G.8011, G.8012, G.8112
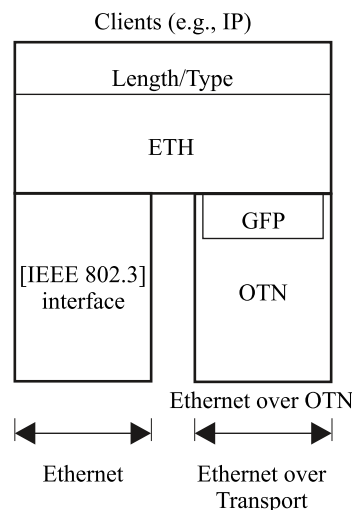# Ethernet service characteristics, and Ethernet & MPLS-TP interfaces

- ITU-T G.8011 establishes a framework, relying on Ethernet layer networks as modeled by ITU-T and MEF, to describe the characteristics of MEF standards-based Ethernet services created based on the introduced service definition, attributes, and operation, administration and maintenance.

- ITU-T G.8012 specifies the Ethernet user-to-network interface, the Ethernet network node interface and an Ethernet over transport interface for the latter while ITU-T G.8112 specifies equivalent constructs for the multi-protocol label switching transport profile layer network.
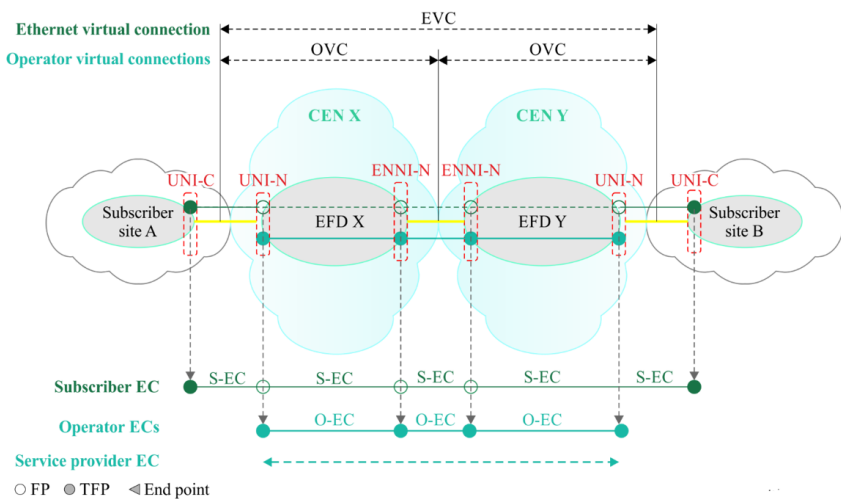
EFD: Ethernet flow domain; O-EC: OVC-Ethernet services layer connection;
S-EC: subscriber-Ethernet services layer connection; TFP: termination flow point

Base MEF architecture

Basic structure of Ethernet and EoT interfaces

1. ITU-T G.8011 – Ethernet service characteristics

Recommendation ITU-T G.8011 establishes a framework to describe Ethernet services based on the documents of a non-profit industry forum of network, cloud and technology providers, the MEF Forum. The framework consists of a set of service definitions, service attributes and operation, administration and maintenance (OAM) for each Ethernet virtual connection (EVC), operator virtual connection (OVC), Ethernet services layer connection (EC), Ethernet user to network interface (UNI) and Ethernet external network-to-network interface (ENNI). The resulting services that can be described do not refer to a particular network technology implementation and are supported by ITU-T and MEF Ethernet layer architecture models.

