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

Internet protocol aspects – Interworking

Ethernet-MPLS network interworking – User plane interworking

ITU-T Recommendation Y.1415

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ITU-T Recommendation Y.1415

Ethernet-MPLS network interworking – User plane interworking

Summary

This Recommendation addresses the required functions for network interworking between a client Ethernet network and an MPLS server network, specifically the user plane interworking mechanisms and procedures. One of the key aspects of network interworking is to provide network support for Ethernet services during the evolution of networks. Details of the interworking model and required interworking functions are described.

Source

ITU-T Recommendation Y.1415 was approved on 13 February 2005 by ITU-T Study Group 13 (2005-2008) under the ITU-T Recommendation A.8 procedure.

Keywords

Ethernet, Interworking, MAC frame, MPLS, Network Interworking, user plane.

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ITU-T Recommendation Y.1415

Ethernet-MPLS network interworking – User plane interworking

1 Scope

This Recommendation focuses on required functions for network interworking between a client Ethernet network and an MPLS server network, specifically the user plane interworking mechanisms and procedures. In particular, it specifies a list of requirements, interworking encapsulation formats and semantics and procedures for Ethernet [1] protocol data unit (PDU) interworking with MPLS. The interworking defined in this Recommendation is applicable to a point-to-point connection between two interworking functions (IWFs).

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] IEEE 802.3-2002, *IEEE Standard for Information technology – Telecommunications and Information Exchange between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*.

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

[3] ITU-T Recommendation Y.1411 (2003), *ATM-MPLS network interworking – Cell mode user plane interworking*.

[4] IEEE 802.1Q-2003, *IEEE standards for local and metropolitan area networks: Virtual bridged local area networks*.

[5] IETF RFC 3031 (2001), *Multiprotocol label switching architecture*.

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

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

[8] IEEE 802.1D-2004, *IEEE standard for local and metropolitan area networks: Media Access Control (MAC) Bridges*.

[9] ITU-T Recommendation Y.1710 (2002), *Requirements for Operation & Maintenance functionality in MPLS networks*.

[10] ITU-T Recommendation Y.1711 (2004), *Operation & Maintenance mechanism for MPLS networks*.

[11] ITU-T Recommendation Y.1730 (2004), *Requirements for OAM functions in Ethernet-based networks and Ethernet services*.

[12] IETF RFC 3032 (2001), *MPLS Label Stack Encoding*.

[13] ITU-T Recommendation G.8011.1/Y.1307.1 (2004), *Ethernet private line service*.

3 Definitions

This Recommendation defines the following terms:

3.1 egress IWF: The IWF where the Ethernet frames are retrieved from MPLS packets (MPLS-to-Ethernet direction).

3.2 flow: See ITU-T Rec. G.809 [2].

3.3 ingress IWF: The IWF where Ethernet frames are encapsulated into MPLS packets (Ethernet-to-MPLS direction).

3.4 interworking: See ITU-T Rec. Y.1411 [3].

3.5 Interworking Function (IWF): See ITU-T Rec. Y.1411 [3].

4 Abbreviations

This Recommendation uses the following abbreviations.

AP	Access Point
ATM	Asynchronous Transfer Mode
DIX	DEC/Intel/Xerox
ETH	Ethernet
EXP	Experimental Bits
FCS	Frame Check Sequence
FIFO	First-In First-Out
IWF	Interworking Function
LSP	Label Switched Path
LSR	Label Switching Router
MAC	Medium (Media) Access Control
MPLS	Multi-Protocol Label Switching
MTU	Maximum Transport Unit
OAM	Operation and Maintenance
PDU	Protocol Data Unit
QoS	Quality of Service
RFC	Request For Comments
S-bit	Stack bit
STP	Spanning Tree Protocol
TCP	Termination Connection Point
TDM	Time Division Multiplexing
TTL	Time To Live

5 Conventions

The term "Ethernet frame" as used in this Recommendation refers to both DIX and IEEE 802.3 MAC (Media Access Control) frames. Furthermore, Ethernet frames may be either tagged (e.g., IEEE 802.1Q [4]) or untagged.

