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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT GENERATION NETWORKS

Internet protocol aspects – Operation, administration and maintenance

Requirements for OAM functions in Ethernet-based networks and Ethernet services

ITU-T Recommendation Y.1730

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ITU-T Recommendation Y.1730

Requirements for OAM functions in Ethernet-based networks and Ethernet services

Summary

This Recommendation provides the motivations and requirements for user-plane operation, administration, and maintenance (OAM) functionality for ETH layer in Ethernet-based networks and Ethernet services. This Recommendation includes the requirements for OAM functions for the point-to-point and multipoint-to-multipoint maintenance entities (MEs) including both dedicated and shared access. It is noted that this Recommendation does not address the administration aspects of OAM.

Source

ITU-T Recommendation Y.1730 was approved on 10 January 2004 by ITU-T Study Group 13 (2001-2004) under the ITU-T Recommendation A.8 procedure.

Keywords

ETH, Ethernet, EPL, EPLAN, ETY, EVPL, EVPLAN, maintenance entity, OAM.

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ITU-T Recommendation Y.1730

Requirements for OAM functions in Ethernet-based networks and Ethernet services

1 Scope

This Recommendation provides the motivations and requirements for user-plane operation, administration, and maintenance (OAM) functionality for ETH layer in Ethernet-based networks and Ethernet services. This Recommendation includes the requirements for OAM functions for the point-to-point and multipoint-to-multipoint maintenance entities (MEs) including both dedicated and shared access. It is noted that this Recommendation does not address the administration aspects of OAM.

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.

[1] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

[2] ITU-T Recommendation G.806 (2000), *Characteristics of transport equipment – Description methodology and generic functionality*.

[3] ITU-T Recommendation G.809 (2003), *Functional architecture of connectionless layer networks*.

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

3 Definitions

3.1 This Recommendation uses the terms defined in ITU-T Rec. G.805:

a) link

b) trail

3.2 This Recommendation uses the terms defined in ITU-T Rec. G.806:

a) anomaly

b) defect

c) failure

d) fault cause

3.3 This Recommendation uses the terms defined in ITU-T Rec. G.809:

a) CLPS

b) CO-CS

c) CO-PS

d) flow domain

e) flow point

f) link flow

g) termination flow point

4 Symbols and abbreviations

This Recommendation uses the following abbreviations:

AP	Access Point
BPDU	Bridge Protocol Data Unit
CBR	Constant Bit Rate
CLPS	Connectionless Packet Switched
CO-CS	Connection-Oriented Circuit Switched
CO-PS	Connection-Oriented Packet Switched
DoS	Denial of Service
EPL	Ethernet Private Line
EPLAN	Ethernet Private LAN
ETH	Ethernet MAC layer network (connectionless)
ETH_CI	ETH Characteristic Information as defined in ITU-T Rec. G.8010/Y.1306
ETY	Ethernet PHY layer network (connection-oriented)
EVPL	Ethernet Virtual Private Line
EVPLAN	Ethernet Virtual Private LAN
FD	Flow Domain
FP	Flow Point
FT	Flow Termination
GARP	Generic Attribute Registration Protocol
LACP	Link Aggregation Control Protocol
LAN	Local Area Network
LF	Link Flow
MAC	Media Access Control
ME	Maintenance Entity
NC	Network Connection
NMS	Network Management System
NNI	Network Node Interface
OAM	Operation, Administration and Maintenance
PHY	Ethernet Physical layer entity
SLA	Service Level Agreement

TFP	Termination Flow Point
TT	Trail Termination
UNI	User Network Interface

5 Reference networks

This Recommendation specifies the requirements for OAM functions which are applied to point-to-point and multipoint-to-multipoint ETH flows. Figure 1 provides a layered network perspective of a point-to-point flow according to the methodology of ITU-T Rec. G.8010/Y.1306. In this particular example, network elements A and D, which are placed in customer premises, are associated with ETH TFPs and the ingress and egress of a network flow.

