PPVPN Working Group
Internet Draft
Document: draft-ietf-l2vpn-vpls-requirements-00.txt
Category: Informational
October 2002
Expires: April 2003

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Requirements for Virtual Private LAN Services (VPLS)

Status of this Memo

1 Abstract

This draft describes service requirements related to emulating a virtual private LAN over an IP or MPLS network infrastructure. The service is called VPLS. It is a class of Provider Provisioned Virtual Private Network [2]. The general requirements can be found in [3].

2 Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 [4].

3 Definitions

3.1 VPLS

Virtual Private LAN Service, a case of L2VPN service distinguished by the support of L2 broadcast. The term is also used, when clear from the context, to refer to a particular instance of VPLS service.

A VPLS service allows the connection of multiple sites in a single broadcast domain over a provider managed IP or MPLS network. All customer sites in the VPLS appear to be on the same LAN regardless of their location.

3.2 VPLS Domain

A Layer 2 VPN that is composed of a community of interest of L2 MAC addresses and VLANs. Each VPLS Domain MAY have multiple VLANs in it.

3.3 VLAN

A customer VLAN identification using some scheme such as IEEE 802.1Q tags, port configuration or any other means. A VPLS service can be extended to recognize customer VLANs as specified in 6.1 .

3.4 VLAN Flooding Scope (VLAN Broadcast Domain)

The scope of flooding for a given VLAN. In a VPLS service, a VLAN

flooding scope is identical to the flooding scope of the VPLS it is part of. If a VPLS service is extended to recognize customer VLANs, the VLAN flooding scope is limited to the broadcast domain of each recognized VLAN.

3.5 VSI

Virtual Switching Instance. A virtual layer 2 forwarding entity that is closed to a VPLS domain membership. VSI forwarding can be based on MAC addresses, VLAN tags, policies, topologies, filters, QoS parameters, and other relevant information on a per VPLS basis.

4 Introduction

Traditionally, the typical connectivity between a service provider and a customer is a WAN link with some type of a point-to-point protocol. This arrangement was borne out of the necessity to traverse TDM circuits originally designed for voice traffic. The introduction of WAN links to network architectures significantly increased the complexity of network topologies and required highly skilled personnel to manage and maintain the network.

One solution to the above has been for service providers to deploy emulated LAN services known in this context as "Transparent LAN" services. These have typically been offered using a mesh of ATM PVCs between locations. While this technique reduced complexity for the customer, it proved inadequate in the area of scaling and ease of management on the provider side.

The aim of this effort is to develop a Virtual Private LAN Service, VPLS, that scales well, is simple to manage, and is based on the existing MPLS or IP backbone.

VPLS emulates a flat LAN with learning and switching capabilities. In a given LAN, there is a reasonably small set of MAC devices with a limited number of MAC addresses to learn and manage. There is no need for additional routing protocol support between the CE and the PE devices. In the VPLS model, the service is transparent to the customer's choice of routing protocol. Moreover, VPLS services also benefit from being transparent to higher layer protocols, so the same technology can transport, for example, IPv4, IPv6, MPLS as well as legacy protocols such as IPX and OSI.