6 Ethernet-MPLS interworking

Multi-protocol label switching (MPLS) technology [5] allows multiple technologies (such as IP, ATM, frame relay, TDM and Ethernet) to be supported over a single networking infrastructure. This Recommendation defines network interworking of MPLS with Ethernet.

Figure 6-1 provides general network architecture for Ethernet-MPLS network interworking where Ethernet networks are interconnected through an MPLS network. For the Ethernet-to-MPLS direction, the Ethernet frames are encapsulated into an MPLS packet by the interworking function (IWF). For the MPLS-to-Ethernet direction, the Ethernet frames are reconstructed from the MPLS packets by the IWF.

The Ethernet-to-MPLS IWF is architecturally located at a Network-Network Interface (NNI) reference point [6].

Figure 6-2 depicts the network functional architecture of Ethernet-MPLS interworking using the diagrammatic techniques of ITU-T Rec. G.805 [7].

Figure 6-3 depicts network reference model and protocol layers for Ethernet-MPLS user plane interworking.

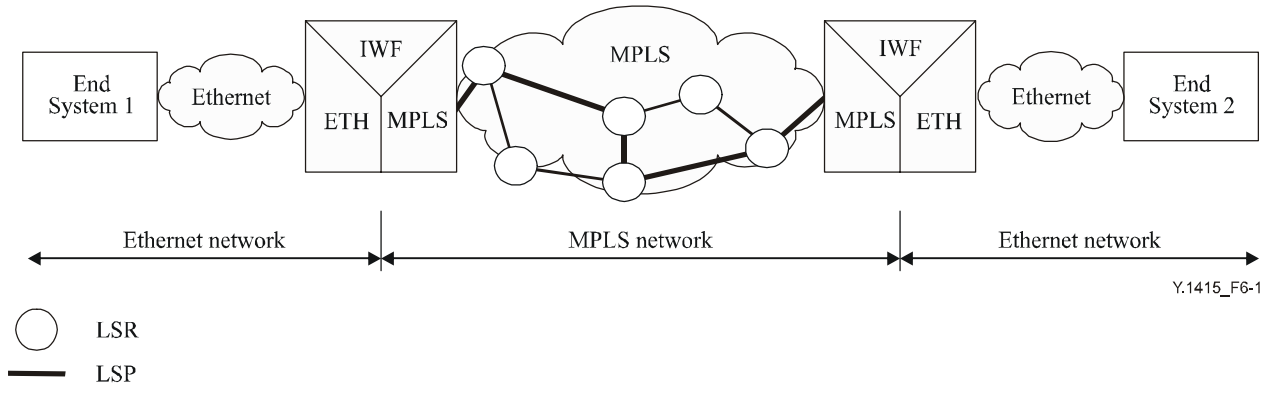
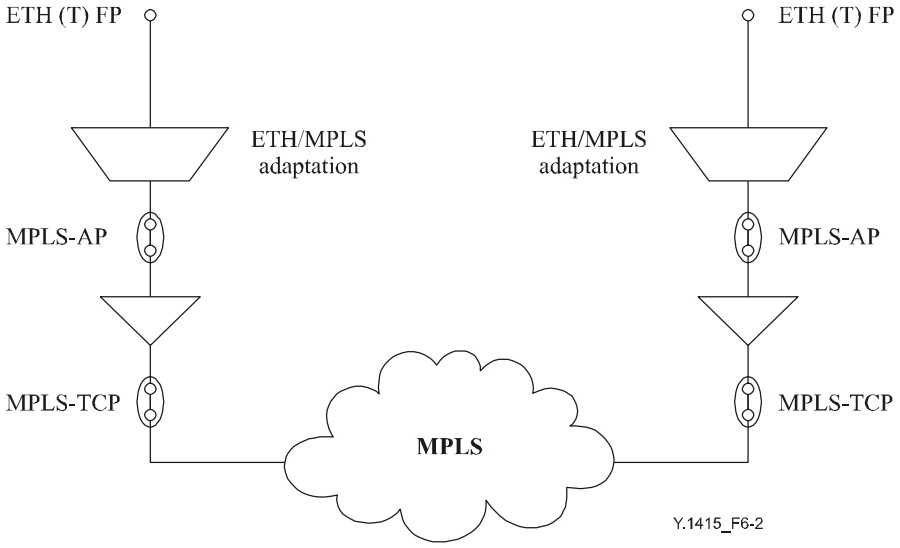