2. ITU-T G.8012 – Ethernet UNI and Ethernet NNI

Recommendation ITU-T G.8012 specifies the Ethernet user-to-network interface (UNI) and the Ethernet network node interface (NNI) where the Ethernet UNI is formed by an Ethernet interface and the Ethernet NNI by an Ethernet interface or an Ethernet over transport interface. The Ethernet over transport (EoT) NNI uses the optical transport hierarchy server layer network. The detailed requirements applicable to these interfaces are specified in a number of ITU-T Recommendations, and in Institute of

Electrical and Electronics Engineers (IEEE) standards (Stds) that are referenced.
This Recommendation defines the interfaces of the Ethernet transport network to be used within and between subnetworks of the Ethernet network, in terms of Ethernet transport hierarchy, formats for mapping and multiplexing client signals into Ethernet connections and formats for multiplexing Ethernet connection signals into Ethernet or non-Ethernet connection signals.
This Recommendation assumes but does not specify the Ethernet component and/or equipment models specified in Recommendation ITU-T G.8021 to support the Ethernet UNI and NNI.
This Recommendation limits the specification of the Ethernet UNI and NNI to Ethernet equipment types aligned with the bridge types specified in IEEE Std 802.1Q and supporting only the untagged, priority-tagged or tagged traffic units covered in Recommendation ITU-T G.8021.

3. ITU-T G.8112 – Interfaces for the MPLS transport profile layer network

Recommendation ITU-T G.8112 specifies the interfaces for the multi-protocol label switching transport profile (MPLS-TP) layer network, in particular the:
• Encapsulation of MPLS-TP client signals into the MPLS-TP characteristic information (MPLS-TP _CI) that will be present on MPLS-TP NNI links in the transport network;
• Encapsulation of MPLS-TP_CI into the

MPLS-TP link frames that will be present on MPLS-TP NNI links in the transport network;
• MPLS-TP layer network within the transport network and associated MPLS-TP multiplexing;
• MPLS-TP nested connection monitoring per layer network level within the transport network;
• MPLS-TP OAM associated with nested connection monitoring in the transport network;
• Encapsulation of MPLS-TP control plane information.
The MPLS-TP network uses various server layer networks like optical transport network (OTN) and Ethernet media access control layer network. The detailed requirements are specified in a number of ITU-T Recommendations, American National Standards Institute standards, IEEE standards and Internet Engineering Task Force requests for comments, which are cited.
This Recommendation specifies point-to-point label-switched paths.
This Recommendation does not cover inter-operator control plane aspects of the MPLS-TP NNI.
This Recommendation provides a representation of the MPLS-TP technology using the methodologies that have been used for other transport technologies [e.g., OTN and Ethernet].

Y.1731, G.8021, G Suppl. 53

Ethernet Operation, Administration and Maintenance (OAM)

- ITU-T G.8013/Y.1731 provides fault management mechanisms (aligned with and beyond those in IEEE Std 802.1Q) and performance monitoring mechanisms for user-plane OAM functionality in Ethernet networks, and supports both point-to-point and multipoint connectivity.

- ITU-T G.8021 specifies the functional components and methodology that should be used to specify the Ethernet transport network functionality (including Ethernet OAM) of network elements.
- ITU-T G Suppl. 53 provides an overview of Ethernet OAM performance monitoring

Example of maintenance entities under OAM per ITU-T G.8013/Y.1731

Overview of ITU-T G.8021 atomic model functions

1. ITU-T G.8013/Y.1731 – Operation, administration and maintenance (OAM) functions and mechanisms for Ethernet-based networks