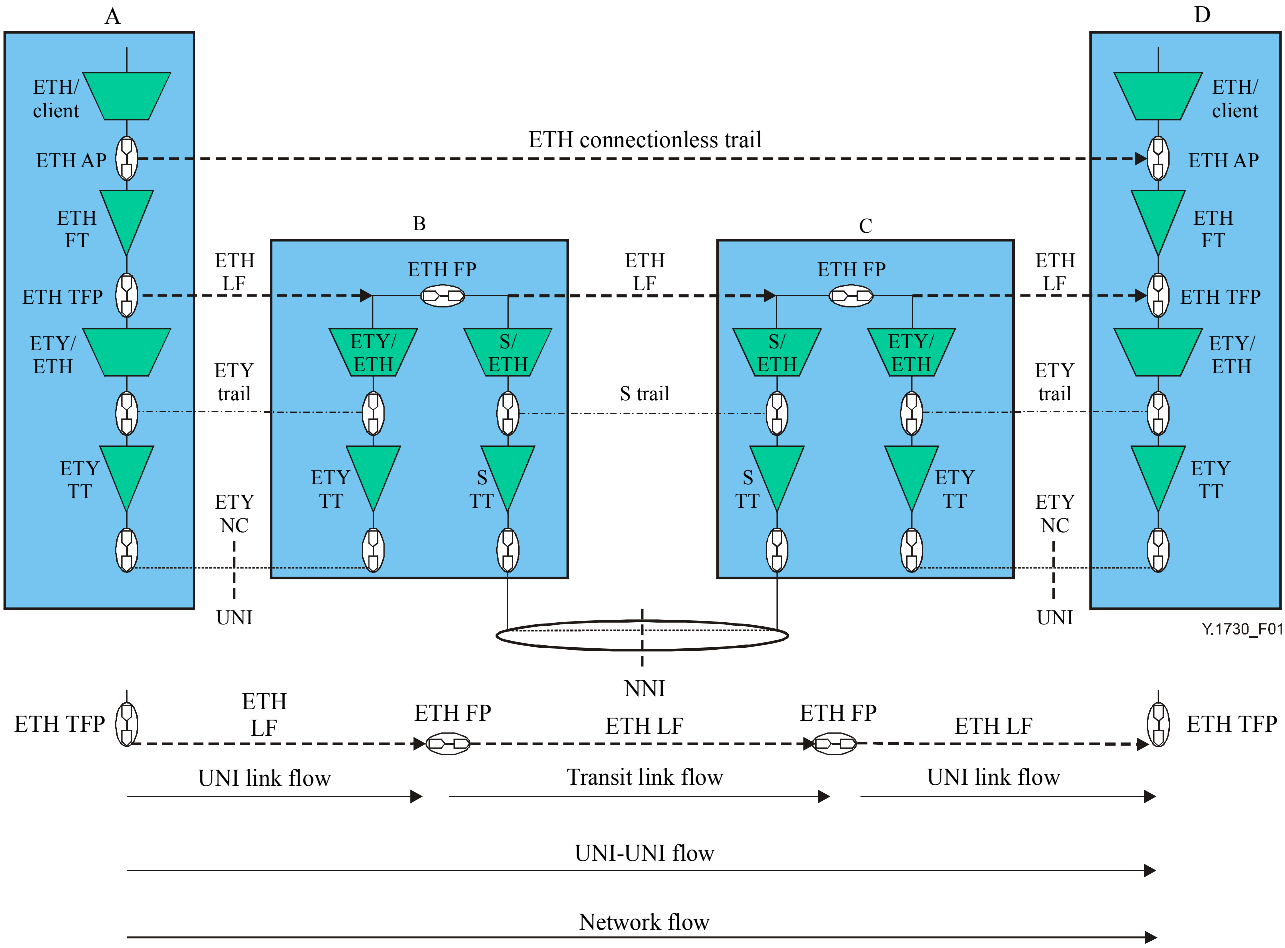

Figure 1/Y.1730 – Example of point-to-point ETH flow reference model (1)

Note that between the network elements B and C, which are placed at the edges of the provider's network, the ETH link flow is supported by a single server layer technology S. S may be connection-oriented circuit switched, connection-oriented packet switched, or connectionless. S may itself be supported by lower layer networks. Also note that although ETY is used for the server layer from A to B and from C to D in this example, it does not preclude the use of other server layers for these portions. This flexibility applies to all the examples in this Recommendation.

A second case of a flow is illustrated in Figure 2. Here the network elements A and D, which are placed in user premises, are associated with ETH FPs, indicating that they are associated with bridging. In this case the "UNI-UNI" flow is between flow points rather than termination flow points. As such the UNI-UNI flow is not the same as the network flow.

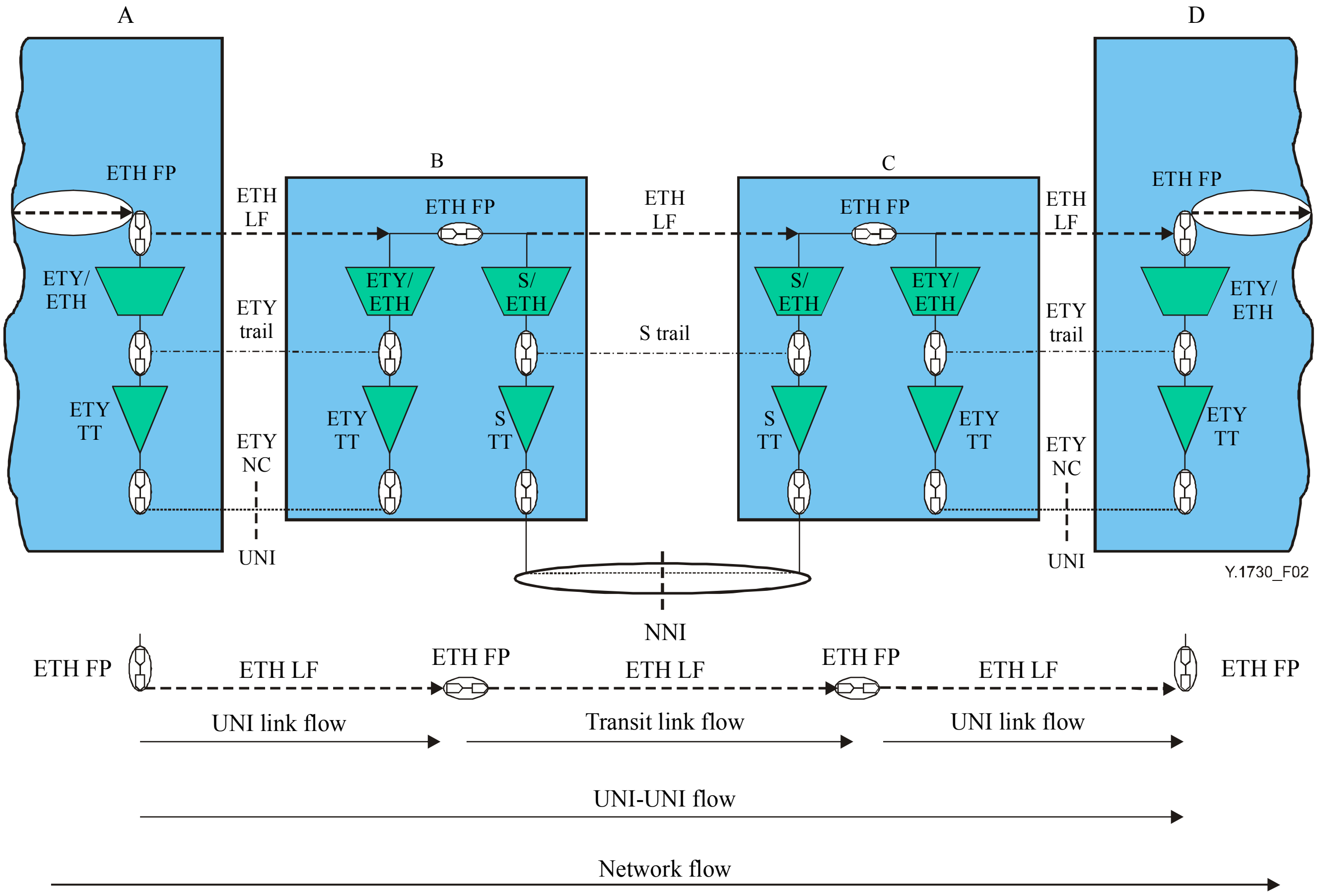

Figure 2/Y.1730 – Example of point-to-point ETH flow reference model (2)

In both the cases above there is a single server technology between the network elements B and C. Reference models where ETH link flows are supported by different server layer technologies, S and Z, are as illustrated in Figures 3 and 4. The difference between Figures 3 and 4 is whether the network elements A and E are associated with termination flow points or flow points.

