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MPLS-TP Security Framework
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Abstract

This document provides a security framework for Multiprotocol Label Switching Transport Profile (MPLS-TP). MPLS-TP extends MPLS technologies and introduces new OAM capabilities, a transport-oriented path protection mechanism, and strong emphasis on static provisioning supported by network management systems. This document addresses the security aspects relevant in the context of MPLS-TP specifically. It describes potential security threats, security requirements for MPLS-TP, and mitigation procedures for MPLS-TP networks and MPLS-TP interconnection to other MPLS and GMPLS networks. This document is built on RFC5920 "MPLS and GMPLS security framework" by providing additional security considerations which are applicable to the MPLS-TP extensions. All the security considerations from RFC5920 are assumed to apply.

This document is a product of a joint Internet Engineering Task Force (IETF) / International Telecommunication Union Telecommunication Standardization Sector (ITU-T) effort to include an MPLS Transport Profile within the IETF MPLS and PWE3 architectures to support the capabilities and functionality of a packet transport network.

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1. Introduction

This document provides a security framework for Multiprotocol Label Switching Transport Profile (MPLS-TP).

As defined in MPLS-TP Requirements [RFC5654] and MPLS-TP Framework [RFC5921], MPLS-TP uses a subset of MPLS features and introduces extensions to reflect the characteristics of the transport technology. The additional functionality include in-band OAM, transport-oriented path protection and recovery mechanisms, and new OAM capabilities developed for MPLS-TP but apply to general MPLS and GMPLS. There is strong emphasis in MPLS-TP on static provisioning support through network management systems (NMS) or Operation Support Systems (OSS).

This document is built on RFC 5920 by providing additional security considerations which are applicable to the MPLS-TP extensions. The security models, threats, requirements, and defense techniques previously defined in [RFC5920] are assumed to apply to general aspect of MPLS-TP.

This document is a product of a joint Internet Engineering Task Force (IETF) / International Telecommunication Union Telecommunication Standardization Sector (ITU-T) effort to include an MPLS Transport Profile within the IETF MPLS and PWE3 architectures to support the capabilities and functionality of a packet transport network.

Readers can refer to [RFC5654] and [RFC5921] for MPLS-TP terminologies, and [RFC5920] for security terminologies which are relevant to MPLS and GMPLS.

1.1. Terminology

Term	Definition
AC	Attachment Circuit
BFD	Bidirectional Forwarding Detection
CE	Customer-Edge device
DoS	Denial of Service
G-ACh	Generic Associated Channel
GAL	G-ACh Label
GMPLS	Generalized Multi-Protocol Label Switching
IP	Internet Protocol
LDP	Label Distribution Protocol
LSP	Label Switched Path
NMS	Network Management System
MPLS	MultiProtocol Label Switching
MPLS-TP	MultiProtocol Label Switching Transport Profile

MS-PW	Multi-Segment Pseudowire
OAM	Operations, Administration, and Maintenance
PE	Provider-Edge device
PSN	Packet-Switched Network
PW	Pseudowire
S-PE	PW Switching Provider Edge
SP	Service Provider
SS-PW	Single-Segment Pseudowire
T-PE	PW Terminating Provider Edge

2. Security Reference Models

This section defines reference models for security in MPLS-TP networks.

The models are built on the architecture of MPLS-TP defined in [RFC5921]. The placement of Service Provider (SP) boundaries plays important role in determining the security models for any particular deployment.

This document defines a trusted zone as being where a single SP has total operational control over that part of the network. A primary concern is about security aspects that relate to breaches of security from the "outside" of a trusted zone to the "inside" of this zone.

2.1. Security Reference Model 1

In reference model 1, a single SP has total control of the PE/T-PE to PE/T-PE part of the MPLS-TP network.

Security reference model 1(a)

An MPLS-TP network with Single Segment Pseudowire (SS-PW) from PE1 to PE2. The trusted zone is PE1 to PE2 as illustrated in Figure 1.