Figure 6-1/Y.1415 – Reference architecture for Ethernet-MPLS network interworking



AP Access Point
FP Flow Point
TCP Termination Connection Point

Figure 6-2/Y.1415 – Functional architecture of Ethernet-MPLS network interworking depicted according to the diagrammatic conventions of ITU-T Rec.G.805

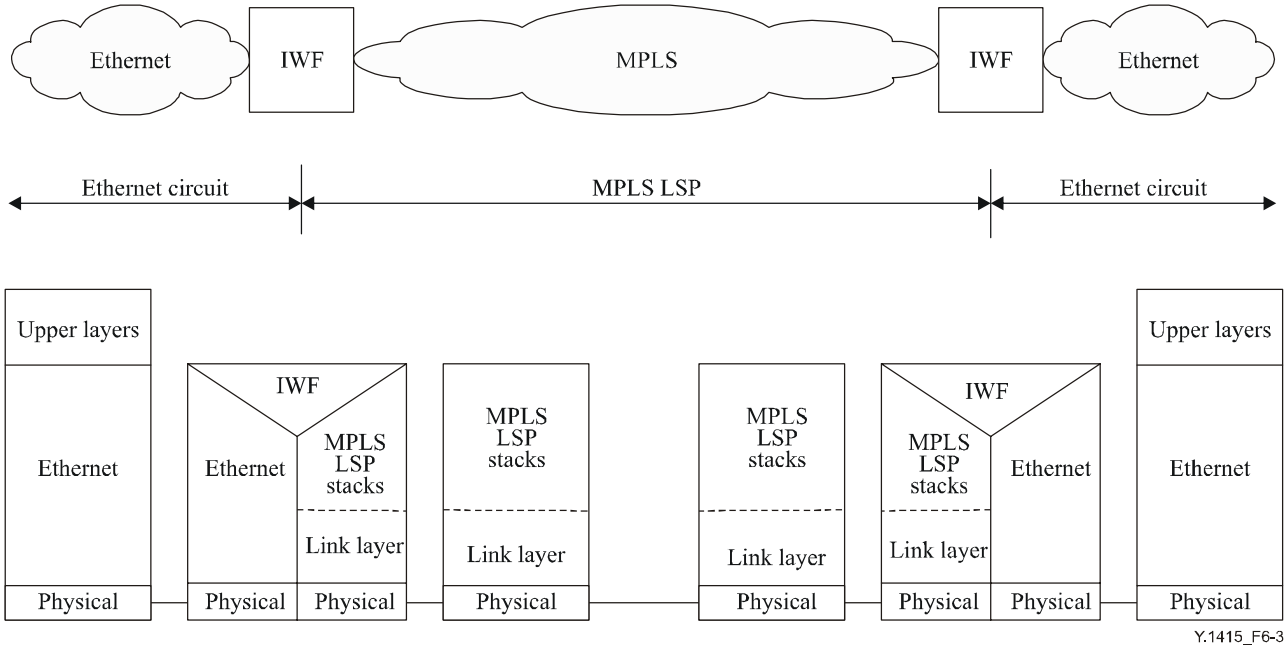


Figure 6-3/Y.1415 – Network reference model and protocol layers for Ethernet-MPLS user plane interworking