Recommendation ITU-T G.8013/Y.1731 specifies mechanisms required to operate and maintain the network and service aspects of the (Recommendation ITU-T G.8010-identified) Ethernet layer network (ETH) layer. It also specifies the Ethernet OAM frame formats and syntax and semantics of OAM frame fields. The OAM mechanisms as described in this Recommendation apply to both point-to-point ETH connections and multipoint ETH connectivity including both multipoint to-multipoint and rooted-multipoint connections. The OAM mechanisms as described in this Recommendation are applicable to any environment independently of how the ETH layer is managed (e.g., using network management systems or operational support systems). The architectural basis for this Recommendation is the Ethernet specification in Recommendation ITU-T G.8010 which also accounts for Institute of Electrical and Electronics Engineers (IEEE) Standard (Std) 802.1Q and IEEE Std 802.3. The OAM functions of the server layer networks used by the Ethernet network and those of the layers above the ETH layer are out of the scope of this Recommendation. ITU-T has prepared Recommendation ITU-T G.8013/Y.1731 in cooperation with the IEEE Project 802.1ag on connectivity fault management. Since the IEEE work is now complete, this Recommendation contains amendments to fully align the final results and includes the appropriate normative references to IEEE documents. Moreover, further detailed work on the implementation details (i.e., the specification of the equipment functions) has been undertaken by ITU-T in Recommendation ITU-T G.8021.

2. ITU-T G.8021 – Characteristics of Ethernet transport network equipment functional blocks

Recommendation ITU-T G.8021 covers the functional requirements of Ethernet functionality within Ethernet transport equipment.

This Recommendation uses the specification methodology defined in Recommendation ITU-T G.806 in general for transport network equipment and is based on the architecture of Ethernet layer networks defined in Recommendation ITU-T G.8010, the interfaces for Ethernet transport networks defined in Recommendation ITU-T G.8012, and in support of services defined in Recommendation ITU-T G.8011.

In particular, but not exclusively, this Recommendation provides processes for Ethernet OAM based on Recommendation ITU-T G.8013/Y.1731.

Processes are also provided in support of other mechanisms, including Ethernet linear and ring protection switching.

The description is generic and no particular physical partitioning of functions is implied. The input/output information flows associated with the functional blocks serve for defining the functions of the blocks and are considered to be conceptual, not physical.

The functionality defined in this Recommendation can be applied at user-to-network interfaces (UNIs) and network-to-network interfaces (NNIs) of the Ethernet transport network.

A set of atomic functions associated with the Ethernet signal transport may be combined in various ways to support a variety of Ethernet services

3. ITU-T G Suppl. 53 – Guidance for Ethernet OAM performance monitoring

Supplement 53 to ITU-T G-series Recommendations provides an informative overview of Ethernet OAM performance monitoring. It informatively describes how Ethernet OAM performance measurements are processed, configured and managed as normatively described in Recommendations ITU-T G.8013, G.8021 and G.8051. It also introduces the modeling for Ethernet OAM performance monitoring as described in Recommendation ITU-T G.8052. In particular, it discusses the counting of Ethernet loss measurement frames.

G.8031, G.8032, G Suppl. 52, 54, 60
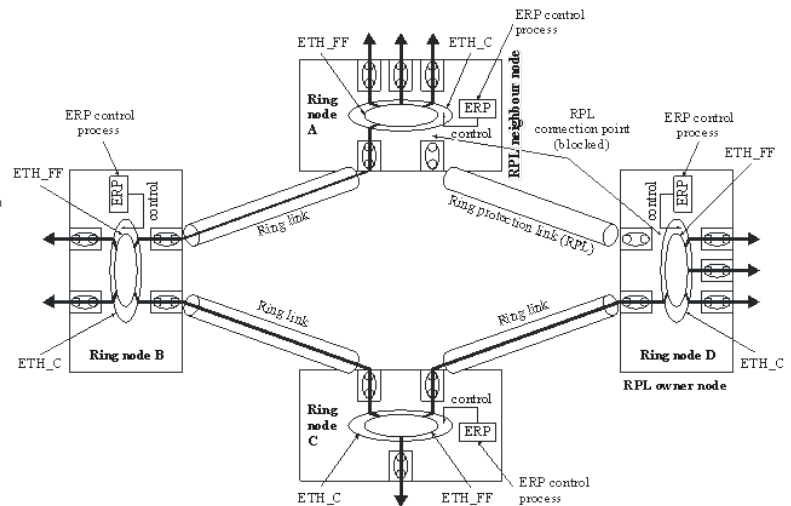
Ethernet Linear and Ring Protection Switching