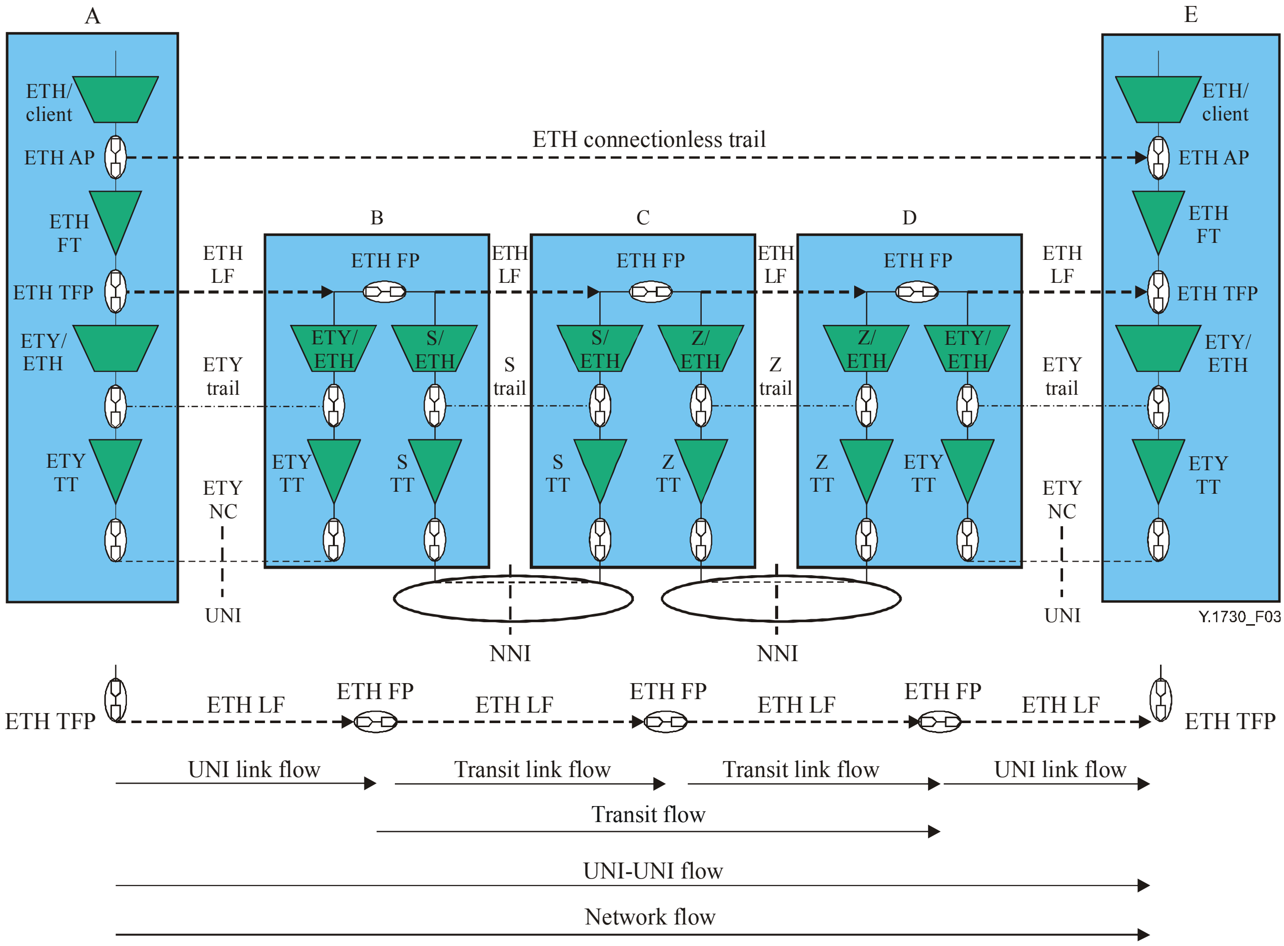

Figure 3/Y.1730 – Example of point-to-point ETH flow reference model (3)

