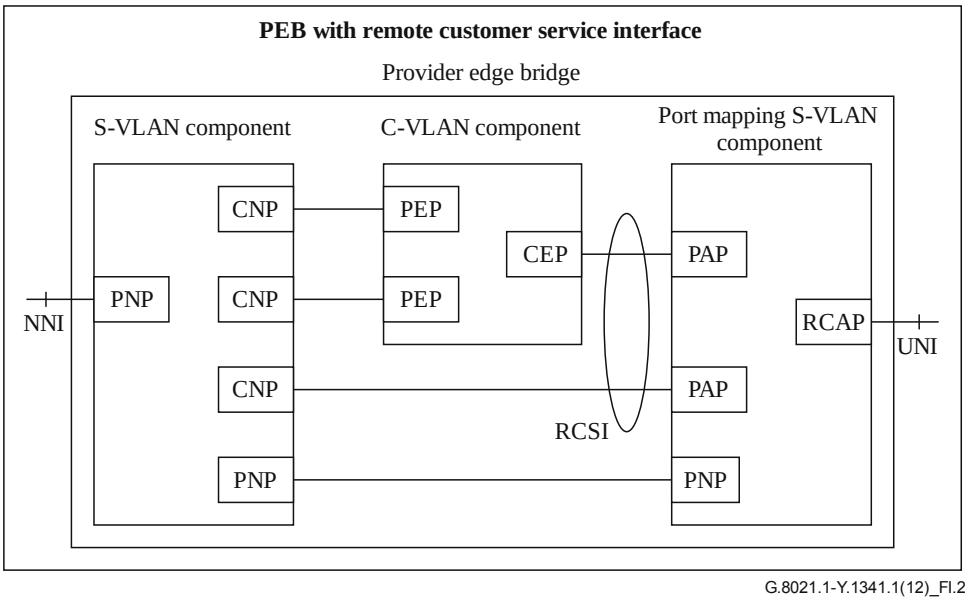


Figure I.2 – RCSI provider edge bridge (PEB)

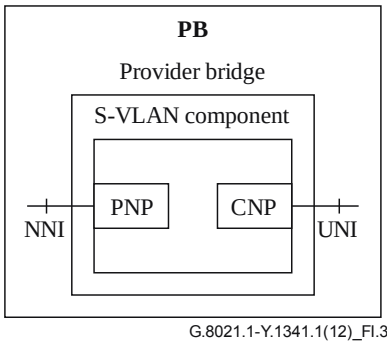


Figure I.3 – Provider bridge (PB)

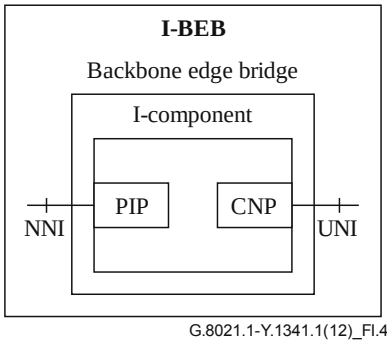


Figure I.4 – I-type backbone edge bridge (I-BEB)

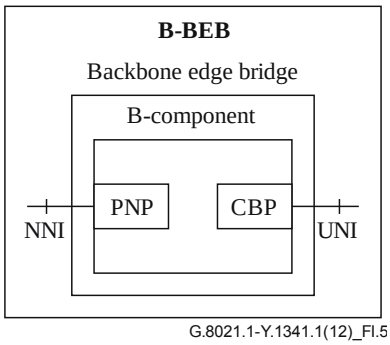


Figure I.5 – B-type backbone edge bridge (B-BEB)

