



MPLS-based Layer 2 VPNs

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Agenda

◆ Introduction

- ❖ Traditional Layer 2 VPNs
- ❖ MPLS-based Layer 2 VPNs
- ❖ Layer 3 VPNs

◆ Details

- ❖ Provisioning
- ❖ Transport
- ❖ Carrying “non-address” information



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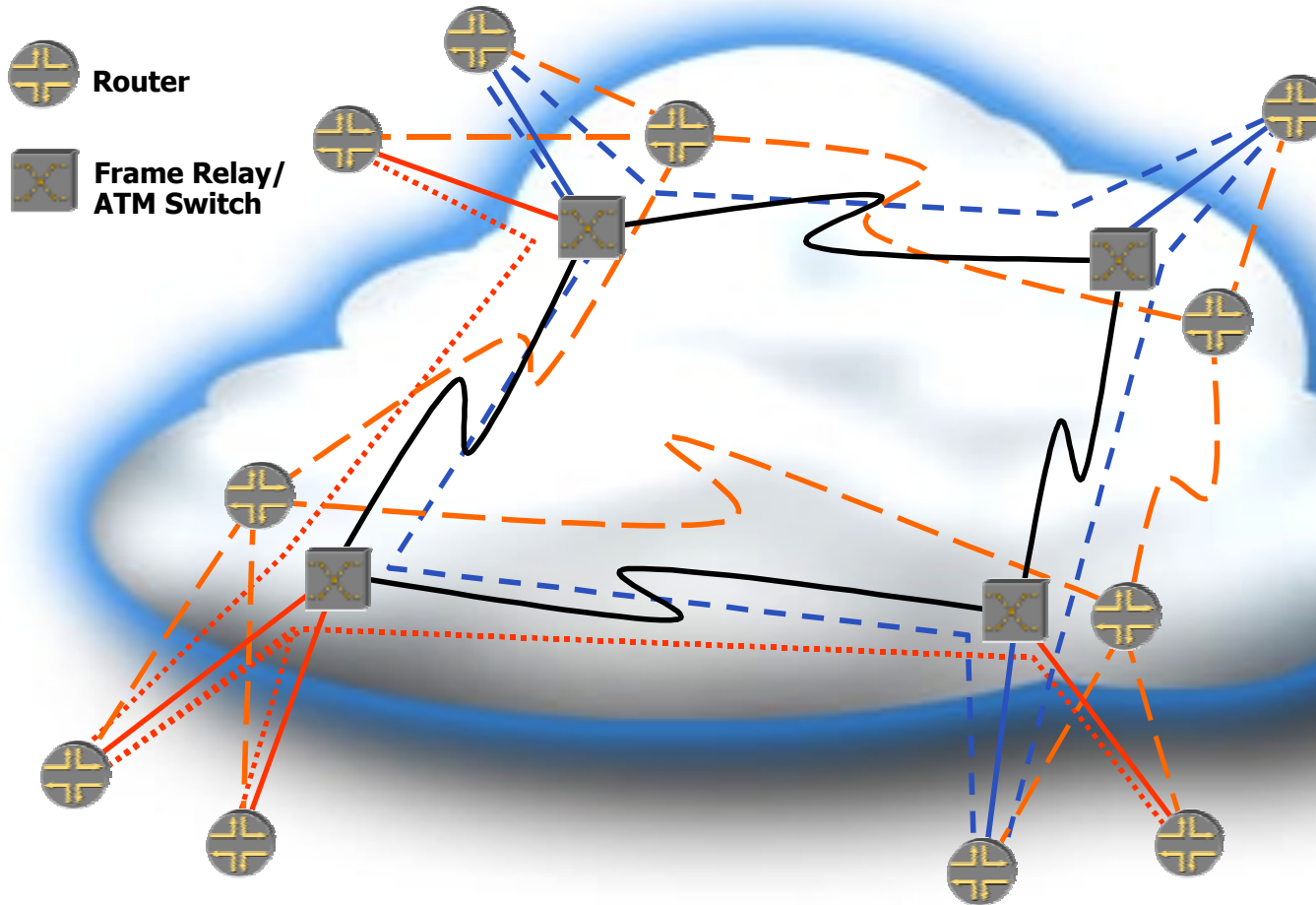
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Traditional (Layer 2) VPNs