7 Requirements

7.1 User plane requirements

For transfer of Ethernet frames in the user plane, the following capabilities are required:

a) the ability to transport multiple Ethernet flows within a single Interworking LSP;

b) the ability to transport Ethernet frames with or without FCS (Frame Check Sequence) retention;

c) maintaining Ethernet frame sequence integrity;

d) support for the traffic contracts and the QoS commitments made to the Ethernet connections;

e) support of bidirectional point-to-point connections between two IWFs with symmetric or asymmetric bandwidth.

7.2 Control plane aspects

For transfer of Ethernet frames, the following are to be signalled or provisioned:

a) exchange of Interworking label(s) between IWFs;

b) correlation of Interworking labels for a bidirectional connection for each Interworking LSP. Mechanisms are to be defined;

c) association of each Interworking LSP label with a Transport LSP label;

d) the ability of the two IWFs to exchange the MTU size that can be supported;

e) the ability to indicate if FCS is retained as part of the payload of the Interworking LSP;

f) presence and use of Common interworking indicators;

g) the ability of the IWF to optionally inspect the user priority field of a tagged Ethernet frame [8] in order to determine the requested QoS and appropriately mark the MPLS packet.

7.3 Management plane aspects

The interworking function shall support transfer of defect information from the server MPLS network to the client Ethernet network. OAM functionality in MPLS networks and OAM mechanisms for MPLS networks are specified in ITU-T Recs Y.1710 [9] and Y.1711 [10] respectively. The transfer of defect information is beyond the scope of this Recommendation. Requirements for OAM functions in Ethernet-based networks and Ethernet services are specified in ITU-T Rec. Y.1730 [11]. The user-to-user OAM and provider OAM are transported transparently when present in an Ethernet frame.

For transparent transfer of Ethernet-related information in the management plane, the interworking function should support transfer or mapping of QoS performance parameters between Ethernet and MPLS network. Such mapping could select a Transport LSP with appropriate QoS for the Ethernet service.

7.4 Traffic Management aspects

The Ethernet client layer shall only deliver traffic to the IWF that conforms to traffic contracts. If the Ethernet client exceeds its traffic contract and the IWF becomes congested, data may be discarded.

8 Functional group considerations for Ethernet-MPLS network interworking

Figure 8-1 provides an illustration of functional grouping for Ethernet-MPLS network interworking.

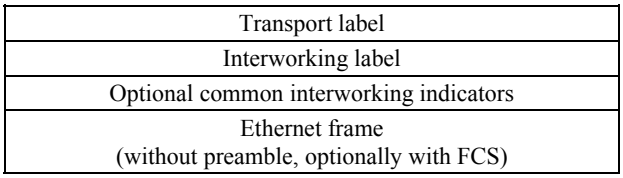


Figure 8-1/Y.1415 – Ethernet-MPLS interworking functional groups

8.1 Transport label

The 4-octet Transport label identifies an LSP which is used to transport traffic between two IWFs. The Transport label is a standard MPLS shim header, as specified in IETF RFC 3032 [12], and is processed by LSRs as described in IETF RFC 3032 [12].

The S bit is set to "0" indicating that this is not the bottom of the label stack.

The setting of the EXP fields is beyond the scope of this Recommendation.

The setting of the TTL fields is beyond the scope of this Recommendation.

Procedures for establishment of the Transport LSP are beyond the scope of this Recommendation.

Since LSPs are unidirectional and Ethernet is bidirectional, two Transport LSPs and hence, in general, two Transport labels are required for Ethernet-MPLS network interworking.

8.2 Interworking label

The interworking function associates an Interworking LSP label with each Ethernet connection.