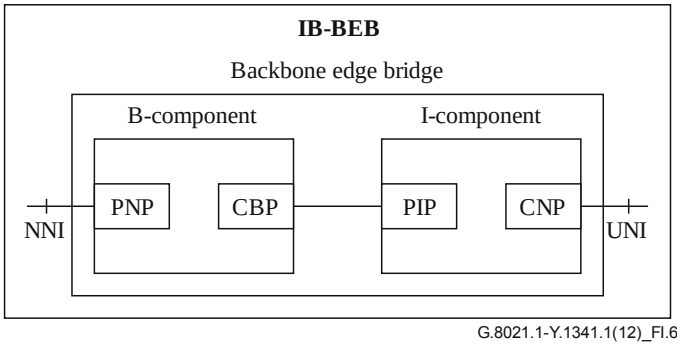


Figure I.6 – IB-type backbone edge bridge (IB-BEB)

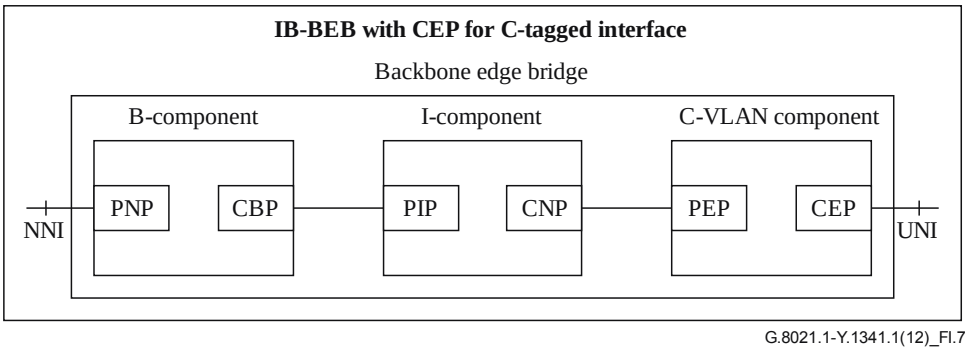


Figure I.7 – IB-BEB with CEP

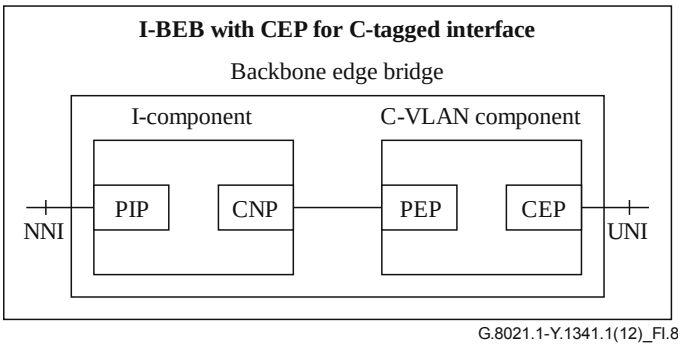


Figure I.8 – I-BEB with CEP

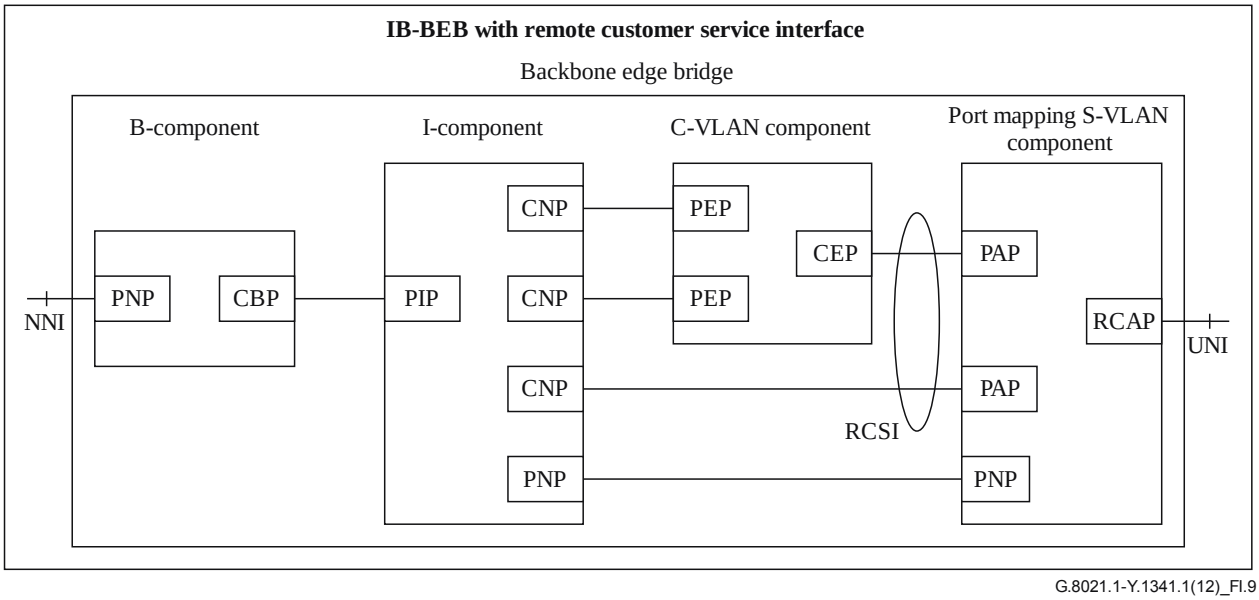