Traditional (Layer 2) VPNs

- ◆ **Provider network technology dictated by VPN services**
 - ❖ **Frame switches? ATM switches?**
- ◆ **Provisioning – complex for provider**
- ◆ **Topology dictated by cost rather than traffic patterns**
- ◆ **Multiple networks – adds to provider's administrative burden**

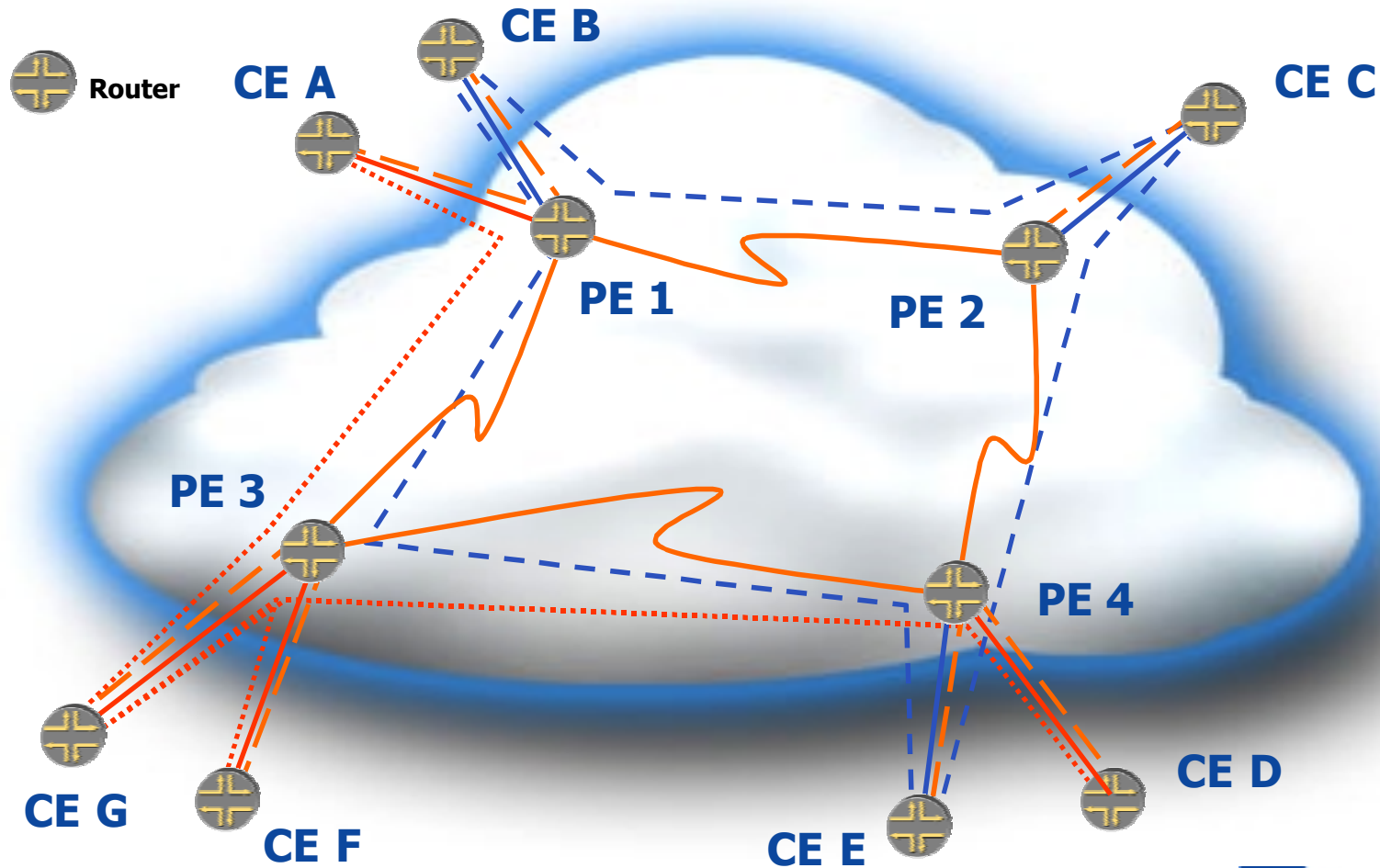


MPLS-Based Layer 2 VPNs

- ◆ **Traditional Layer 2 VPN from customer's point-of-view**
 - ❖ **Layer 3 independent**
 - ❖ **Provider not responsible for routing**
- ◆ **MPLS transport in provider network**
 - ❖ **Isolation between edge and core technologies**
- ◆ **Auto-provisioning VPN**
- ◆ **Single network architecture for both Internet traffic and VPN traffic**