The 4-octet Interworking label uniquely identifies one Interworking LSP carried inside a Transport LSP. The Interworking label is a standard MPLS shim header, as specified in IETF RFC 3032 [12]. More than one Interworking LSP may be supported by one Transport LSP. The Interworking label is processed only at the ingress or the egress IWF.

The S bit is set to "1" to indicate the bottom of the label stack.

The setting of the EXP field is for further study.

The TTL field shall not be set to less than 2.

Procedures for establishment of the Interworking LSP are beyond the scope of this Recommendation.

Since LSPs are unidirectional and Ethernet is bidirectional, two Interworking LSPs and hence, in general, two Interworking labels are required for Ethernet-MPLS network interworking.

8.3 Common interworking indicators

The Common interworking indicators functions are related to the Interworking LSP.

For general interworking with MPLS networks, the Common interworking indicators functional group is comprised of a Control field, a Fragmentation and Length field and a Sequence number field. Use of the Common interworking indicators is optional, however, when used all fields shall be present.

Figure 8-2 illustrates the structure of the Common interworking indicators.

Bit							
8	7	6	5	4	3	2	1
Control (1 octet)							
Fragmentation and length (1 octet)							
Sequence number (2 octets)							

NOTE – Bit 8 is the most significant bit.

Figure 8-2/Y.1415 – Common interworking indicators functional group

8.3.1 Control field

This field is not used in this Recommendation.

8.3.2 Fragmentation and Length fields

These fields are not used in this Recommendation.

Fragmentation field

The 2-bit Fragmentation field indicates if any fragmentation of the original frame has been done to fulfil the MTU requirements. This field is not used in this Recommendation.

Length field

The 6-bit Length field indicates the length of the payload in order to compensate for padding applied to the MPLS packet.

This field is not used in this Recommendation.

8.3.3 Sequence number field

The Sequence number field is used to check the sequence integrity of MPLS packets sent from the ingress IWF to the egress IWF. When Ethernet services are transported over an underlying MPLS based network, it is required that the MPLS network maintain the sequence integrity of the Ethernet frames encapsulated in the MPLS packets.

Even under the normal "first in first out" (FIFO) operation, it is possible that misordering of the packets could occur. As an option, the Sequence number field can be set by the IWF in the Ethernet-to-MPLS direction. The Sequence number is a 2-octet field using a 16-bit, unsigned circular space. The sequence number value of "0" is used to indicate that the sequence number check algorithm is not used.

8.3.3.1 Setting the sequence numbers

If the sequence number field is used, then the following procedures apply in the Ethernet-to-MPLS direction:

- The sequence number shall be set to 1 for the first MPLS packet transmitted on the Interworking LSP.
- For each subsequent MPLS packet, the sequence number shall be incremented by 1.
- If the value of the incremented sequence number is 65535 for the current MPLS packet, the sequence number shall be set to 1 for the following MPLS packet.

If the ingress IWF does not use the sequence number, then the sequence number field shall be set to zero.

8.3.3.2 Processing the sequence numbers

The purpose of the sequence number processing is to detect misordered packets. If the IWF is capable of monitoring sequence integrity, then the following procedures shall be used.

When an Interworking LSP is initially set up, the "expected sequence number" associated with it shall be initialized to 1.

- If the sequence number is "0", the sequence integrity of the packets cannot be determined by the IWF. In this case, the received packet is considered to be in order.
- Otherwise, if the sequence number ≥ the expected sequence number and the sequence number – the expected sequence number < 32768, then the received packet is considered to be in order.
- Otherwise, if the sequence number < the expected sequence number and the expected sequence number – the sequence number ≥ 32768, then the received packet is considered to be in order.
- Otherwise, the received packet is out of order.
- If the received packet is in order, then the expected sequence number = the sequence number +1 mod 2^{16}.
- If the expected sequence number = 0, then the expected sequence number = 1.

If an IWF does not support receive sequence number processing, then the sequence number field may be ignored.