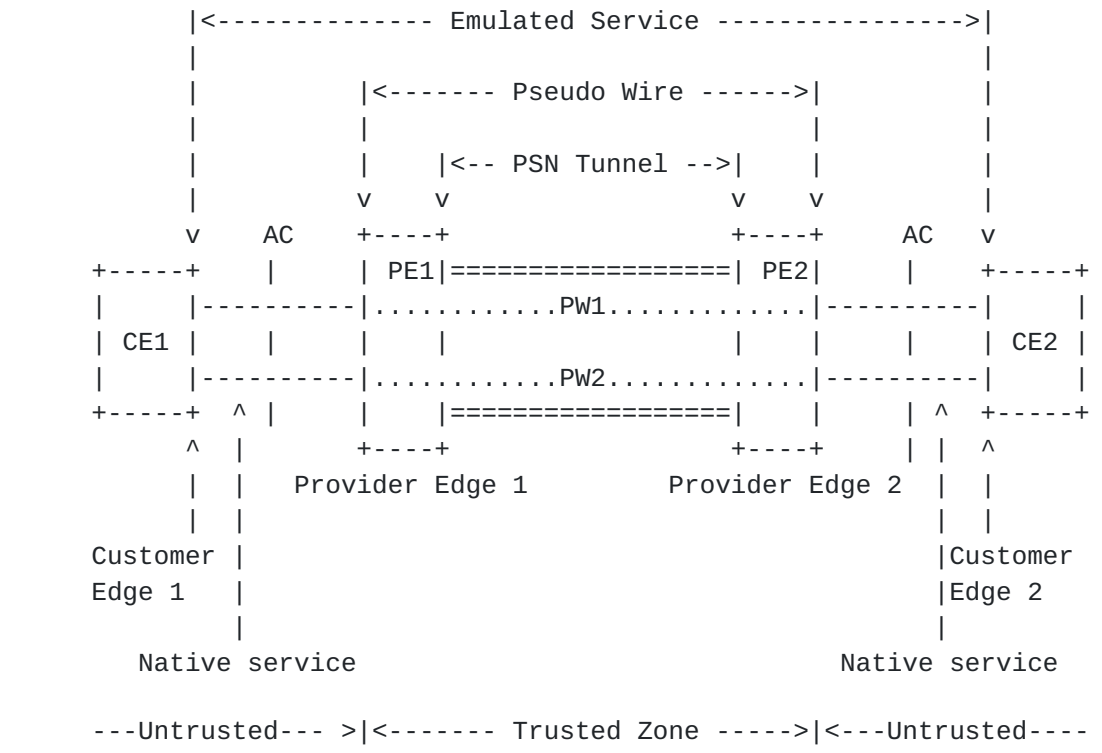

Figure 1. MPLS-TP Security Model 1(a)

Security reference model 1(b)

An MPLS-TP network with Multi-Segment Pseudowire (MS-PW) from T-PE1 to T-PE2. The trusted zone is T-PE1 to T-PE2 in Figure 2.

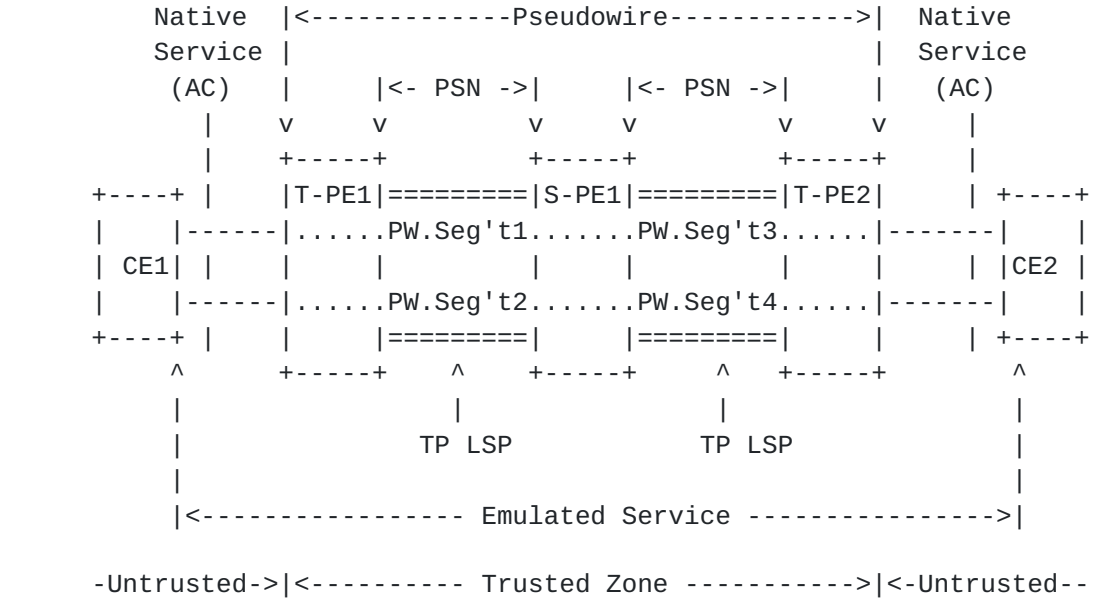

Figure 2. MPLS-TP Security Model 1(b)

2.2. Security Reference Model 2

In reference model 2, a single SP does not have the end-to-end control of the segment from PE/T-PE to PE/T-PE. Some S-PE(s), T-PE(s) may be under the control of other SPs, or the SP's customers, or its partners. In this case, the MPLS-TP network is not contained within a single trusted zone.