MPLS-Based Layer 2 VPNs





Privacy \neq Security

- ◆ **Encryption is a must if you want security**
- ◆ **Where's the weak point?**
- ◆ **CE-to-CE**
 - ❖ **Use IPSec!**
 - ❖ **Not "PP" VPN**
- ◆ **PE-to-PE**
 - ❖ **Per VPN**
 - ❖ **Per PE-to-PE session**



Layer 3 VPNs

- ◆ **SP participates in customers' routing**
 - ❖ **Out-sourced routing**
 - ❖ **Added SP responsibilities**
 - ❖ **Value-added service ~ cost structure**
- ◆ **BGP MPLS VPNs**
 - ❖ **QoS/CoS, Carrier of Carriers, inter-SP VPNs**
- ◆ **Virtual routers**
- ◆ **Migration may take some work**



Provisioning the Network

- ◆ **PE-to-PE MPLS LSPs**
 - ❖ **Key: signaling**
 - ❖ **LDP LSPs**
 - ❖ **RSVP-TE LSPs**
 - ❖ **LDP over RSVP tunneling**
 - ◆ **Fully-meshed Traffic Engineered core**
 - ◆ **Edge-to-edge LDP LSPs**
- ◆ **Used for all services – IP, L2 VPNs, L3 VPNs, differentiated services**
- ◆ ***Provisioned independent of Layer 2 VPNs!***



Provisioning a VPN

- ◆ **Key: signaling**
 - ❖ **Auto-discovery of members, auto-assignment of inter-member circuits**
 - ❖ **Flexible VPN topology**
 - ❖ **Signaling using LDP or BGP**
- ◆ **$O(N)$ configuration for the whole VPN**
 - ❖ **Could be more for complex topologies**
- ◆ **$O(1)$ configuration to add a site**
 - ❖ **“Overprovision” DLCIs at customer sites**