- ITU-T G.8031 specifies the linear automatic protection switching (APS) protocol and protection switching mechanisms for Ethernet layer network (ETH) linear topologies.
- ITU-T G.8032 specifies the ring APS protocol and protection switching mechanisms for ETH ring

topologies.
- As carrier-grade protection switching mechanisms, ITU-T G.8031 and G.8032 support a large variety of applications, examples of which are informatively described in ITU-T G Suppl. 52, 54, 60.
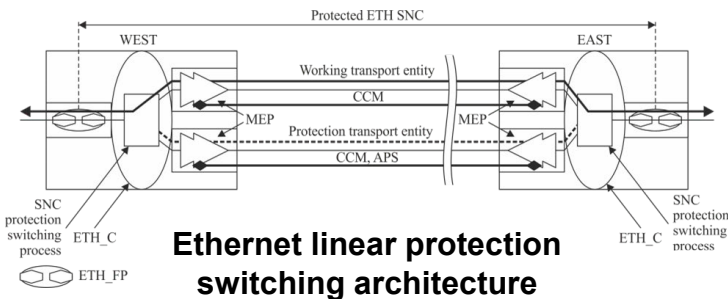
Ethernet linear protection switching architecture
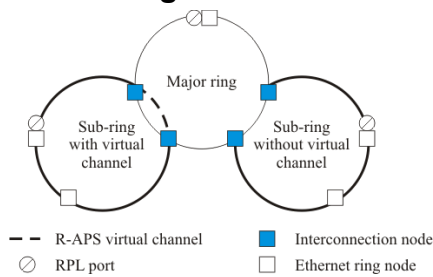
Ring interconnection options

Ethernet ring protection switching architecture

1. ITU-T G.8031 – Ethernet linear protection switching

Recommendation ITU-T G.8031 defines the APS protocol and linear protection switching mechanisms for point-to-point VLAN-based ETH subnetwork connection (SNC) in Ethernet transport networks. Linear 1+1 and 1:1 protection switching architectures with unidirectional and bidirectional switching are defined in this Recommendation.

This Recommendation relies on Continuity Check Messages (CCMs), Linear APS messages, and Maintenance Entity Group (MEG) End Points (MEPs) as described in Recommendation ITU-T G.8013/Y.1731 and as supported by Recommendation ITU-T G.8021 that also supports the attendant SNC protection process.

2. ITU-T G.8032 – Ethernet ring protection switching

Recommendation ITU-T G.8032 defines the ring automatic protection switching (RAPS) protocol and protection switching mechanisms for ETH ring topologies. The protection protocol defined in this Recommendation enables protected point-to-point, point-to-multipoint and multipoint-to-multipoint connectivity within

a ring or interconnected rings, called "multi-ring/ladder network" topology. The ETH ring maps to the physical layer ring structure.

This Recommendation relies on Ring APS messages, MEG Intermediate Points (MIPs) and MEPs as described in Recommendation ITU-T G.8013/Y.1731 and as supported by Recommendation ITU-T G.8021 that also supports the attendant ring protection control process.

3. ITU-T G Suppl. 52 – Ethernet ring protection switching

Supplement 52 to ITU-T G-series Recommendations provides supplemental information that informatively (rather than normatively) describes how ITU-T G.8032 can support various Ethernet services (E-Line, E-LAN, E-Tree) and how it can be used in various network applications. Additionally, examples of Ethernet ring interconnection, guidelines for configuration and management procedures, protection switching for multiple Ethernet ring protection (ERP) instances and end-to-end network/service resiliency involving ITU-T G.8032, are described.

This supplement is intended to consolidate and expand upon related

material in Recommendation ITU-T G.8032.

4. ITU-T G Suppl. 54 – Ethernet linear protection switching

Supplement 54 to ITU-T G-series Recommendations provides supplemental information that informatively (rather than normatively) provides examples of network application scenarios involving Recommendation ITU-T G.8031.