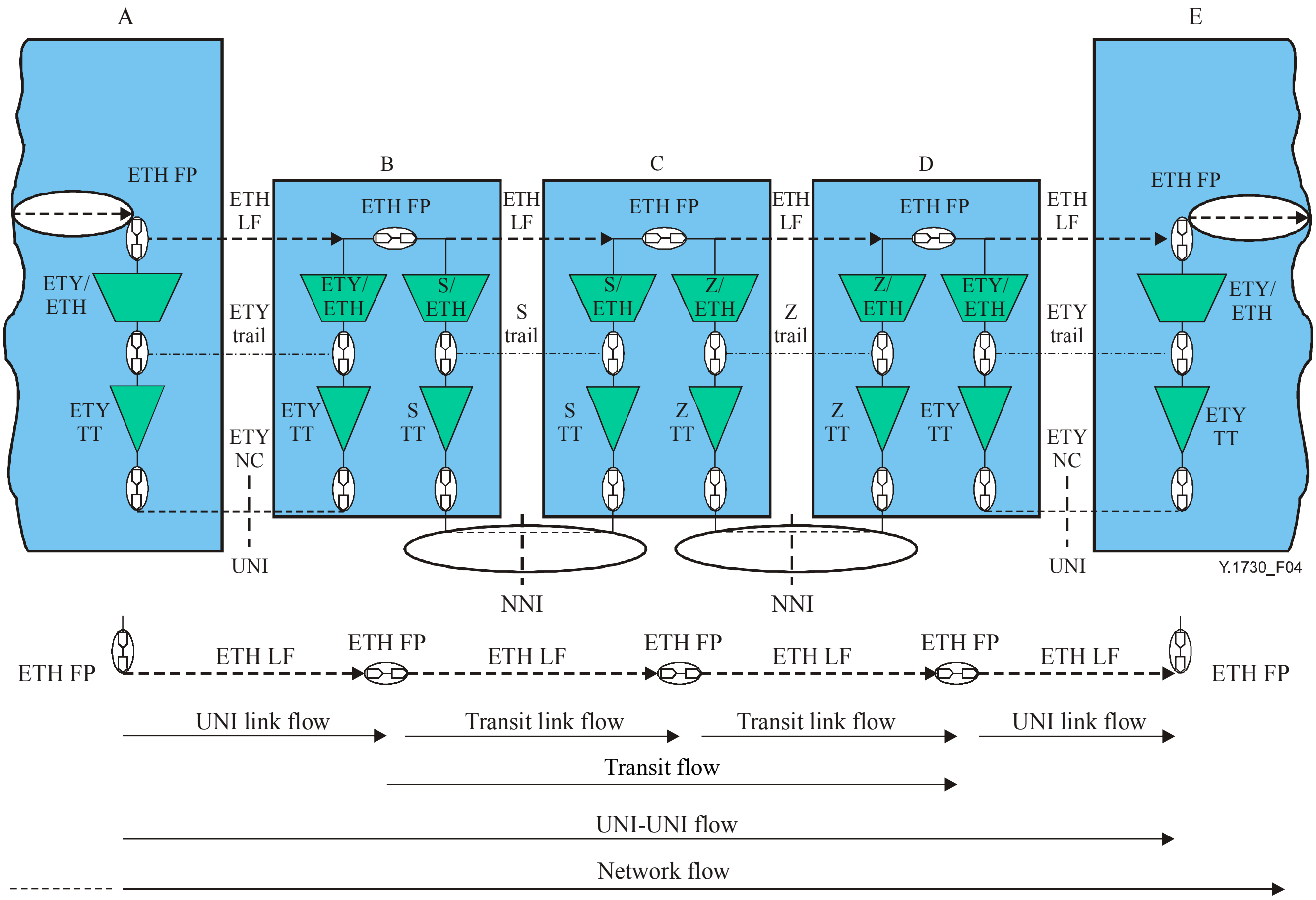

Figure 4/Y.1730 – Example of point-to-point ETH flow reference model (4)

Figure 5 shows the functional model of the hand-off portion between two providers. A and B denote the network elements placed at the boundary. It should be noted that the server layer between the hand-off points can be any ETH server layer although ETY is used in this example.

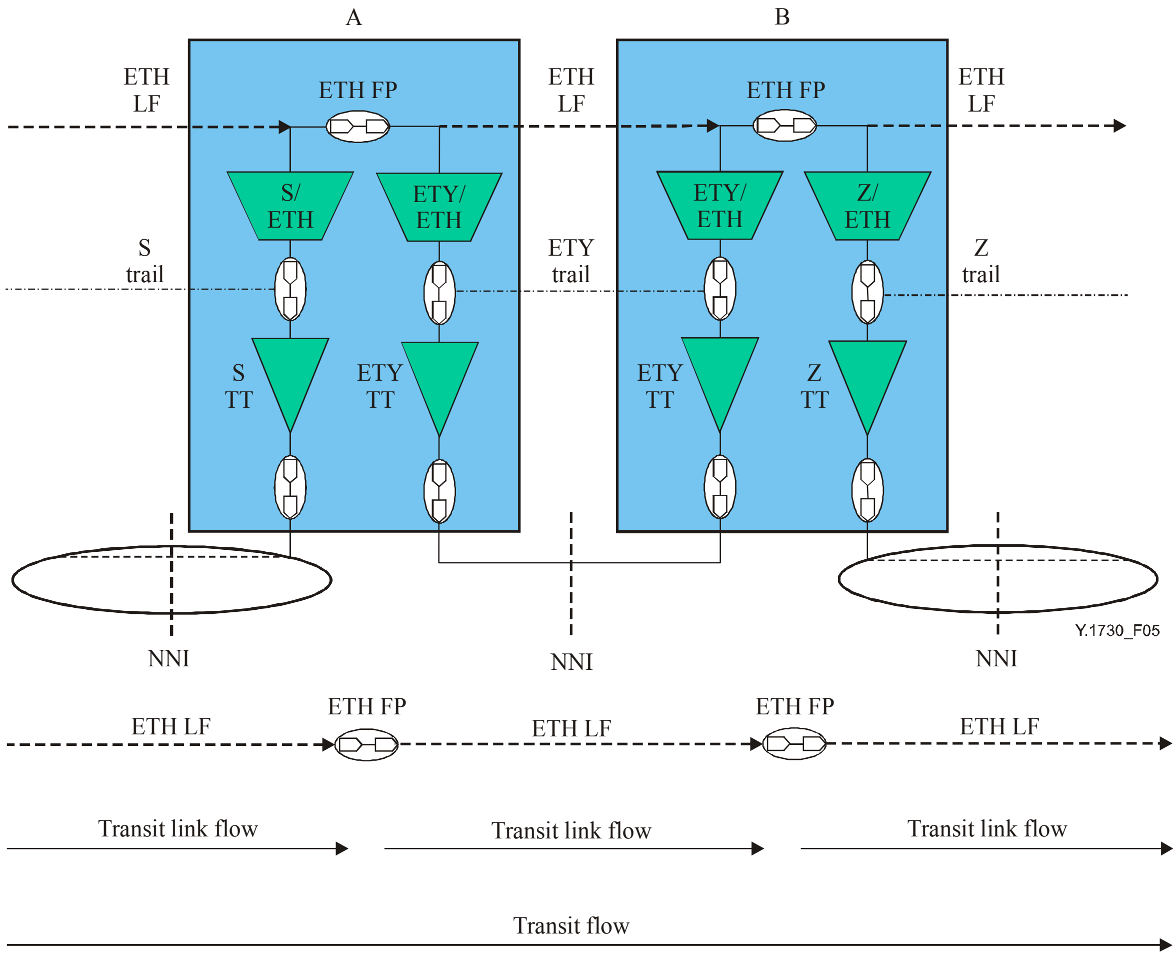

Figure 5/Y.1730 – Example of hand-off point reference model

The view of the reference models in terms of layer networks and the relationships can be simplified by considering only the flows present in the ETH layer network (single layer network view). This is illustrated in Figures 6 and 7. Figure 6 is the ETH layer network view of Figures 1 and 2 while Figure 7 is the ETH layer network view of Figures 3 and 4 (different server layer technologies).