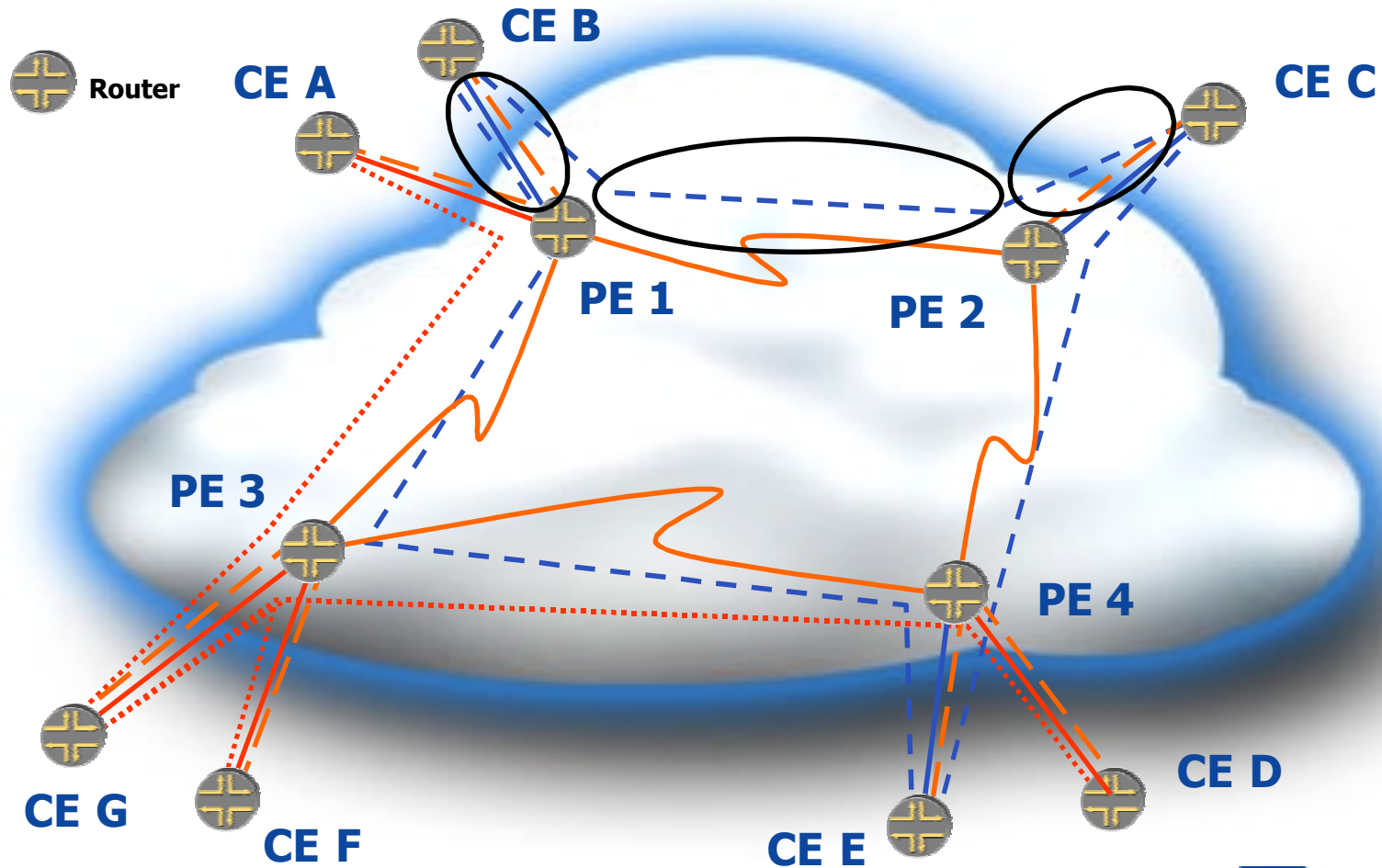


Provisioning Customer Sites

- ◆ **List of DLCIs, one for each other site, some spare (over-provisioning)**
- ◆ **DLCIs independently numbered at each site**
- ◆ **LMI, inverse ARP and/or routing protocols for auto-discovery and learning addresses**
- ◆ **No changes as VPN membership changes (until over-provisioning runs out)**