5. ITU-T G Suppl. 60 – Ethernet linear protection switching with dual node interconnection

Supplement 60 to ITU-T G-series Recommendations provides supplemental information that informatively (rather than normatively) describes potential solutions to support dual node interconnection based on the ITU-T G.8031 Ethernet linear protection switching to support resilient interconnection with an adjacent recovery domain. Other viable means of supporting dual node interconnection for Ethernet are known to exist. This Supplement is intended to give examples based on Recommendation ITU-T G.8031 only.

G.8113.1, G.8113.2, G.8121, G.8121.1, G.8121.2

MPLS-TP OAM and equipment specifications

- ITU-T G.8113 series Recommendations specify fault management and performance monitoring mechanisms to meet the MPLS-TP OAM requirements in IETF RFC 5860. ITU-T G.8113.1 focuses on user-plane OAM while ITU-T G.8113.2 is based on the tools defined for MPLS in IETF

RFCs for data plane OAM.
- ITU-T G.8121 series Recommendations describe the corresponding functional components and the methodology that should be used to describe MPLS-TP layer network functionality of network elements.
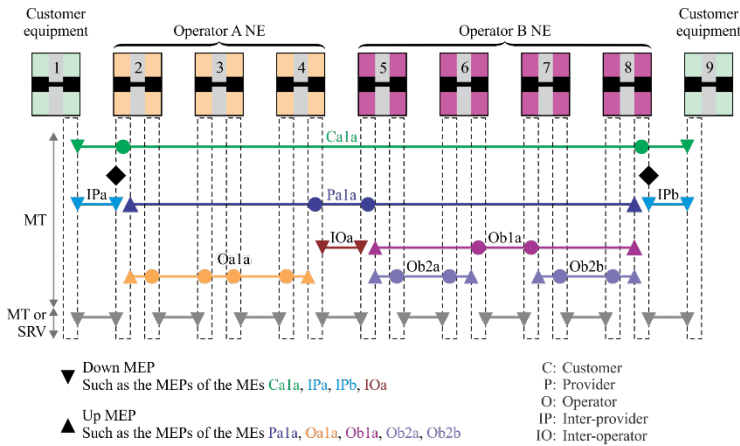
Example of maintenance entities under OAM per ITU-T G.8113.1 and G.8113.2
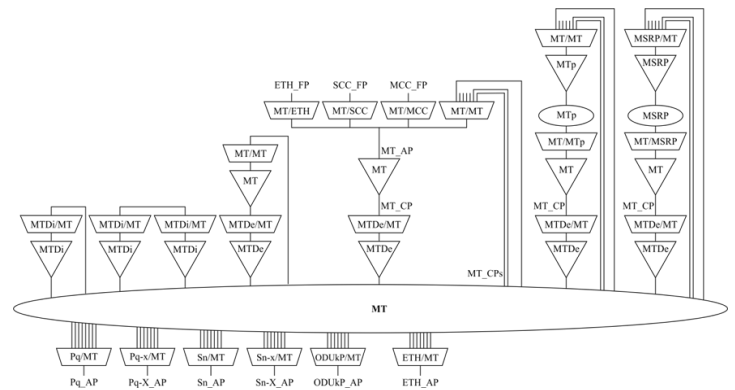
MPLS-TP atomic functions per ITU-T G.8121

The five following Recommendations provide a representation of the multi-protocol label switching transport profile (MPLS-TP) technology using the methodologies that have been used for other transport technologies [e.g., optical transport network (OTN) and Ethernet].