Figure I.9 – RCSI IB-type backbone edge bridge (RCSI IB-BEB)

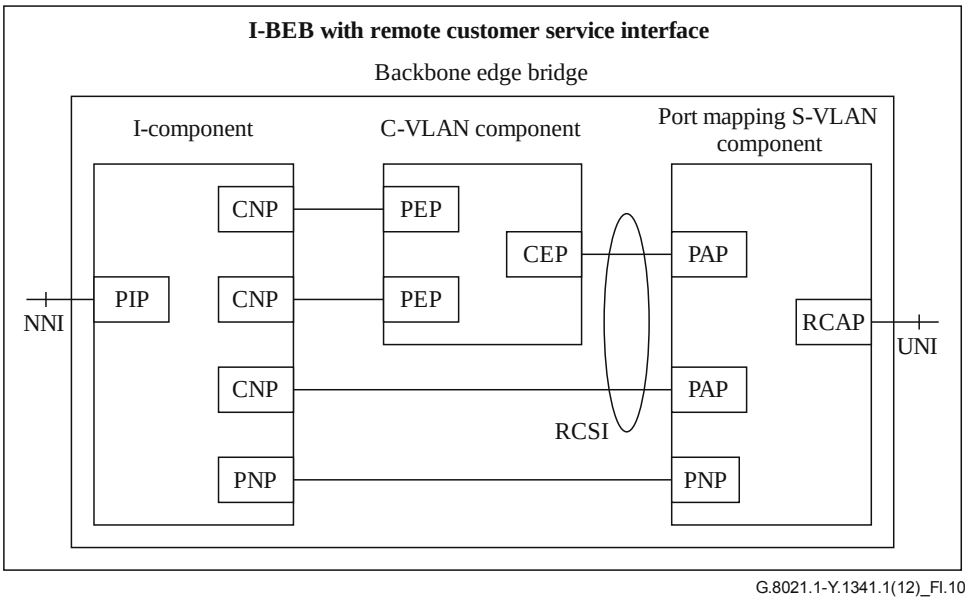


Figure I.10 – RCSI I-type backbone edge bridge (RCSI I-BEB)

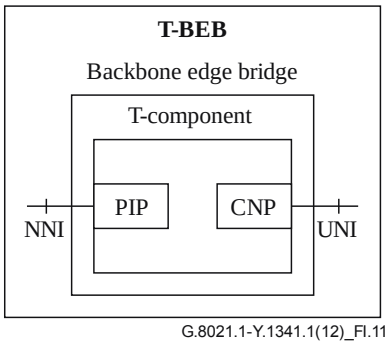


Figure I.11 – T-type backbone edge bridge (T-BEB)