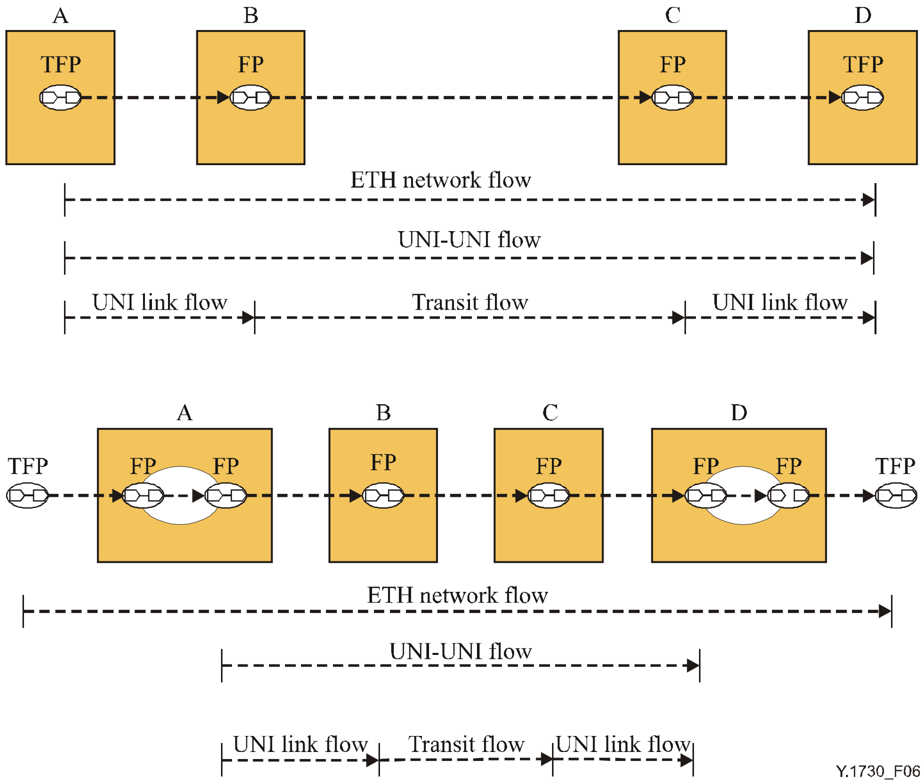

Figure 6/Y.1730 – Examples of point-to-point flow reference models (1 and 2) in the ETH layer network (single layer network view)

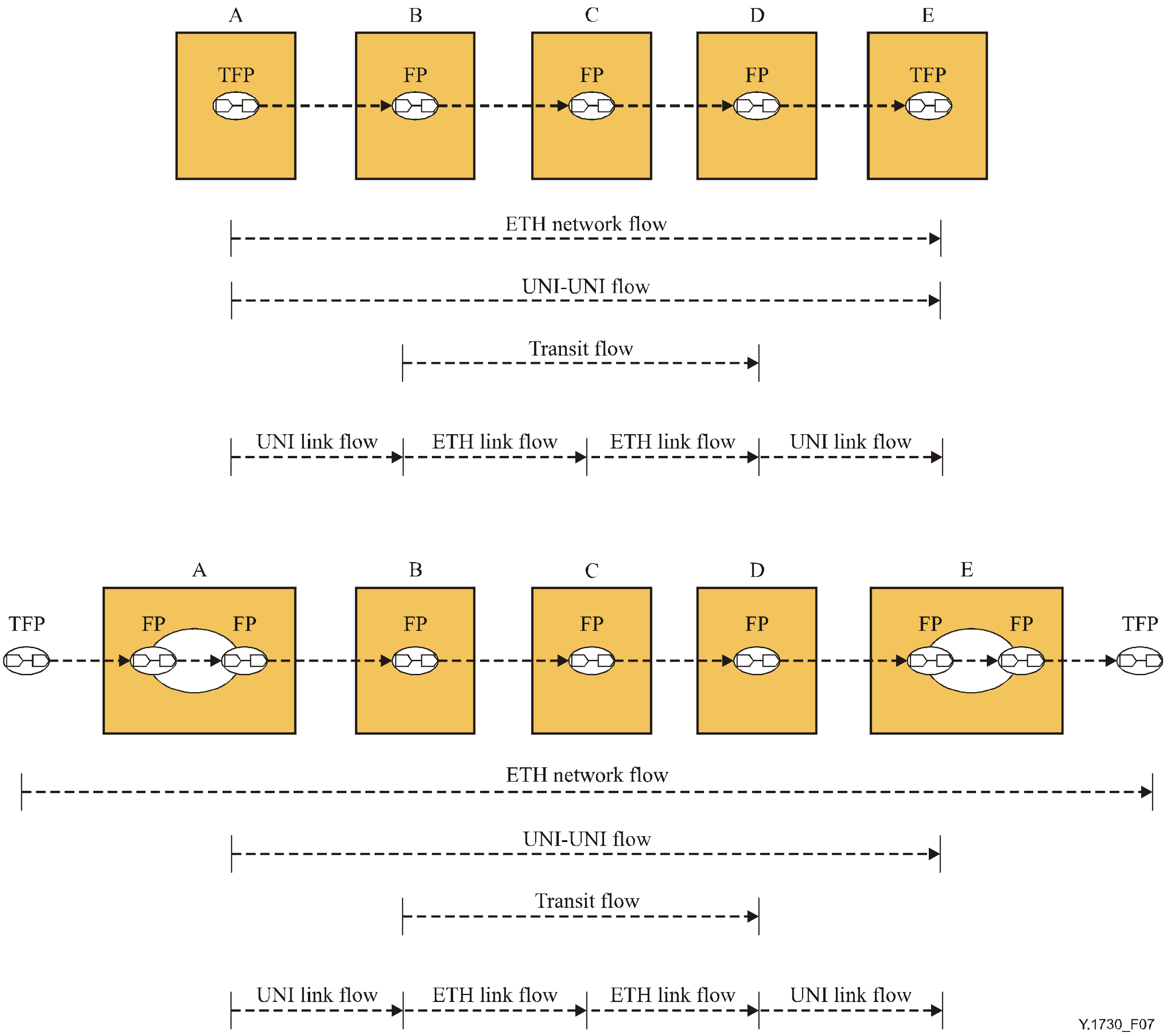

Figure 7/Y.1730 – Examples of point-to-point flow reference models (3 and 4) in the ETH layer network (different server layer technologies)

This single layer network view is used to describe the multipoint-to-multipoint case. This is illustrated in Figure 8. The ETH flow domain (FD) is present as a provider network. In this figure, network elements A, B, C, D, E and F are network elements owned by each user. A to E are end stations while F is a bridge (matrix FD). G, H and I are provider network elements placed at the edge of the provider FD. J is a network element placed in the core of the provider's network. G to J are bridges (matrix FDs).