1. ITU-T G.8113 series Recommendations
The two Recommendations in the ITU-T G.8113 series specify mechanisms to meet the MPLS-TP operations, administration and maintenance (OAM) requirements defined in Internet Engineering Task Force (IETF) request for comments (RFC) 5860.
They also specify the MPLS-TP OAM packet formats, syntax and semantics of MPLS-TP OAM packet fields.
The OAM mechanisms defined in these Recommendations assume common forwarding of the MPLS-TP user packets and MPLS-TP OAM packets.
These Recommendations are intended to be aligned with the IETF RFCs applicable to MPLS normatively referenced by these Recommendations.

1.1 ITU-T G.8113.1 – Operations, administration and maintenance mechanisms for MPLS-TP in packet transport networks
Recommendation ITU-T G.8113.1 specifies mechanisms for user-plane OAM in MPLS-TP networks.
In transport networks, the OAM return path

is always in band. The MPLS-TP OAM mechanisms described in this Recommendation apply to co-routed bidirectional point-to-point MPLS-TP connections.
This Recommendation is compliant with the transport profile of MPLS as specified by IETF RFC 5654. In the event of a misalignment in MPLS-TP-related architecture, framework and protocols between this ITU-T Recommendation and the normatively referenced IETF RFCs, the RFCs will take precedence.

1.2. ITU-T G.8113.2 – Operations, administration and maintenance mechanisms for MPLS-TP networks using the tools defined for MPLS
Recommendation ITU-T G.8113.2 specifies OAM mechanisms based on the tools defined for MPLS in IETF RFCs for data plane OAM in MPLS-TP networks.
In transport networks using co-routed bidirectional point to-point connections, the OAM return path is always in-band.

2 ITU-T G.8121 series Recommendations
The three Recommendations in the ITU-T G.8121 series describe both the functional components and the methodology that should be used to describe MPLS-TP layer network functionality of network elements.
They do not describe individual MPLS-TP network equipment as such.

2.1 ITU-T G.8121 – Characteristics of MPLS-TP equipment functional blocks
Recommendation ITU-T G.8121 defines protocol neutral constructs.
This Recommendation is intended to be aligned with the IETF RFCs applicable to MPLS normatively referenced by this Recommendation.

2.2 ITU-T G.8121.1 – Characteristics of MPLS-TP equipment functional blocks supporting ITU-T G.8113.1/Y.1372.1 OAM mechanisms
Recommendation ITU-T G.8121.1's descriptions are based on the protocol neutral constructs defined in Recommendation ITU-T G.8121 and on the tools defined in Recommendation ITU T G.8113.1/Y.1372.1.

2.3 ITU-T G.8121.2 – Characteristics of MPLS-TP equipment functional blocks supporting ITU-T G.8113.2/Y.1372.2 OAM mechanisms
Recommendation ITU-T G.8121.2's descriptions are based on the protocol neutral constructs defined in Recommendation ITU T G.8121/Y.1381 and on the tools defined in Recommendation ITU T G.8113.2/Y.1372.2.
This Recommendation is intended to be aligned with the IETF RFCs applicable to MPLS normatively referenced by this Recommendation.

G.8131, G.8132, G.8133

# MPLS-TP Protection Switching – Linear, Shared Ring, Dual-Homing

- ITU-T G.8131 focuses on subnetwork connection protection switching and describes uni- and bidirectional switching types and revertive/non-revertive operation types.
- ITU-T G.8132 focuses on shared ring protection switching. Point-to-point MPLS-TP LSPs are

