Applicability analysis of Generalized Multiprotocol Label Switching (GMPLS) protocols for the Layer 1 Virtual Private Network (L1VPN) Enhanced Mode

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Status of this Memo

Abstract

   This document provides an applicability analysis on the use of
   Generalized Multiprotocol Label Switching (GMPLS) protocols and
   mechanisms to satisfy the requirements of the Layer 1 Virtual Private
   Network (L1VPN) Enhanced Mode.

   L1VPNs provide customer services and connectivity at layer 1 over
   layer 1 networks. The operation of L1VPNs is divided into the Basic
   Mode and the Enhanced Mode, where the Enhanced Mode of operation
   features exchange of routing information between the layer 1 network
   and the customer domain.

In addition, this document identifies areas where additional protocol
extensions or procedures are needed to satisfy the requirements of
the L1VPN Enhanced Mode, and provides guidelines for potential
extensions.

Table of Contents

1. Contributors

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several authors who are listed here in alphabetic order. Contact
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2. Terminology

The reader is assumed to be familiar with the terminology in
[RFC3031], [RFC3209], [RFC3471], [RFC3473], [RFC4202], [RFC4026] and
[L1VPN-FW].

3. Introduction

This document shows the applicability of existing Generalized
Multiprotocol Label Switching (GMPLS) protocols and mechanisms to the
Layer 1 Virtual Private Network (L1VPN) Enhanced Mode. In addition,
this document identifies several areas where additional protocol
extensions or modifications are needed to meet the L1VPN Enhanced
Mode service requirements set out in [L1VPN-FW].

In particular, this document shows section by section (from Section 5
to 8) the applicability of GMPLS protocols and mechanisms to each
sub-model of the Enhanced Mode mentioned in [L1VPN-FW], along with
additional work areas needed to fully support the requirements for
each sub-model.

Note that discussion in this document is limited to areas where GMPLS
protocols and mechanisms are relevant.

As will be described in this document, support of the Overlay
Extension service model and the Virtual Node service model are well
covered by existing protocol mechanisms already described in other
documents, with only minor protocol extensions required. The Virtual
Link service model and the Per-VPN Peer service model are not
explicitly covered by existing documents, but can be realized by
extending current GMPLS protocols and mechanisms as described in this
document.

The following section lists areas where additional work may be
required to fully support the requirements for each sub-model. Some
of the requirements are optional, therefore the additional work is
also optional.

Commonalities of mechanisms over various sub-models, as well as over
the L1VPN Basic Mode need to be considered. Also, various mechanisms
should be coordinated in such a way that services are provided in a
fully functional manner.

3.1 Work Items

This list of additional work areas is a summary derived from the main
body of this document. The list will be updated in later versions of
this document along with the development of the additional or
enhanced requirements and increased understanding of the issues. As
work progresses on protocol extensions, this list will be updated to
remove completed items, and the body of this document will be updated
to describe the analysis of protocol extensions. The intention is
that this whole section is removed when the work has been completed
and this document progresses to become an RFC.

o Routing representation (how a VPN should be represented in routing,
  e.g., single area, multi-area, multi-AS). See Sections 6.3 and 7.3.
o Signaling and routing for support of the Per-VPN Peer service
  model. See Section 8.3.

3.2 Existing Solutions Drafts

This section lists existing solution documents that describe how the
L1VPN Enhanced Mode may be constructed using the mechanisms of GMPLS.
This document draws on those solutions and explains their
applicability and suggests further extensions to make the solutions
more closely match the framework described in [L1VPN-FW]. Further
solution documents may be listed in a future version of this
document.

o [GVPN] describes a suite of port-based Provider-provisioned VPN
  services called Generalized VPNs (GVPNs) that use BGP for VPN
  auto-discovery and GMPLS as a signaling mechanism.

o [L1VPN-BM] addresses the L1VPN Basic Mode signaling.

Note that although [L1VPN-BM] specifies signaling mechanisms for
L1VPN Basic Mode, it is applicable to the L1VPN Enhanced Mode, unless
otherwise specified. Therefore, main focus of this document is how to
realize routing related information exchange between a CE and a PE.

4. General Guidelines

This section provides general guidelines for L1VPN solutions. Note
that applicability to specific sub-models will be separately
described in following sections.

One important general guideline is that protocol mechanisms should be
re-used where possible. This means that solutions should be
incremental, building on existing protocol mechanisms rather than
developing wholly new protocols. Further, as service models are
extended or developed resulting in the requirement for additional
functionalities, deltas should be added to the protocol mechanisms
rather than developing new techniques. [L1VPN-FW] describes how the

service models can be seen to provide "cascaded" functionality, and
this should be leveraged to achieve re-use of protocol extensions so
that, for example, it is highly desirable that the same signaling
protocols and extensions are used in both the Basic Mode and the
Enhanced Mode.