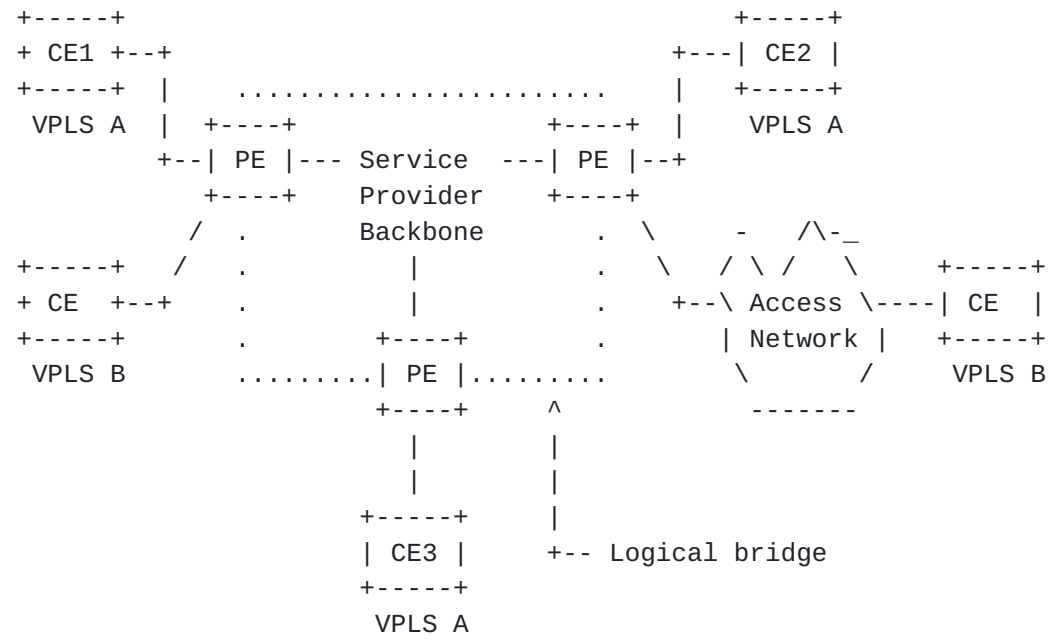
The VPLS model, while offering significant benefits for both customers and service providers, retains all the quintessential characteristics of L2 networks including their well known

limitations e.g. the maximum practical number of hosts on a single LAN, etc. A likely application of this model is to connect a few sites with only a single customer router at each site, or a small number of customer hosts, at each site, connected via the VPLS.

The scope of this document will be limited to supporting Ethernet as the access framing technology for VPLS implementation.

5 VPLS Reference Model

The following diagram shows a VPLS reference model where PE devices that are VPLS-capable provide a logical interconnect such that CE devices belonging to a specific VPLS appear to be connected by a single logical Ethernet bridge. A VPLS can contain a single VLAN or multiple, tagged VLANs.



Separate L2 broadcast domains are maintained on a per VPLS basis by PE devices. Such domains are then mapped onto tunnels in the service provider network. These tunnels can either be specific to a VPLS (e.g. as with IP) or shared among several VPLSs (e.g. as with MPLS tunnel LSPs). In the above diagram, the top PE routers maintain separate forwarding instances for VPLS A and VPLS B.

The CE-to-PE links can either be direct physical links, e.g. 100BaseTX, or logical links, e.g. ATM PVC, T1/E1 TDM, or RFC1490-encapsulated links, over which bridged Ethernet traffic is carried.

The PE-to-PE links carry tunneled Ethernet frames using different tunneling technologies (e.g., GRE, IPSec, MPLS, L2TP, etc.).

Each PE device learns remote MAC addresses, and is responsible for proper forwarding of the customer traffic to the appropriate end nodes. It is responsible for guaranteeing each VPLS topology is loop free.

6 VPLS General Requirements

6.1 Layer 2 Domain representation

A VPLS system MUST distinguish different customer domains. Each of these customer domains MUST appear as a L2 broadcast domain network behaving like a LAN (Local Area Network). These domains are referred to as VPLS domains.

A VPLS MAY span multiple service providers. Each VPLS MUST carry a unique identification within a VPLS system. It is RECOMMENDED that VPLS identification be globally unique.

Each VPLS domain MUST be capable of learning and forwarding based on MAC addresses thus emulating an Ethernet virtual switch to the customer CE devices attached to PEs.

A VPLS system MAY recognize customer VLAN identification. In that case, a VLAN MUST be recognized in the context of the VPLS it is part of. If customer VLANs are recognized, separate VLAN broadcast domains SHOULD be maintained.

A provider's implementation of a VPLS system SHOULD NOT constrain the customer's ability to configure LAN topologies, tags, 802.1 p-bits, or any other Layer 2 parameters.

6.2 VPLS Topology

The VPLS system MAY be realized using one or more network tunnel topologies to interconnect PEs, ranging from simple point-to-point to distributed hierarchical arrangements. The typical topologies

include:

- point-to-point
- point-to-multipoint, a.k.a. hub and spoke
- any-to-any, a.k.a. full mesh
- mixed, a.k.a. partial mesh
- hierarchical

Regardless of the topology employed, the service to the customers MUST retain the typical LAN any-to-any connectivity. This requirement does not imply that all traffic characteristics (such as bandwidth, QoS, delay, etc.) be necessarily the same between any two end points.