9 Procedures

This clause provides procedures for encapsulating Ethernet frames into MPLS packets at the ingress IWF and retrieving Ethernet frames from MPLS packets at the egress IWF.

9.1 Encapsulation

The ingress IWF is responsible for generation of an MPLS packet of the following formats. Figures 9-1 and 9-2 show the MPLS packet format for the Ethernet frame encapsulation with and without the Common interworking indicators.

Bits							
8	7	6	5	4	3	2	1
Transport label (4 octets)							
Interworking label (4 octets)							
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
Sequence number (2 octets)							
Ethernet frame (without preamble, optionally with FCS)							

NOTE – Bit 8 is the most significant bit.

Figure 9-1/Y.1415 – Ethernet frame encapsulation with Common interworking indicators

8	7	6	5	4	3	2	1
Transport label (4 octets)							
Interworking label (4 octets)							
Ethernet frame (without preamble, optionally with FCS)							

NOTE – Bit 8 is the most significant bit.

Figure 9-2/Y.1415 – Ethernet frame encapsulation without Common interworking indicators

9.2 Transport label

The ingress IWF prepends a Transport label conforming to 8.1.

9.3 Interworking label

The ingress IWF prepends an Interworking label conforming to 8.2.

9.4 Common interworking indicators

When the Common interworking indicators is used, the following subclauses describe the procedures to be followed.

9.4.1 Control field

The Control field for ETH-MPLS network interworking is set to "0" by the ingress IWF and is ignored by the egress IWF.

9.4.2 Fragmentation and Length fields

These fields are not used in this Recommendation. They are set to "0" by the ingress IWF and are ignored by the egress IWF.

9.4.3 Sequence number field

Procedures for setting and processing are described in 8.3.3.

9.5 Processing of Ethernet frames at the ingress IWF

When Ethernet frames arrive at the ingress IWF they are checked for framing and FCS errors. If errors are detected, the frame is discarded. The preamble is removed and optionally the FCS is removed. Next it is determined whether the resulting frame is an IEEE 802.3 control protocol PDU. If it is, it is processed according to 9.1.7 layer 2 control processing of ITU-T Rec. G.8011.1/Y.1307.1 [13]. All frames to be carried are encapsulated as illustrated in Figures 9-1 and 9-2 for delivery to the MPLS network.

9.6 Processing of MPLS packets at the egress IWF

For the purposes of this Recommendation, it is assumed that no malformed MPLS packets are delivered to the egress IWF. When an MPLS packet arrives at the egress IWF, the labels and Common interworking indicators are processed as described above and then removed. If the FCS has been retained by the ingress IWF, then the FCS is checked and if an error is detected processing is terminated. If no error has been detected, it is then determined whether the resulting frame is an IEEE 802.3 control protocol PDU. If it is, it is processed according to 9.1.7 layer 2 control processing of ITU-T Rec. G.8011.1/Y.1307.1 [13]. If FCS has been discarded, it is now recalculated and appended to the frame. An Ethernet frame is reconstructed for delivery to the Ethernet network.

10 Security considerations

Security aspects have not been addressed in this Recommendation.

Appendix I

Support of multipoint Ethernet services

The IWF defined in the body of this Recommendation supports a point-to-point Ethernet connection. Multipoint services may be provided by supplementing this Recommendation with additional functions within the Ethernet layer network. Note that the IWF and the additional functions may be implemented within a single network element.

Figure I.1 depicts an example of multipoint services supported by Interworking LSPs.