protected at the MPLS-TP section layer.
- ITU-T G.8133 focuses on PW dual-homing protection based on the description in IETF RFCs 8184 and 8185. Point-to-point MPLS-TP PWs are protected against failures within or at the edges of the MPLS-TP network.
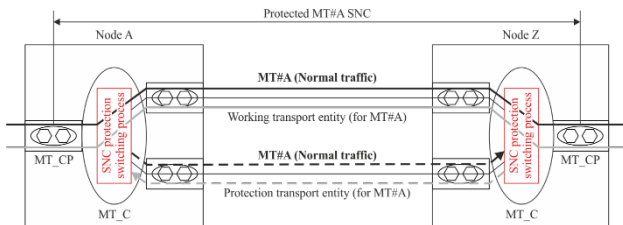
Bidirectional 1:1 SNC/S protection switching architecture per ITU-T G.8131
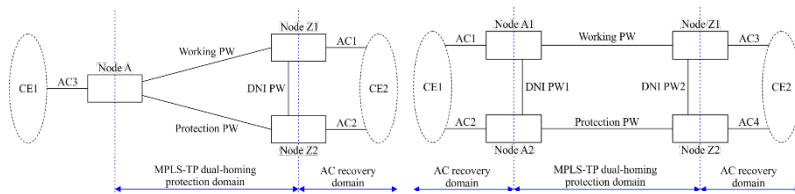
One- and two-side MPLS-TP dual-homing reference networks per ITU-T G.8133
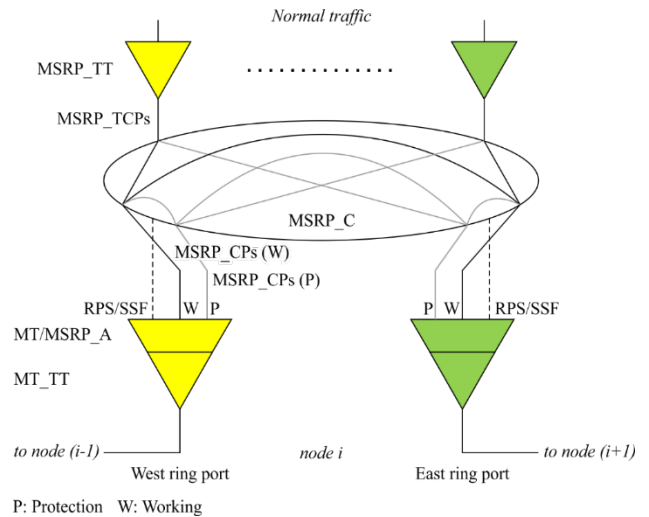
MSRP functional model per ITU-T G.8132

The three following Recommendations provide a representation of the multi-protocol label switching transport profile (MPLS-TP) technology using the methodologies that have been used for other transport technologies [e.g., optical transport network (OTN) and Ethernet].

These ITU-T Recommendations are intended to be aligned with the Internet Engineering Task Force (IETF) MPLS requests for comments (RFCs) normatively referenced by these Recommendations.

1. ITU-T G.8131 – Linear protection switching for MPLS transport profile

Recommendation ITU-T G.8131 provides architecture and mechanisms for linear protection switching for MPLS-TP networks. The automatic protection coordination protocol, and 1+1 and 1:1 protection architecture are defined in this Recommendation. This Recommendation describes the protection switching functionality for point-to-point connections using the automatic protection switching (APS) mode defined in IETF RFC 7271.

2. ITU-T G.8132 – MPLS-TP shared ring protection

Recommendation ITU-T G.8132 provides architecture and mechanisms for shared ring protection for MPLS-TP networks. It describes the MPLS-TP shared ring protection (MSRP) mechanisms and the ring protection switch (RPS) protocol defined in IETF RFC 8227. The mechanisms defined in this Recommendation protect point-to-point MPLS-TP label switched paths (LSPs) against failures at the MPLS-TP section layer.

3. ITU-T G.8133 – Dual-homing protection for multi-protocol label switching transport profile pseudowires

Recommendation ITU-T G.8133 provides architecture and mechanisms for pseudowire (PW) dual-homing protection in MPLS-TP networks. It also describes the dual-homing coordination (DHC) protocol defined in IETF RFC 8184 and IETF RFC 8185.

Both one-side and two-side dual-homing protection mechanisms are provided.

The mechanisms defined in this Recommendation protect point-to-point MPLS-TP PWs against failures within or at the edges of the MPLS-TP network.