Security Reference Model 2(a)

An MPLS-TP network with Multi-Segment Pseudowire (MS-PW) from T-PE1 to T-PE2. The trusted zone is T-PE1 to S-PE1, as illustrated in Figure 3.

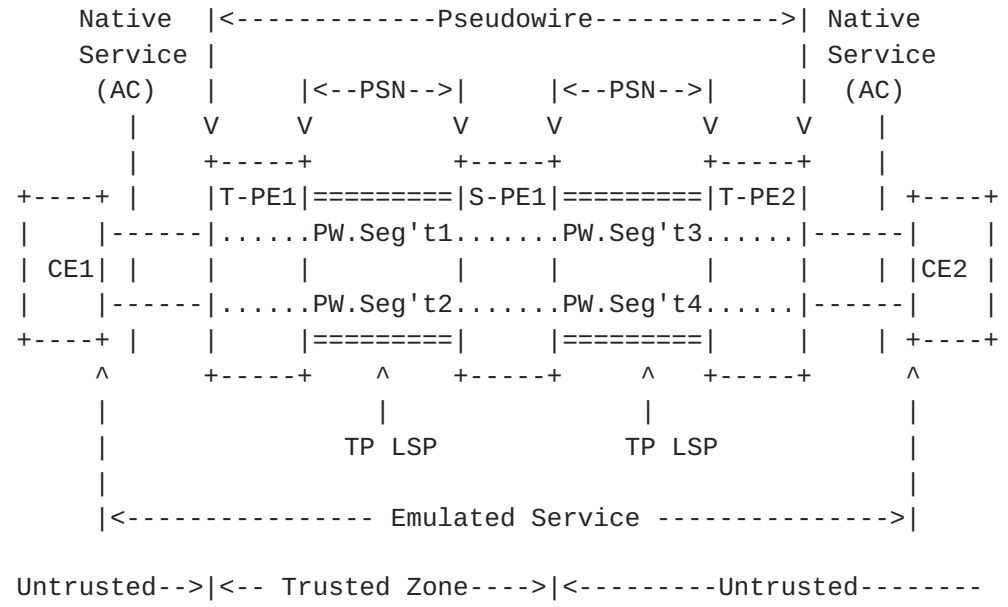

Figure 3. MPLS-TP Security Model 2(a)

Security Reference Model 2(b)

An MPLS-TP network with Multi-Segment Pseudowire (MS-PW) from T-PE1 to T-PE2. The trusted zone is the S-PE1 only, as illustrated in Figure 4.