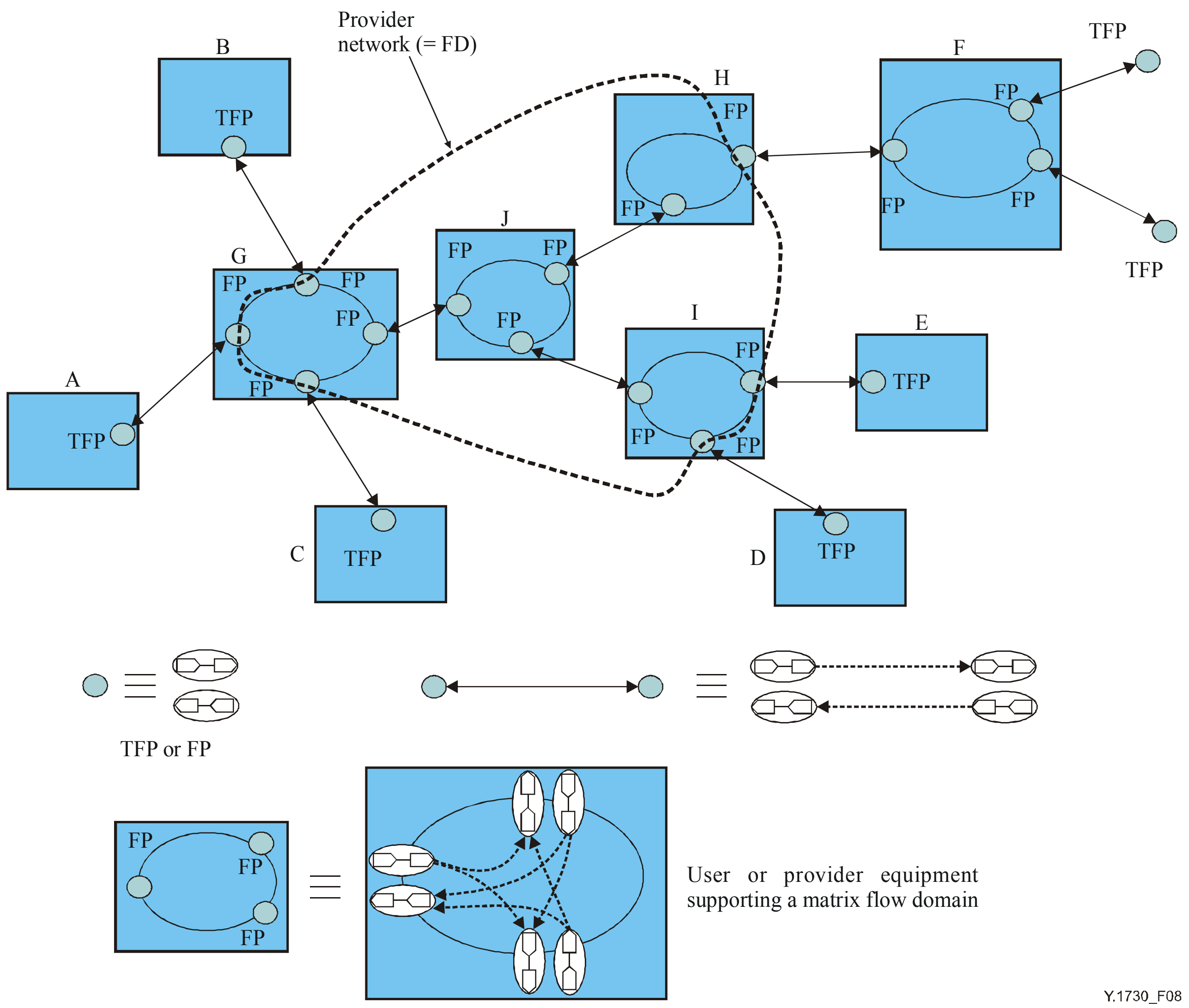

Figure 8/Y.1730 – Multipoint-to-multipoint reference model in the ETH layer network

6 Point-to-point and LAN service types

There are two point-to-point service classes: Ethernet private line (EPL) and Ethernet virtual private line (EVPL). These may be further classified as providing a full rate or fractional rate service. The reference model for these services is that of Figures 6 and 7.

There are two LAN service classes provided by multipoint-to-multipoint flows, Ethernet private LAN (EPLAN) and Ethernet virtual private LAN (EVPLAN). The reference model for these services is that of Figure 8.

These services are described in Appendix II.

7 Motivation for OAM functionalities for Ethernet-based networks

It is recognized that OAM functionality is important in public networks for ease of network operation, for verifying network performance, and to reduce operational costs. OAM functionality is especially important for networks that are required to deliver (and hence be measurable against) network performance and availability objectives. In order to offer a reliable Ethernet service that can support the requirements of a service level agreement (SLA), it is necessary that the Ethernet service has its own OAM capabilities.

The major motivations for Ethernet OAM are discussed further below.

1) Ethernet provides a unique connection-oriented layer network, ETY, and a connectionless layer network, ETH, and hence there will be failure modes that are only relevant to Ethernet. In general, lower-layer (server-layer) or higher-layer (client-layer) OAM mechanisms cannot act as a substitute for Ethernet OAM functionality. This observation is also critical to ensure that network technologies can evolve independently.
2) Operators need to determine Ethernet availability and network performance, noting that network performance metrics are only meaningful when the service is in the available state. This information may also be used for accounting and billing purposes to ensure that customers are not inappropriately charged for degraded services or service outages.
3) Reduce operating costs, by allowing efficient detection, handling, and diagnosis of defects. Lack of automatic defect detection and handling forces operators to increase their engineering and support workforce, and hence increases overall operating costs.
4) Reduce the duration of defects and thus improve the availability performance.
5) Demonstrate a commitment to provide customer traffic security/confidentiality by ensuring that any defect that results in misdirected customer traffic is desired to be detectable/diagnosible and leads to appropriate actions, e.g., squelching of traffic where relevant.
6) Minimize the number of defects that are not automatically detected and still require a customer to report a problem. Proactive maintenance actions like this item also help drive down operating costs by minimizing the opportunity for incorrect defect diagnosis, and (like the previous item) they also promote customer trust of an operator.
7) Allow differentiation of defects arising from lower layers to those from within the Ethernet layered network structure to be considered, so that more intelligent protection-switching actions can be used.

8 General requirements for Ethernet ETH layer OAM functions

The following requirements should be satisfied by Ethernet OAM:

1) Support of client/server OAM relationships between Ethernet and its server layers (e.g., signal fail/signal degrade). Applicability of this item to LAN services is for further study. Applicability of this item in the case where the server layer is connection-oriented and the client layer is a connectionless LAN service is for further study.

2) Both on-demand and continuous connectivity verification of communication between edges of OAM maintenance entities to confirm that defects do not exist across the monitored Ethernet maintenance entity.

3) If a defect occurs, it is necessary to detect it, diagnose it, localize it, notify network management systems, and take corrective actions appropriate to the type of defect. The primary objective is to reduce operating costs by minimizing service interruptions, operational repair times, and operational resources.