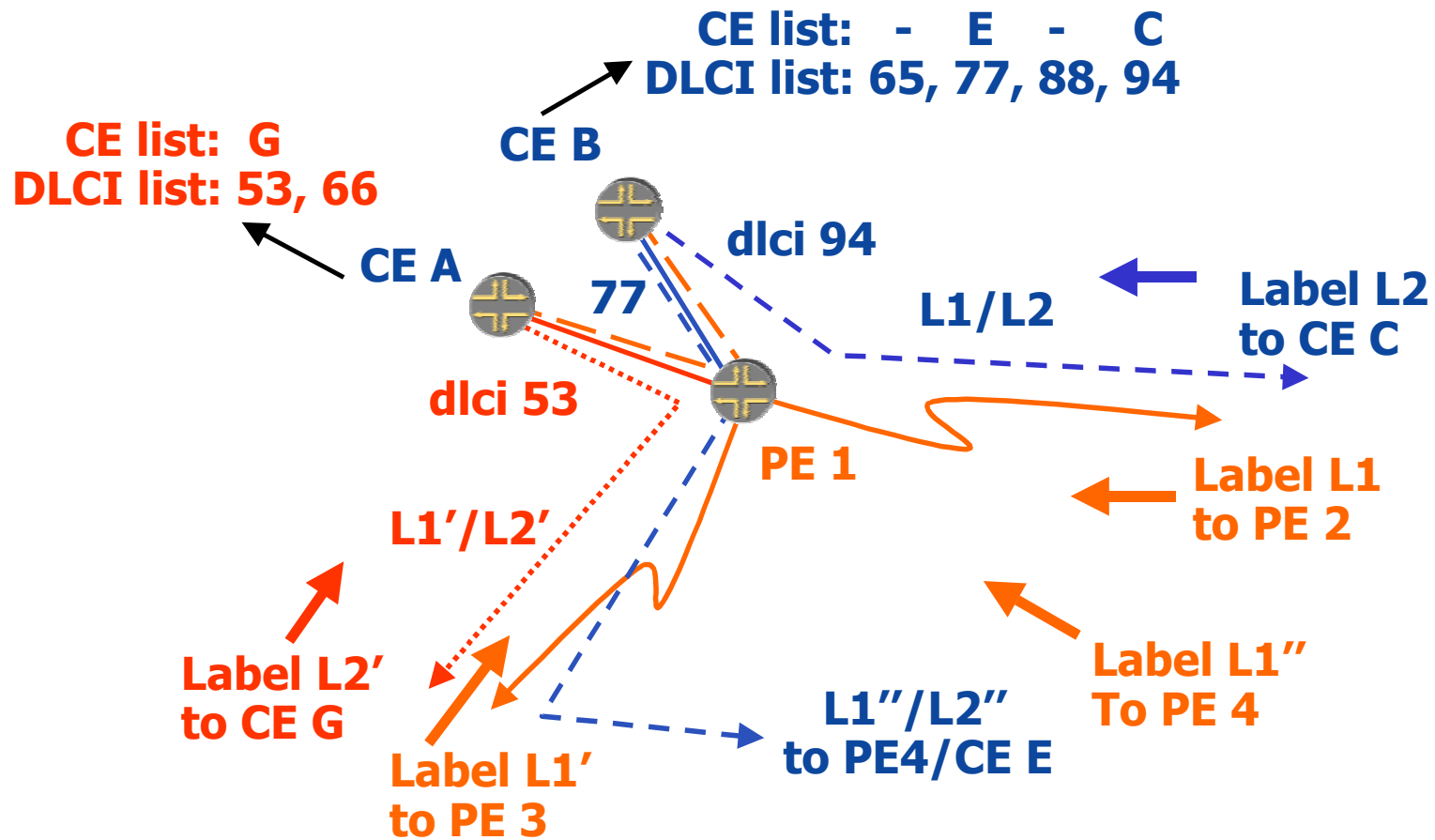


VPN Transport



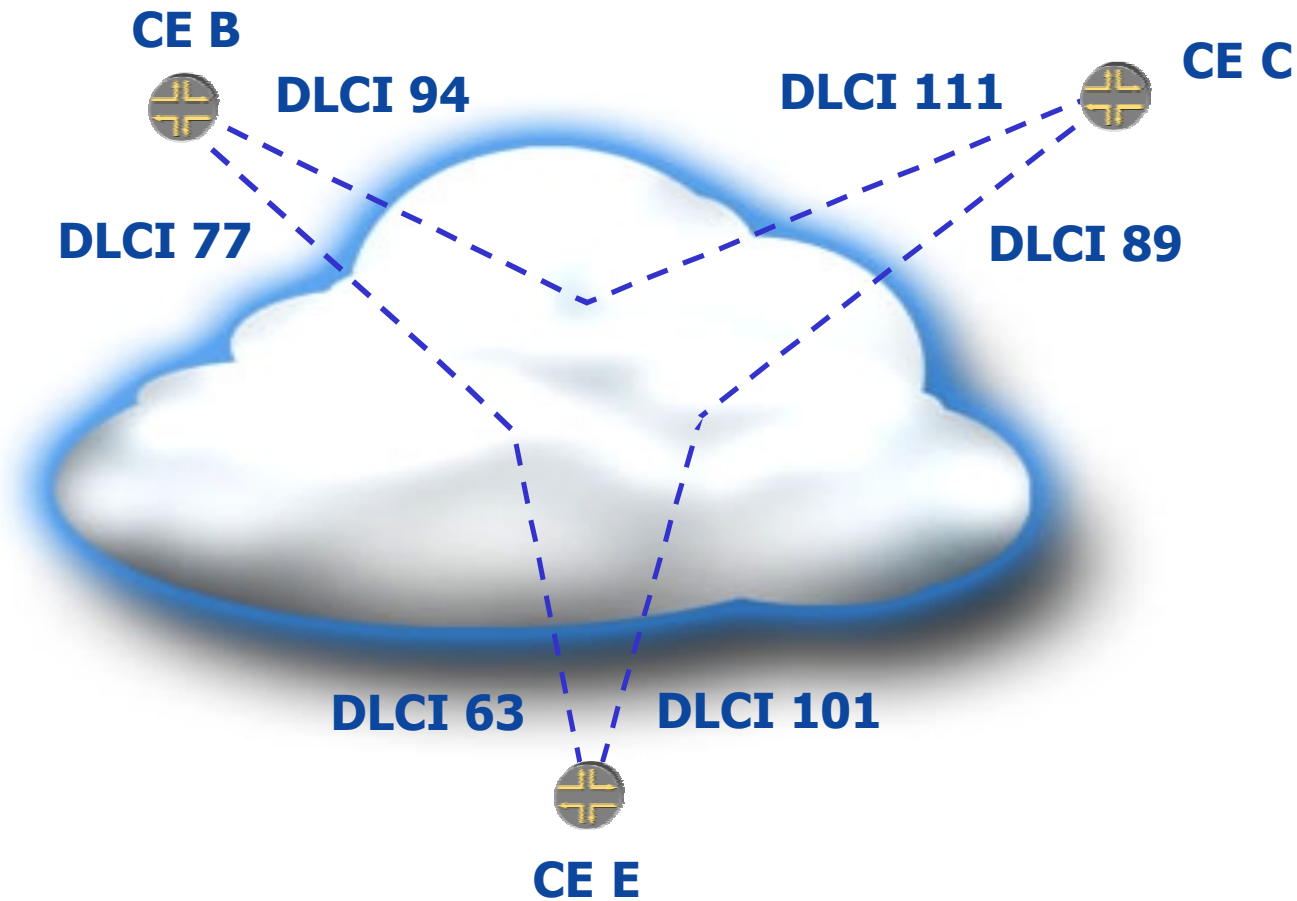


VPN Transport





Virtual Network





Signaling

- ◆ **Compact representation of mapping of layer 2 address to inner label**
- ◆ **Signaling through either BGP or LDP**
- ◆ **Arbitrary topologies possible; common ones such as full mesh and hub-and-spoke easy to configure**



Packet Format (1)

Packet format from customer:

<dlci><UI><proto><layer 3 packet>

Remove DLCI; add two labels

Packet format in network:

<MPLS encap><outer label><inner label>

<UI><proto><layer 3 packet>

In the example, outer label = L1, inner = L2



Packet Format (2)

At destination PE: remove MPLS encap and label(s), add new DLCI to get:

<dlci'><UI><proto><layer 3 packet>

- ◆ **Effectively, the SP network acts as a big Frame Relay switch for this VPN**



“Non-address” Information

- ◆ **What about F/B ECN, DE, C/R, ...?**
 - ❖ **Use experimental bits to carry this info**
 - ❖ **Can't squeeze 4 bits into 3, so use twice the number of labels if needed**
- ◆ **Not for preferential treatment in the core!**
 - ❖ **For this, use MPLS with Diff-Serv**
 - ❖ **Different DLCIs mapped to different PE-to-PE LSPs (L-LSPs) or different EXP bits (E-LSPs)**
 - ❖ **DE/not DE mapped to different EXP bits**



Summary

- ◆ **MPLS-based Layer 2 VPNs identical to Layer 2 VPNs from customers' perspective**
 - ❖ **Familiar paradigm**
 - ❖ **Easy to migrate**
- ◆ **Benefits**
 - ❖ **Single network infrastructure**
 - ❖ **Auto-provisioning**
 - ❖ **Layer 3 and routing independent**
- ◆ **Drawbacks**
 - ❖ **Layer 2 dependent**



Future Work

- ◆ **MPLS as layer 2 to CE**
 - ❖ **CE needs to be MPLS-aware**
- ◆ **“Secure” MPLS**
- ◆ **VLANs as layer 2 to CE**
- ◆ **Carrier of carriers model, inter-SP VPNs**
- ◆ **CoS support**



Thank you!

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