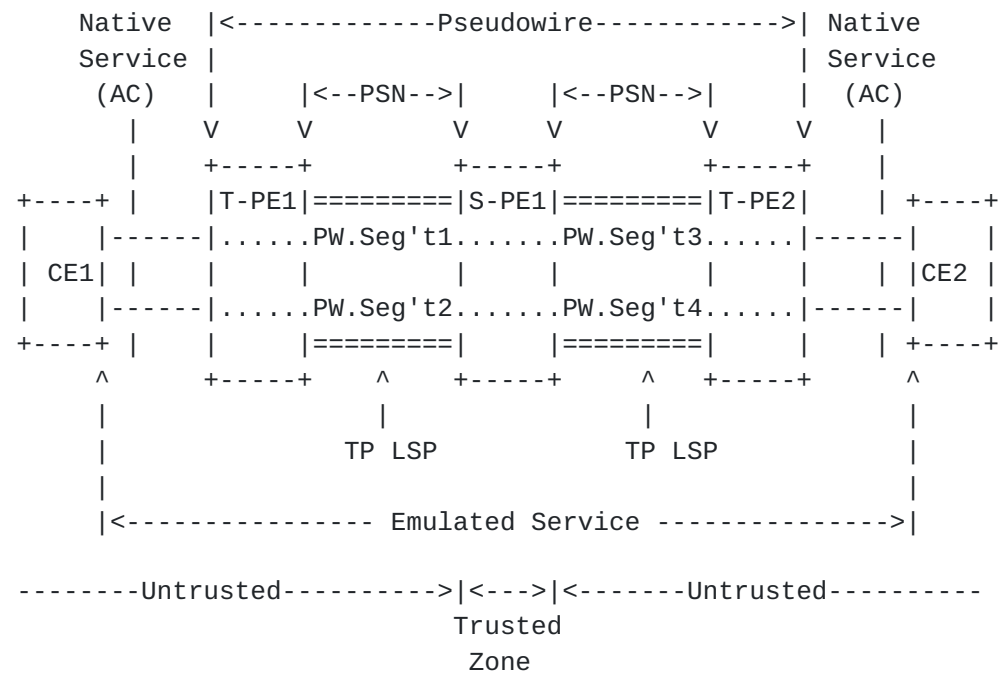

Figure 4. MPLS-TP Security Model 2(b)

Security Reference Model 2(c)

An MPLS-TP network with Multi-Segment Pseudowire (MS-PW) from different Service Providers with inter-provider PW connections. The trusted zone is T-PE1 to S-PE3, as illustrated in Figure 5.

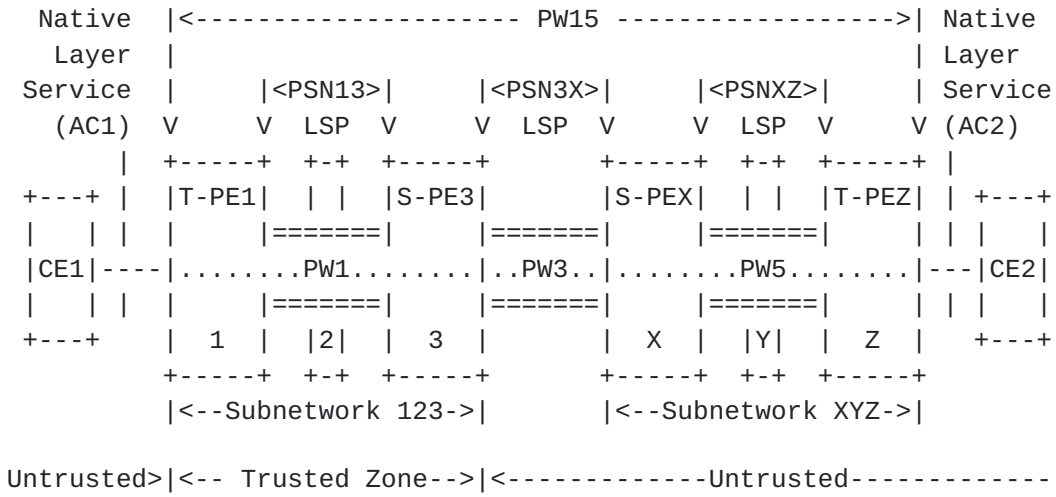

Figure 5. MPLS-TP Security Model 2(c)

In general, the boundaries of a trusted zone must be carefully defined when analyzing the security properties of each individual network. The security boundaries determine which reference model

should be applied to given network topology.

3. Security Threats

This section discusses various network security threats that are unique to MPLS-TP and may endanger MPLS-TP networks.

Attacks to GAL or G-ACh may include:

- GAL or BFD label manipulation, which includes insertion of false labels and modification, deletion, or replay of messages.

- DoS attack through in-band OAM by generating excessive G-ACh/GAL and BFD messages which consume significant bandwidth and potentially cause congestion.

These attacks can cause unauthorized protection switchover, inability to restore, or loss of network connectivity.

When a NMS is used for LSP setup, the attacks to NMS can cause the above effect as well. Although this is not unique to MPLS-TP, MPLS-TP network can be particularly vulnerable to NMS attack due to the fact that static provisioning through NMS is a commonly used model. In the static provisioning model, a compromised NMS can potentially be comparable to a comprised control plane plus a comprised management plane in the dynamic controlled network model.

Attacks to NMS may come from external attackers, or insiders. Outside attacks are initiated outside of the trusted zone by unauthorized user of the MPLS-TP network management systems. Insider attack is initiated from inside of the trusted zone by an entity with authorized access to the management systems, but performs unapproved harmful functions to the MPLS-TP networks. These attacks may be directly targeted to the NMS, or via the compromised communication channels between the NMS and the network devices that are being provisioned, or through the access of the users to the provisioning tools. The security threat may include disclosure of information, generating false OAM messages, taking down MPLS-TP LSPs, connecting to the wrong MPLS-TP tunnel end points, and DoS attacks to the MPLS-TP networks.