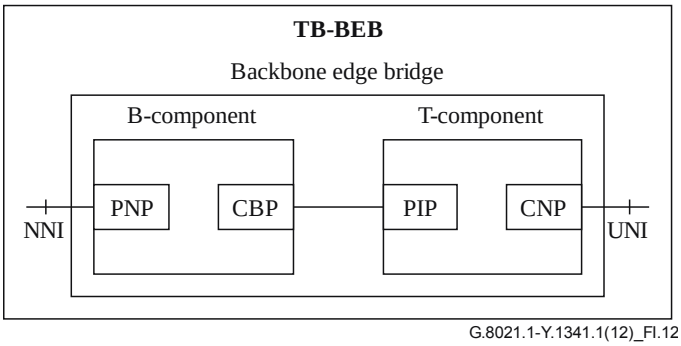


Figure I.12 – TB-type backbone edge bridge (TB-BEB)

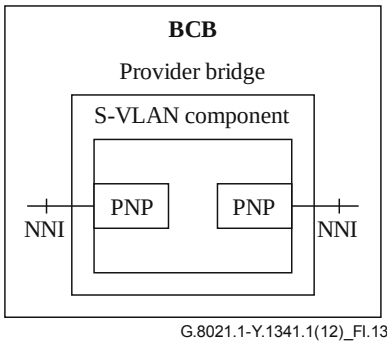


Figure I.13 – Backbone core bridge (BCB)

Appendix II

IEEE 802.1Q provider network considerations

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

II.1 OAM

In a provider backbone bridging (PBB) network or a provider backbone bridging with traffic engineering (PBB-TE) network, interconnected via physical links (e.g., [IEEE 802.3], OTN), OAM may be instrumented at several layers, such as:

- S-VLAN, per S-VID
- Backbone service instance (BSI), per I-SID
- B-VLAN, per B-VID
- Ethernet switched path (ESP), per <ESP-DA, ESP-SA, ESP-VID> tuple
- Link maintenance domain levels

To support exhaustive fault isolation capabilities within PBB or PBB-TE networks, OAM at both the BSI and B-VLAN/ESP layers, is necessary. Refer to [IEEE 802.1Q] clauses 26.8 and 26.9 for more details.

PBB networks can support a peering NNI handoff, interconnected via I-tagged interfaces. Refer to [IEEE 802.1Q] clause 26.6.2 for more details. In order to provide for fault isolation between peered PBB networks, it is important that BSI I-SID layer OAM is instrumented.

II.2 Network hierarchy and scalability

To interconnect customer networks in a scalable manner, PBB/PBB-TE was defined to address the 4094 services scaling limitation in metro PB networks. This was achieved by supporting the multiplexing of PB S-VLANs into PBB BSIs, followed by the multiplexing of those BSIs into PBB B-VLANs or PBB-TE ESPs. Further, a hierarchal structure for PBB/PBB-TE was defined in order to allow multiple levels of PBB/PBB-TE networks. Refer to [IEEE 802.1Q] clause 26.6.1 for more details. Specifically, Figure 26-1 from [IEEE 802.1Q] illustrates this network hierarchy.

Note that both PBB B-VLANs and PBB-TE ESPs can be deployed in the same network by partitioning the B-VID space accordingly.

Obviously, if BSIs are not multiplexed into PBB B-VLANs or PBB-TE ESPs and are instead mapped 1-to-1 (I-SID↔B-VID/ESP), then the network scalability is significantly reduced since only a combined maximum of 4094 BSIs (i.e., the B-VID space) can be supported.

Further, if the PBB or PBB-TE network is overlaid on an existing PB network, rather than deployed between subtending PB networks, then the network scalability is reduced yet again. This is because the combination of BSIs and PB services is limited to 4094 (i.e., the B-VID space and S-VID space are one and the same because the tags are identical).