4) In the case of the service provider UNI-UNI OAM maintenance entity, OAM mechanisms provided should ensure (as far as reasonably practicable) that customers should not have to detect failures. It is therefore necessary that defects associated with this entity are detected and notified automatically by the service provider.

5) The following anomalies should be automatically detected and corresponding defect states, with well-defined entry/exit criteria and appropriate consequent actions, should be defined:
   - simple loss of connectivity;
   - unintended self-replication (e.g., looping, denial of service (DoS) attack);
   - lost frames;
   - errored frames;
   - misinserted frames (e.g., misinsertion of a frame into unintended VLANs).

6) It should be noted that not all of these OAM functions need to be present for a certain service.

7) OAM functions should detect anomalies which impact the transport of user ETH flows in the network. Ethernet OAM frames should be forwarded on the same route as the user ETH flow is forwarded.

8) A defect event in a given layer network should not cause multiple alarm events to be raised, nor cause unnecessary corrective actions to be taken, in any higher-layer level client-layer network. The Ethernet layer network should support alarm suppression for server layer sourced defects whose presence have been communicated by forward defect indication means. Ethernet layer network should support forward defect indication capability where possible.

9) OAM functions should be simple and easily configured (ideally automatically) to allow efficient scaling to large network sizes.

10) The use of Ethernet OAM functions should be optional for the operator. Network operators should be able to choose which OAM functions to use and which flows they apply them to.

11) Ethernet OAM functions should be backward compatible. The design of Ethernet OAM functions should ensure that Ethernet bridges that do not support such functions will be able to be configured to either silently discard the OAM frames addressed to an ETH (termination) flow point in this bridge, or let OAM frames pass through transparently if not addressed to an ETH (termination) flow point in this bridge without disturbing the user traffic or causing unnecessary actions.

12) There should be a capability to measure availability and network performance of a maintenance entity. Since network performance metrics are only meaningful when the Ethernet flow is in the available state, then the entry/exit of the available state and all appropriate consequent action (like the starting/stopping of network performance metric aggregation) should be specified.

13) The functionality of an Ethernet OAM flow should not be dependent on any specific server or client layer network. This is architecturally critical to ensure that layer networks can evolve (or new/old layer networks can be added/removed) without impacting other layer networks.

14) The functionality of an Ethernet OAM flow should be sufficiently independent of any specific control plane such that any changes in the control plane do not impose changes in user-plane OAM (including the case of no control plane). Like the previous requirement, this is also architecturally critical to ensure that user-plane and control-plane protocols can evolve (or new/old control-plane protocols added/removed) without impacting each other.

15) Connectivity status assessment should not be dependent on the dynamic behaviour of customer traffic.

16) The OAM functions should perform reliability even under degraded link conditions (e.g., error events).

17) If the UNI-to-UNI Ethernet flow is being transported over networks belonging to different operators, the one that offers the service to the customer should be aware of a service fault even if the fault and detection point are located in the network of another operator.

18) The "down" time of the service should be able to be recorded for performance and availability measurements.

19) OAM requirements should address both network operator and service provider constructs where a service provider can span across multiple network operator domains.

9 Requirements for ETH maintenance entities

The reference models indicate traffic flows. OAM flows can be inserted and extracted at the reference points, namely the ETH flow points and ETH termination flow points of the reference models. The (point-to-point or multipoint-to-multipoint) OAM flows represent the maintenance entities (MEs). The following ETH maintenance entities are defined:

– customer UNI-UNI maintenance entity in the ETH layer network between reference points on the customer side of the UNI;

– service provider UNI-UNI maintenance entity in the ETH layer network between reference points on the service provider network side of the UNI;

– segment OAM maintenance entity between ETH flow points. A segment may be:
  - between flow points on the boundary of a service provider network (access link ME);
  - between flow points on the boundaries of two adjacent service provider/network operator network elements or networks (intra-domain ME, inter-domain ME);
  - between any flow points as required.

Refer to ITU-T Rec. G.8010/Y.1306 for illustrations of maintenance entities within reference networks.

10 Required OAM functions

Necessary OAM functions for Ethernet services include:

10.1 Point-to-point services

- continuous connectivity check (CC);
- alarm suppression function;
- intrusive loopback and non-intrusive loopback;
- traceroute;
- discovery;
- performance monitoring;
- survivability function (e.g., protection switching, restoration, etc.).

10.2 Multipoint-to-multipoint services

- continuous connectivity check (CC);
- alarm suppression function;
- non-intrusive loopback;
- traceroute;
- discovery;
- performance monitoring;
- survivability function (e.g., protection switching, restoration, etc.).

11 Security aspects

The following items are related to security aspects:

- item 5 of clause 7;
- item 5 of clause 8.

In addition, the following items should be considered:

1) OAM should have mechanisms that make sure customers are not able to trigger any service provider/network operator OAM function.
2) OAM should have mechanisms that make sure service provider/network operator OAM flows, which are meant for their internal use, are confined within their networks and do not leak out to customers or other service providers/network operators.
3) OAM should have mechanisms to detect misdelivered flows.

Appendix I

Examples of the protocol stack reference model

Figure I.1 depicts examples of the protocol stack reference model for Ethernet services as defined by the IEEE Std 802. This reference model can be used to show the traffic flow through different protocol stack layers for the following types of traffic:

- user data traffic;
- user control traffic (such as user BPDUs, user-to-user OAM, UNI OAM, etc.);
- provider control traffic (e.g., provider OAM, provider BPDUs, provider GARP, etc.).

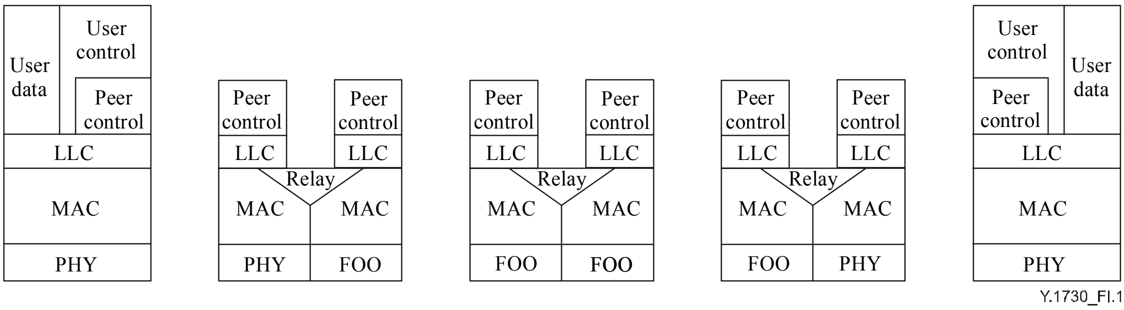

Figure I.1/Y.1730 – Protocol stack reference model

As can be seen from Figure I.1, Ethernet MAC sub-layer can reside on top of a variety of transport layers (e.g., referred to in the figure as FOO). The generic FOO transport layer can itself consist of one or more network layers.