There are other more generic security threat, such as: Unauthorized observation of data traffic (including traffic pattern analysis), modification, or deletion of a provider's or user's data, as well as replay or insertion of inauthentic data into a provider's or user's data stream. These types of attacks apply to MPLS-TP traffic regardless of how the LSP or PW is set up in a similar way to how they apply to MPLS traffic regardless how the LSP is set up. More

details on the above mentioned threat are documented in [RFC5920].

The threats may be resulting from malicious behavior or accidental errors.

Example 1: Attack from users: Users of the MPLS-TP network may attack the network infrastructure or attack other users.

Example 2: Attack from insiders: Employees of the operators may attack the MPLS-TP network, especially through NMS.

Example 3: Attack from inter-connecting SPs or other partners: Other SPs may attack the MPLS-TP network, particularly through the inter-provider connections.

Example 4: Attack as the result of operation errors: Operation staff may fail to follow the operational procedures or make operational mistakes.

4. Defensive Techniques

The defensive techniques presented in this document and in [RFC5920] are intended to describe methods by which some security threats can be addressed. They are not intended as requirements for all MPLS-TP deployments. The specific operational environment determines the security requirements for any instance of MPLS-TP. Therefore, protocol designers should provide a full set of security capabilities, which can be selected and used where appropriate. The MPLS-TP provider should determine the applicability of these techniques to the provider's specific service offerings, and the end user may wish to assess the value of these techniques to the user's service requirements.

Authentication is the primary defense technique to mitigate the risk of the MPLS-TP security threat "GAL or BFD label manipulation", and "DoS attack through in-band OAM" discussed in Section 3. Authentication refers to methods to ensure that message sources are properly identified by the MPLS-TP devices with which they communicate. Authentication includes entity authentication for identity verification, management system authentication, peer-to-peer authentication, message integrity and replay detection to ensure the validity of message streams, network-based access controls such as packet filtering and firewalls, host-based access controls, isolation, aggregation, protection against denial of service, and event logging. Where these techniques apply to MPLS and GMPLS in general, they are described in Section 5.2 of [RFC5920].

In addition to authentication, the following defense should also be

considered to protect MPLS-TP networks.

- Use of Isolated Infrastructure for MPLS-TP

One way to protect the MPLS-TP infrastructure network is to use dedicated network resources to provide MPLS-TP transport services. For example, in security model 2 (Section 2.2), the potential risk of attacks on the S-PE1 or T-PE1 in the trusted zone may be reduced by using non-IP-based communication paths, so that the paths in the trusted zone cannot be reached from the outside via IP.

- Verification of Connectivity

To protect against deliberate or accidental misconnection, mechanisms can be put in place to verify both end-to-end connectivity and segment-by-segment resources. These mechanisms can trace the routes of LSPs in both the control plane and the data plane. Note that the connectivity verification tools are now developed for general MPLS networks as well.

The defense techniques are apply generally to MPLS/GMPLS are not detailed here, for example:

1) Authentication: including Management System Authentication, Peer-to-Peer Authentication, Cryptographic Techniques for Authenticating Identity;

2) Access Control Techniques;

3) Use of Aggregated Infrastructure;

4) Mitigation of Denial of Service Attacks;

5) Monitoring, Detection, and Reporting of Security Attacks.

Readers can refer to [RFC5920] for details.

It is important to point out the following security defense techniques which are particularly critical for NMS due to the strong emphasis on static provisioning supported by NMS in MPLS-TP deployment. These techniques include: Entity authentication for identity verification, encryption for confidentiality, message integrity and replay detection to ensure the validity of message streams, as well as users access control and events logging which must be applied for NMS and provisioning applications.

5. Security Considerations

Security considerations constitute the sole subject of this document and hence are discussed throughout.

This document evaluates MPLS-TP specific security risks and mitigation mechanisms which may be used to counter the potential threats. All of the techniques presented involve mature and widely implemented technologies that are practical to implement. It is meant to assist equipment vendors and service providers, who must ultimately decide what threats to protect against in any given configuration or service offering from a customer's perspective as well as from a service provider's perspective.

6. IANA Considerations

This document contains no new IANA considerations.

7. Acknowledgements

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8. References

8.1. Normative References

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[RFC5920] Fang, L., Ed., "Security Framework for MPLS and GMPLS Networks", RFC 5920, July 2010.

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