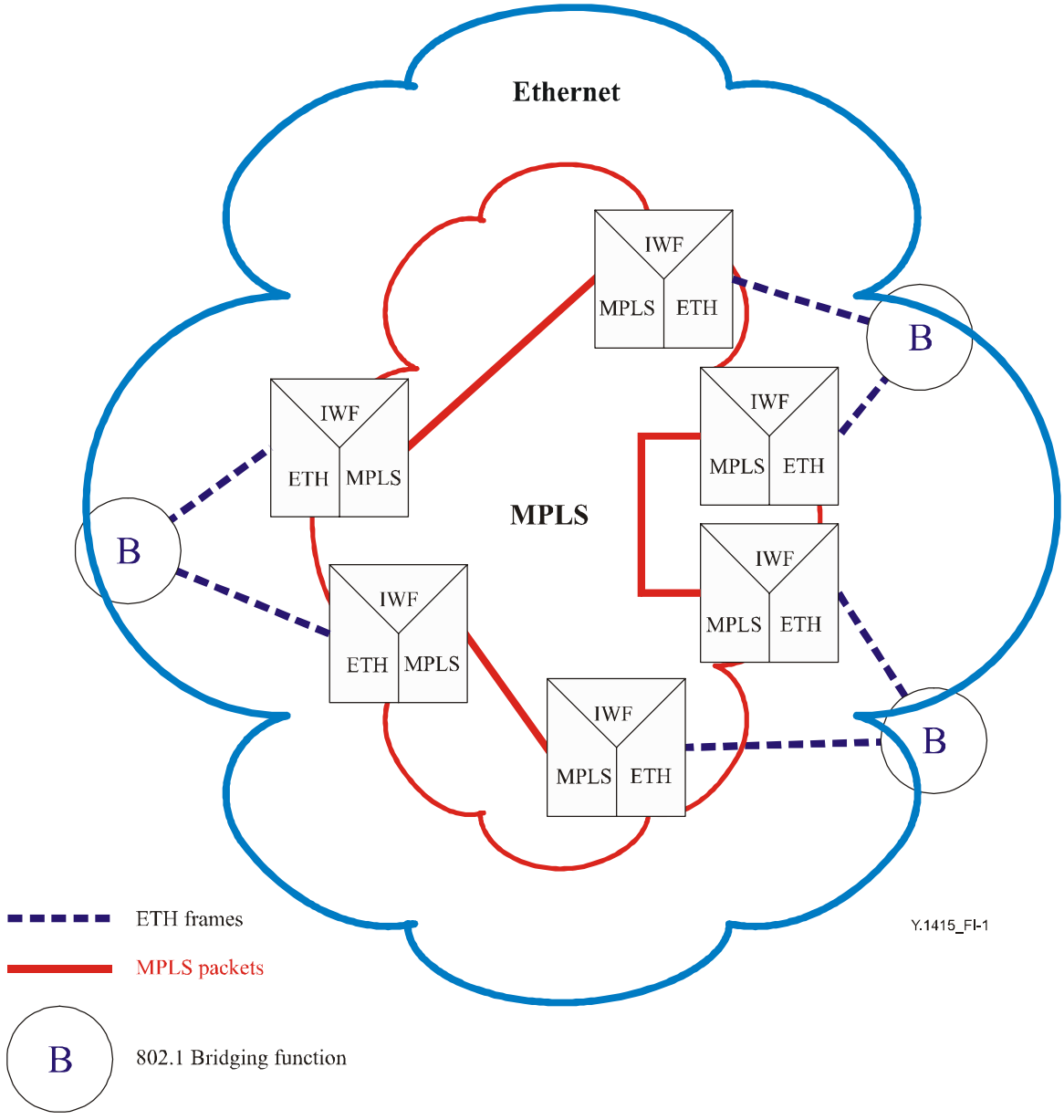


Figure I.1/Y.1415 – Ethernet network with multipoint connectivity supported by Interworking LSPs

In this example, a full mesh of Interworking LSPs is provided between all bridging functions. The bridging functions implement MAC learning, MAC aging, frame flooding, and frame replication as described in IEEE 802.1D [8]. However, the bridging functions do not implement Spanning Tree Protocol (STP), loops being prevented by not forwarding Ethernet frames received from an IWF to another IWF. Further details are beyond scope of this Recommendation.

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