In addition, the following are general guidelines.

- The support of L1VPNs should not necessitate any change to core (P)
  devices. Therefore, any protocol extensions made to facilitate
  L1VPNs need to be made in a backward compatible way allowing GMPLS
  aware P devices to continue to function.
- Customer (C) devices not directly involved in providing L1VPN
  services should also be protected from protocol extensions made to
  support L1VPNs. Again, such protocol extensions need to be backward
  compatible. Note however, that some L1VPN service models allow for
  VPN connectivity between C devices rather than between CE devices:
  in this case, the C devices may need to be aware of protocol
  extensions.
- Solutions should aim to minimize the protocol extensions on CE
  devices.
- Solutions should be scalable and manageable. Solutions should not
  require L1VPN state to be maintained on the P devices as much as
  possible.
- Solutions should be secure. Providers should be able to screen and
  protect information based on their operational policies.
- Solutions should provide an operational view of the L1VPN for the
  customer and provider. There should be a common operational and
  management perspective in regard to other (L2 and L3) VPN services.

5. Overlay Extension Service Model

5.1 Overview of the Service Model

This service model complements the Basic Mode and may assume all of
the requirements, solutions and work items for that model.

In this service model, a CE receives from its attached PEs a list of
TE link addresses to which it can request a VPN connection (i.e.,
membership information).

The CE may also receive some TE information concerning these CE-PE
links within the VPN (e.g., switching type).

The CE does not receive any of the following from the PE.

- Routing information about the core provider network.
- Information about P device addresses.
- Information about P-P, PE-P or PE-PE TE links.

- Routing information about other customer sites. The CE may have
  access to routing information about the remainder of the VPN (C-C
  and CE-C links), but this is exchanged by control plane tunneling
  on the CE-CE connections and is not passed to the CE in the control
  plane exchange between PE and CE.

5.2 Applicability of Existing Solutions

The following are required in this service model (in addition to
requirements in the L1VPN Basic Mode).

- VPN membership information exchange between a CE and PE.
- CE-PE TE link information exchange between a CE and a PE.

[GVPN] covers the requirement to exchange membership information
between the CE and the PE based on BGP. Furthermore, [BGP-TE] allows
the exchange of CE-PE TE link information between a CE and a PE.

5.3 Additional Work Area(s)

None.

6. Virtual Node Service Model

6.1 Overview of the Service Model

In this service model, there is a private routing exchange between
the CE and the PE, or to be more precise between the CE routing
protocol instance and the VPN routing protocol instance running on
the PE. The provider network is considered as one private node from
the customer's perspective. The routing information exchanged between
the CE and the PE includes CE-PE TE link information, customer
network (i.e., remote CE sites), and may include TE links (Forwarding
Adjacencies) connecting CEs (or Cs) across the provider network as
well as control plane topology information from the customer network
(i.e., CE sites).

6.2 Applicability of Existing Solutions

The following are required in this service model.

- VPN routing
- Signaling: CE-CE Label Switching Path (LSP) setup, deletion, and
  modification

[GVPN] covers most of the requirements.

Specifically, [GVPN] handles VPN routing by a per VPN database called
the GVSI (Generalized Virtual Switching Instance) held in each PE.

GVSIs are inter-connected by tunnel-based control channels, and
routing adjacencies are established between them. BGP is used for
auto-discovery of remote GVSIs (VPN auto-discovery) in the same VPN.
GVSIs advertise VPN routing information by using a single ROUTER_ID
to represent the provider network as one node.

It is also possible to use IGP-based auto-discovery (based on [L1VPN-
OSPF-DISC]), instead of BGP-based auto-discovery.

Signaling mechanisms are covered by [L1VPN-BM].

6.3 Additional Work Area(s)

o Routing Representation

  [GVPN] allows flexible routing configuration for each VPN (e.g.,
  single IGP area, multiple IGP areas, or multiple ASes).

  However, it may be valuable to consider how to represent a VPN in
  routing. This may simplify the solution (e.g., in terms of
  scalability). This requires further discussion.

7. Virtual Link Service Model

7.1 Overview of the Service Model

In this service model, virtual links are established between PEs. A
virtual link is assigned to each VPN and disclosed to the
corresponding CEs. The routing information exchanged between the CE
and the PE includes CE-PE TE links, customer network (i.e., remote CE
sites), virtual links (i.e., PE-PE links) assigned to each VPN, and
may include CE-CE (or C-C) Forwarding Adjacencies as well as control
plane topology from the customer network (i.e., CE sites).