6.3 Redundancy and Failure Recovery

The VPLS infrastructure SHOULD provide redundant paths to assure high availability. The reaction to failures SHOULD result in an attempt to restore the service using alternative paths.

The intention is to keep the restoration time small. It is RECOMMENDED that the restoration time be less than the time it takes the CE devices, or customer L2 control protocols, to detect a failure in the VPLS.

In cases where the provider knows a priori about impending changes in network topology, the network SHOULD have the capability to reconfigure without a loss, duplication, or re-ordering of customer packets. This situation typically arises with planned network upgrades or scheduled maintenance activities.

6.4 Policy Constraints

A VPLS system MAY employ policy constraints governing various interconnection attributes for VPLS domains. Typical attributes include:

- Selection of available network infrastructure
- QoS services needed
- Protection services needed
- Availability of higher level service access points (see 9.7)

Policy attributes SHOULD be advertised via the VPLS system's control plane.

6.5 PE nodes

The PE nodes are the devices in the VPLS system that store information related to customer VPLS domains and employ methods to forward customer traffic based on that information. In this document, the PE nodes are meant in logical sense. In the actual implementations, the PE nodes may be comprised of several physical devices. Conversely, a single physical device may contain more than one PE node.

All forwarding decisions related to customer VPLS traffic MUST be made by PE nodes. This requirement prohibits any other network components from altering decisions made by PE nodes.

6.6 PE-PE Interconnection and Tunneling

A VPLS system MUST provide for connectivity between each pair of PE nodes. The connectivity is referred to as transport tunneling or simply tunneling.

There are several choices for implementing transport tunnels. Some popular choices include MPLS, IP in IP tunnels, variations of

802.1Q, etc. Regardless of the choice, the existence of the tunnels and their operations MUST be transparent to the customers.

6.7 PE-CE Interconnection and Profiles

A VPLS system MUST provide for connectivity between PE nodes and CE nodes. That connectivity is referred to as an Attachment Circuit (AC). Attachment Circuits MAY span networks of other providers or public networks.

There are several choices for implementing ACs. Some popular choices include Ethernet, ATM (DSL), Frame Relay, MPLS-based virtual circuits etc. Regardless of the choice, the ACs MUST use Ethernet frames as the Service Protocol Data Unit (SPDU).

A CE access connection over an AC MUST be bi-directional in nature.

PE devices MAY support multiple ACs on a single physical interface. In such cases, PE devices MUST NOT rely on customer controlled parameters for distinguishing between different access connections. For example, if VLAN tags were used for that purpose, the provider

would be controlling the assignment of the tag values and would strictly enforce compliance by the CEs.

An AC connection, whether direct or virtual, MUST maintain all committed characteristics of the customer traffic, such as QoS, priorities etc. The characteristics of an AC connection are only applicable to that connection.

7 Control Plane Requirements

7.1 Provider Edge Signaling

The control protocols SHOULD provide methods for signaling between PEs. The signaling SHOULD inform of membership, tunneling information, and other relevant parameters.

The infrastructure MAY employ manual configuration methods to provide this type of information.

The infrastructure SHOULD use policies to scope the membership and reachability advertisements for a particular VPLS.

7.2 VPLS Membership Discovery

The control plane and/or the management plane SHOULD provide methods to discover the PEs which connect CEs forming a VPLS.

7.3 Support for Layer 2 control protocols

The VPLS system's control protocols SHOULD allow transparent operation of Layer 2 control protocols employed by customers.

A VPLS system MUST ensure that loops be prevented. This can be accomplished through a loop free topologies or appropriate forwarding rules. Control protocols such as Spanning Tree (STP) or similar could be employed. The system's control protocols MAY use indications from customer control protocols, e.g. STP, to improve the operation of a VPLS.

7.4 Scaling Requirements

In a VPLS system, the control plane traffic increases with the growth of VPLS membership. Similarly, the control plane traffic increases with the number of supported VPLS domains. The rate of

growth of the associated control plane traffic SHOULD be linear.

The use of control plane resources increases with the number of hosts connected to a VPLS. The rate of growth of the demand for control process resources SHOULD be linear. The control plane MAY offer means for enforcing a limit on the number of customer hosts attached to a VPLS.