User data traffic is injected/extracted at the user stations (end points) and with respect to the intermediate nodes it stays at the MAC sub-layer and does not go through any (sub-)layer above it (e.g., does not go through LLC or any layer above it).

User control traffic can be broken into two categories:

a) user-to-user control traffic; and

b) user-to-provider control traffic.

The first category of user control traffic is seen as user data by intermediate nodes and thus it stays within the MAC sub-layer with respect to the provider nodes. Some examples for this category of traffic are user OAM, user BPDU messages, and user GARP messages. The second category of user control traffic (user-to-provider control traffic) is intercepted by the first provider node and it gets passed to the control plane for processing. Some examples of user-to-provider control traffic are UNI OAM, LACP, 802.1X, and 802.3X.

Provider control traffic is the control traffic between different provider nodes. Depending on the type of the traffic, it can either stay at the MAC sub-layer with respect to the provider intermediate nodes or it can be passed to the upper layers for further processing. Some examples of this kind of traffic are provider's BPDUs, provider's GARP messages, and provider's OAM messages.

NOTE – The IEEE layers and model is different from the ITU-T Recs G.805/G.809 architectural model and layers. For example LLC, peer control, user control, and user data are not layers according to ITU-T Recs G.805/G.809.

Appendix II

Service description

The definition of Ethernet services is under study (Draft new ITU-T Rec. G.8011.1/Y.1307.1, *Ethernet over Transport – Ethernet Services Framework*, which is under development in ITU-T Q.12/15). This informal appendix summarizes the raw definitions of point-to-point (EPL, EVPL) and multipoint-to-multipoint (EPLAN, EVPLAN) Ethernet services as proposed when this Recommendation is approved.

II.1 Ethernet service

An Ethernet service is defined by a set of characteristics for an ETH flow.

II.2 Private service

A private service is characterized by:

- one or more ETH links, within the transport network, which are allocated to transport the ETH_CI of a single customer service instance;
- ETH links which are supported by CO-CS or CO-PS trails with a 1:1 relationship between ETH links and server layer trails;
- an ETH_CI which does not compete for bandwidth with the ETH_CI of other service instances.

II.3 Virtual private service

A virtual private service is characterized by:

- one or more ETH links, within the transport network, which are allocated to transport the ETH_CI of one or more customer service instances (N:1 relationship), and these ETH links are supported by CBR CO-CS or CO-PS trails;
- one or more ETH links, within the transport network, which are allocated to transport the ETH_CI of a single customer service instance. Each ETH link is supported by a non-CBR CO-PS or CLPS trail (1:1 relationship). Multiple of those non-CBR CO-PS or CLPS trails are supported by server layer CO-CS trails (N:1 relationship);
- an ETH_CI which competes for bandwidth with ETH_CI of other service instances.

Note that if the link resources allocated are sufficient, then the virtual private service will behave in a way that is similar to a private service.

II.4 Line service

A line service is a point-to-point service provided over ETH links within the provider network.

A line service has the following further characteristics:

- One (or more) ETH link(s) within the transport network is (are) allocated to transport the ETH_CI of one customer service instance, between two flow points.
- No additional ETH flow points can be added to the service.

An Ethernet Private Line (EPL) service is both a private service and a line service. An Ethernet Virtual Private Line (EVPL) service is both a virtual private service and a line service.

II.5 LAN service

A LAN service is a multipoint service provided over one or more ETH flow domains (and the ETH links between them) within the provider network.

A LAN service has the following further characteristics:

- One (or more) ETH link(s) within the transport network is (are) allocated to transport the ETH_CI of one customer service instance, between at least two flow points.
- ETH flow points can be added to/deleted from this service.

An Ethernet Private LAN (EPLAN) service is both a private service and a LAN service. An Ethernet Virtual Private LAN (EVPLAN) service is both a virtual private service and a LAN service.

Figure II.1 depicts the differences between a line service and a LAN service.

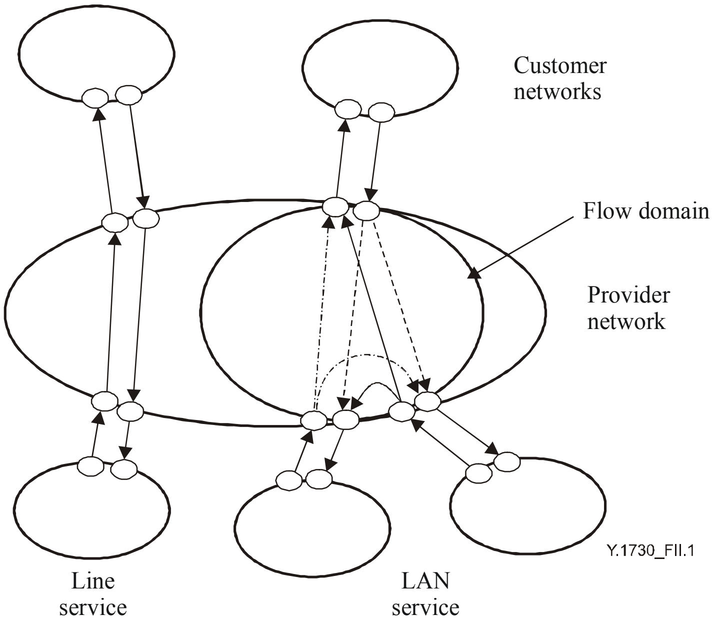

Figure II.1/Y.1730 – Line vs. LAN service

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– ITU-T Recommendation G.8011.1/Y.1307.1 (Draft), *Ethernet over Transport – Ethernet Services Framework*.

– IEEE Standard 802-2001, *IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture*.

– IEEE Standard P802.1D-2004, *IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges*.

NOTE 1 – 802.1D-2004 incorporates 802.1t and 802.1w.

– IEEE Standard 802.1Q-2003, *IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks*.

NOTE 2 – 802.1Q-2003 incorporates 802.1u, 802.1v, and 802.1s.

– IEEE draft Standard P802.1ad/D2.0, *Draft Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks – Amendment 4: Provider Bridges*.

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