7.2 Applicability of Existing Solutions

Currently, there is no solution document for this type of service
model.

7.3 Additional Work Area(s)

Simple modifications of [GVPN], in addition to enhancements mentioned
in Section 6.3, may realize this type of service model. Modifications
could be:

- Do NOT modify the ROUTER_ID of the TE link information when
  advertising a CE-PE TE link to the CE (in the OSPF packet header as
  well as in the LSA header).

   - Set up Forwarding Adjacency LSPs (FA-LSPs, GVSI-LSPs in [GVPN]
     terms) between PEs to construct virtual links, and advertise these
     FAs in VPN routing. Note these FAs (virtual links) may be assigned
     private addresses, which means customer assigned addresses (or that
     customers are allowed to configure addresses). This may require
     extensions to current IGP behavior.

   There could be other ways to construct virtual links (e.g., virtual
   links without actually setting up an FA-LSP [MRN-REQ]).

   Resource management for a dedicated data plane is a mandatory
   requirement for the Virtual Link service model. This could be
   realized by assigning pre-configured FA-LSPs to each VPN routing
   protocol instance (no protocol extensions needed) in order to
   instantiate the necessary FAs.

   Note that as in the case of the Virtual Node service model, solution
   details may differ depending on the routing representation. This
   requires further discussion.

8. Per-VPN Peer Service Model

8.1 Overview of the Service Model

   In this service model, the provider partitions TE links within the
   provider network per VPN. The routing information exchanged between
   the CE and the PE includes CE-PE TE links, customer network (i.e.,
   remote CE sites), as well as partitioned portions of the provider
   network, and may include CE-CE (or C-C) Forwarding Adjacencies and
   control plane topology from customer network (i.e., CE sites). Note
   that PEs may abstract routing information about the provider network
   and advertise it to CEs.

   Note scalability must be carefully considered for advertising
   provider network routing information to the CE [INTER-DOMAIN-FW].

8.2 Applicability of Existing Solutions

   Currently, there is no solution document for this type of service
   model.

8.3 Additional Work Area(s)

   There are two approaches for this service model.

   o Signaling and routing for support of the per-VPN Peer service
     model

     Option1: Virtual Link based approach

The Per-VPN Peer service model may be realized by extending the
virtual link technique so that not only PEs but also Ps that
contain end points of virtual links in the abstracted topology
contain VPN routing instances. There may be no additional
protocol extensions needed from the Virtual Link service model.

   Option2: Virtual Node based approach

The Per-VPN Peer service model may be realized by extending the
virtual node technique so that PEs selectively advertise
provider internal TE links to CEs. There are several extensions
needed for this.

   Details are for further study.

9. Discussion

This section summarizes items for which existing solutions may need
to be extended in order to fulfill the full set of L1VPN Enhanced
Mode functionalities.

For the Overlay Extension service model and the Virtual Node service
model, the existing solutions can be applied with few extensions.

As described in Sections 7.2 and 8.2, there are no existing solutions
to support the Virtual Link service model and the Per-VP Peer service
model. For the Virtual Link service model, however, minor extensions
from existing solutions are expected to meet the requirements.

Note that the list of additional work areas will be updated in later
versions of this document with the development of additional or
enhanced requirements and further understanding of the issues.

   o Routing representation
     - One building block for the Enhanced Mode
     - Further discussion required (single area, multi areas, multi
       ASes, etc.)
     - Impact: Details to be studied (routing etc.)

   o Signaling and routing for support of the Per-VPN Peer service model
     - Details for further study

10. Manageability Considerations

Section 11 of [L1VPN-FW] describes manageability considerations for
L1VPNs.

This document defines a following new manageability requirement
specific for the L1VPN Enhanced Mode.

MIB modules MUST be available for any protocol extensions for the
L1VPN Enhanced Mode.

A future revision of this document may cover more aspects.

11. Security Considerations

Section 12 of [L1VPN-FW] describes security considerations for
L1VPNs. This document defines a following new security requirements
specific for the L1VPN Enhanced Mode.

In the L1VPN Enhanced Mode, since there is a routing adjacency
between a CE and a PE, care must be taken whether the provider
network's control plane topology information is leaked to the CE. Due
to security concerns, this is not recommended in general, and there
must be a mechanism to prevent such operation.

A future revision of this document may cover more aspects.

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13. Acknowledgments

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