8 Data Plane Requirements

8.1 Transparency

VPLS service is intended to be transparent to Layer 2 customer networks. It SHOULD NOT require any special packet processing by the end users before sending packets to the provider's network.

8.2 QoS and packet re-ordering

A VPLS system SHOULD have capabilities to enforce QoS parameters.

The queuing and forwarding policies SHOULD preserve packet order for packets with the same QoS parameters.

The service SHOULD not duplicate packets.

8.3 Broadcast Domain

The Broadcast Domain is defined as the flooding scope of a Layer 2 network. A separate Broadcast Domain MUST be maintained for each VPLS.

In addition to VPLS Broadcast Domains, a VPLS system MAY recognize customer VLAN Broadcast Domains. In that case, the system SHOULD maintain a separate VLAN Broadcast Domain for each customer VLAN. A VLAN Broadcast Domain MUST be a subset of the owning VPLS Broadcast Domain.

8.4 MAC address learning

A VPLS service SHOULD derive all topology and forwarding information from packets originating at customer sites. Typically, MAC addresses learning mechanisms are used for this purpose.

In a VPLS system, MAC address learning MUST take place on a per

Virtual Switching Instance (VSI) basis, i.e. in the context of a VPLS and, if supported, in the context of VLANs therein.

8.5 Unicast, Unknown Unicast, Multicast, and Broadcast forwarding

VPLS MUST be aware of the existence and the designated roles of special MAC addresses such as Multicast and Broadcast addresses. VPLS MUST forward these packets according to their intended functional meaning and scope.

Broadcast packets MUST be flooded to all destinations.

Multicast packets MUST be flooded to all destinations. However, a VPLS system MAY employ multicast snooping techniques, in which case multicast packets SHOULD be forwarded only to their intended destinations.

Unicast packets MUST be forwarded to their intended destinations.

Unknown Unicast packets MUST be flooded to all destinations in the flooding scope of the VPLS (or VLAN). If the VPLS service relies on MAC learning for its operations, it MUST assure proper forwarding of packets with MAC addresses that have not been learned. Once destination MAC addresses are learned, unicast packets SHOULD be forwarded only to their intended destinations.

A provider MAY employ a method to limit the scope of flooding of Unknown Unicast packets in cases where a customer desires to conserve its bandwidth or wants to implement certain security policies.

8.6 Virtual Switching Instance

VPLS Provider Edge devices MUST maintain a separate Virtual Switching Instance (VSI) per each VPN. Each VSI MUST have

capabilities to forward traffic based on customer's traffic parameters such as MAC addresses, VLAN tags (if supported), etc. as well as local policies.

VPLS Provider Edge devices MUST have capabilities to classify incoming customer traffic into the appropriate VSI.

Each VSI MUST have flooding capabilities for its Broadcast Domain to facilitate proper forwarding of Broadcast, Multicast and Unknown Unicast customer traffic.

8.7 Minimum MTU

The VPLS service MUST support customer frames with payload 1500 bytes long. The service MAY offer support for longer frames.

The service MUST NOT fragment packets. Packets exceeding committed MTU size MUST be discarded.

The committed minimum MTU size MUST be the same for a given instance of VPLS. Different VPLS instances MAY have different committed MTU sizes. If VLANs are supported, all VLANs within a given VPLS MUST inherit the same MTU size.

8.8 Multilink Access

The VPLS service SHOULD support multilink access for CE devices. The VPLS service MAY support multihome access for CE devices.

8.9 End-point VLAN tag translation

If VLANs are recognized, the VPLS system MAY support translation of customers' VLAN tags. Such service simplifies connectivity of sites that want to keep their tag assignments or sites that belong to different administrative entities. In the latter case, the connectivity is sometimes referred to as L2 extranet.

8.10 Support for MAC Services

VPLS are REQUIRED to provide MAC service compliant with IEEE 802.1D specification [5] Section 6. Compliance with this section facilitates proper operation of 802.1 LAN and seamless integration of VPLS with bridged Local Area Networks. It is also useful to compare [6], [7], and [8].

A MAC service in the context of VPLS is defined as the transfer of user data between source and destination end stations via the service access points using the information specified in the VSI.