Appendix III

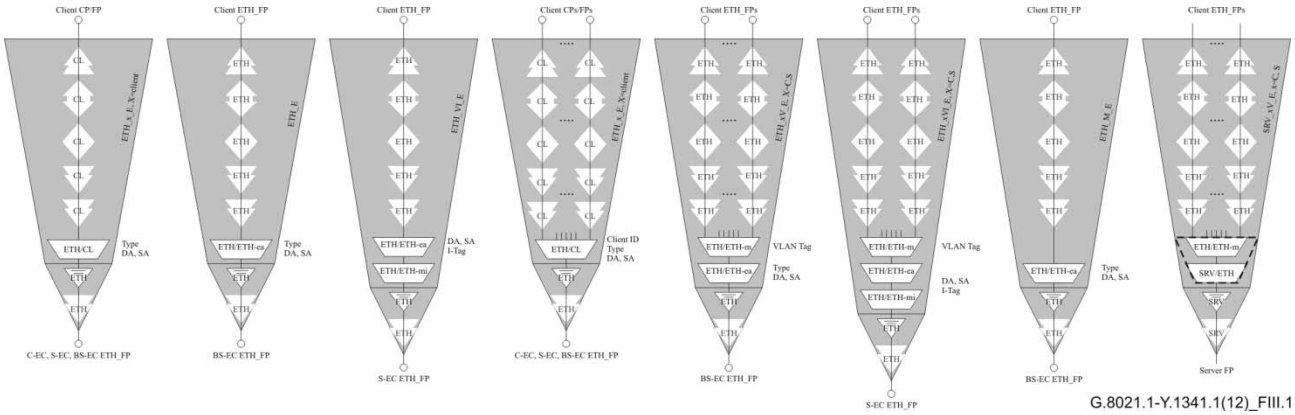
Layer processor and edge processor to ITU-T G.8021 atomic functions expansion

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

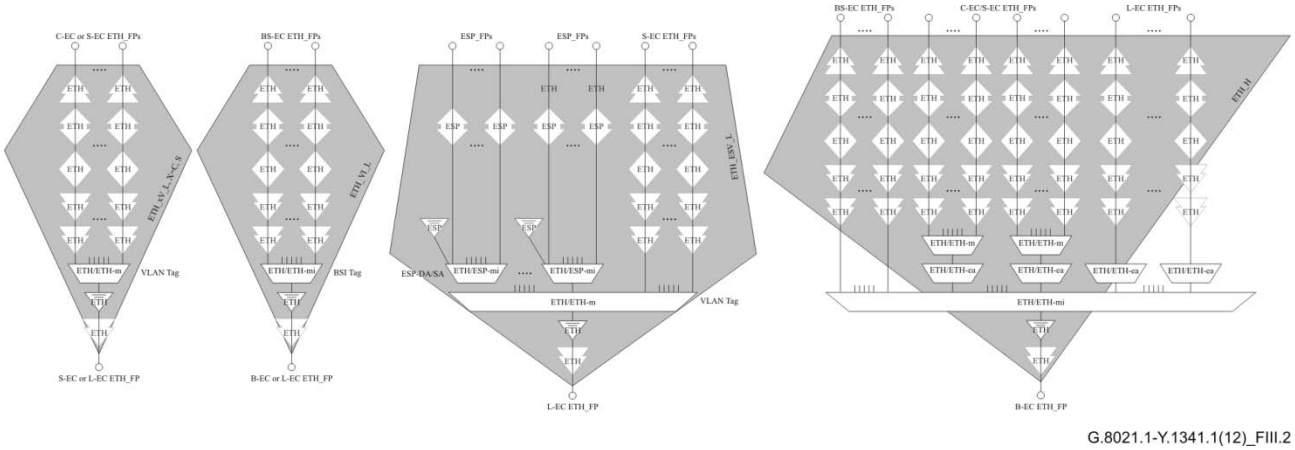
This Recommendation uses several large functions to simplify the diagrams. These functions are not atomic, and each contained function is available for use individually should that be required.

Contained functions which are light grey are optional and need not appear in all implementations. This allows for MIPs and MEPs to be instantiated as required while not requiring a separate drawing for each and every possible OAM configuration.

The signal names C-EC, S-EC, BS-EC, B-EC, L-EC are defined in [ITU-T G.8012.1]. These symbols contain transport functions providing for full layer encapsulation.



These symbols contain functions that only provide tag stacking and do not create a new layer boundary.



Bibliography

[b-ITU-T G-Sup.52] ITU-T G-series Recommendations – Supplement 52 (2012), *Ethernet ring protection switching.*

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