1. A PE device that provides VPLS MUST NOT be directly accessed by end stations except for explicit management purposes.

2. All MAC addresses MUST be unique within a given broadcast domain.

3. The topology and configuration of the VPLS MUST NOT restrict the MAC addresses of end stations

9 Management and Operations Requirements

9.1 VPLS configuration and monitoring

A VPLS system MUST have capabilities to configure, manage, and monitor its different components.

It SHOULD be possible to create several disjoint instances of VPLS systems within the same underlying network infrastructures.

The infrastructure SHOULD monitor all characteristics of the service that are reflected in the customer SLA. This includes but is not limited to bandwidth usage, packet counts, packet drops, service outages, etc.

9.2 VPLS operations

The operations of a VPLS systems is controlled by an Administrative Authority (Admin). The Admin is the originator of all operational parameters of a VPLS system. Conversely, the admin is also the ultimate destination for the status of the VPLS system and the related statistical information. A typical VPLS system spans several such Admins.

A VPLS system MUST support proper dissemination of operational parameters to all elements of a VPLS system in the presence of multiple Admins.

A VPLS system MUST employ mechanisms for sharing operational parameters between different Admins. These mechanism MUST NOT assume any particular structure of the different Admins. For example the VPLS should not be relying on Admins forming a hierarchy.

A VPLS system SHOULD support policies for proper selection of operational parameters coming from different Admins. Similarly, a VPLS system SHOULD support policies for selecting information to be disseminated to different Admins.

A VPLS system SHOULD employ discovery mechanisms to minimize the amount of operational information maintained by the Admins. For

example, if an admin adds or removes a customer port on a given PE,

the remaining PEs should determine the necessary actions to take without the Admins having to explicitly reconfigure those PEs.

9.3 CE Provisioning

The VPLS MUST require only minimal or no configuration on the CE devices, depending on the CE device that connects into the infrastructure.

9.4 Customer traffic policing

The VPLS service SHOULD provide the ability to police and/or shape customer traffic entering and leaving the VPLS system.

9.5 Dynamic Service Signaling

A Provider MAY offer to customers an in-band method for selecting services from the list specified in the SLA. A Provider MAY use the same mechanism for reporting statistical data related to the service.

9.6 Class of Service Model

The VPLS service MAY define a graded selection of classes of traffic. These include, but are not limited to

- range of priorities
- best effort vs. guaranteed effort
- range of minimum delay characteristics

9.7 VPLS service access option.

The VPLS service SHOULD allow for a Provider based Service Access for orderly injection of L3 or higher services to the customers' VPLS networks.

In particular, the system SHOULD allow to build L3VPN services, including L3 interworking schemes such as ARP mediation or similar.

As a value added service, a Provider MAY offer access to other services such as, IP gateways, storage networks, content delivery etc.

9.8 Testing

The VPLS service SHOULD provide the ability to test and verify operational and maintenance activities on a per VPLS basis and, if supported, on a per VLAN basis.

9.9 Learning information from customer devices

The VPLS service SHOULD provide means for limiting the amount of information learned from customer devices. For example, VPLS implementations may limit the number of MAC addresses learned from the customers' devices.

10 Security Requirements

10.1 Traffic separation

A VPLS system MUST provide traffic separation between different VPLS domains. If VLANs are supported, the system MUST provide traffic separation between customer VLANs within each VPLS domain.

10.2 Provider network protection.

A VPLS system MUST be immune to malformed or maliciously constructed customer traffic. This includes but is not limited to duplicate or invalid L2 addresses, customer side loops, short/long packets, spoofed management packets, spoofed VLAN tags, etc.

The VPLS infrastructure devices MUST NOT be accessible from the VPLS.

10.3 Value added security services

Value added security services such as encryption and/or authentication of customer packets, certificate management, and similar are OPTIONAL.

Security measures employed by the VPLS system SHOULD NOT restrict implementation of customer based security add-ons.

11 References

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12 Acknowledgments

We would like to acknowledge extensive comments provided by Loa Anderson, Joel Halpern, and Eric Rosen. The authors, also, wish to extend appreciations to their respective employers and various other people who volunteered to review this work and provided feedback.

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