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ISP Architecture – MPLS Overview, Design and Implementation for WISPs.

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MTCINE #1409

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    - Design/Implement/Operate BGP/MPLS/OSPF Wireline and WISP service provider networks
    - Design/Implement/Operate Data Center (Enterprise and Cloud) networks
  - **Certifications**
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    - MikroTik – MTCWE, MTCUME, MTCRE, MTCTCE, MTCNA
    - Cisco/Microsoft – CCNP, CCNA, MCP

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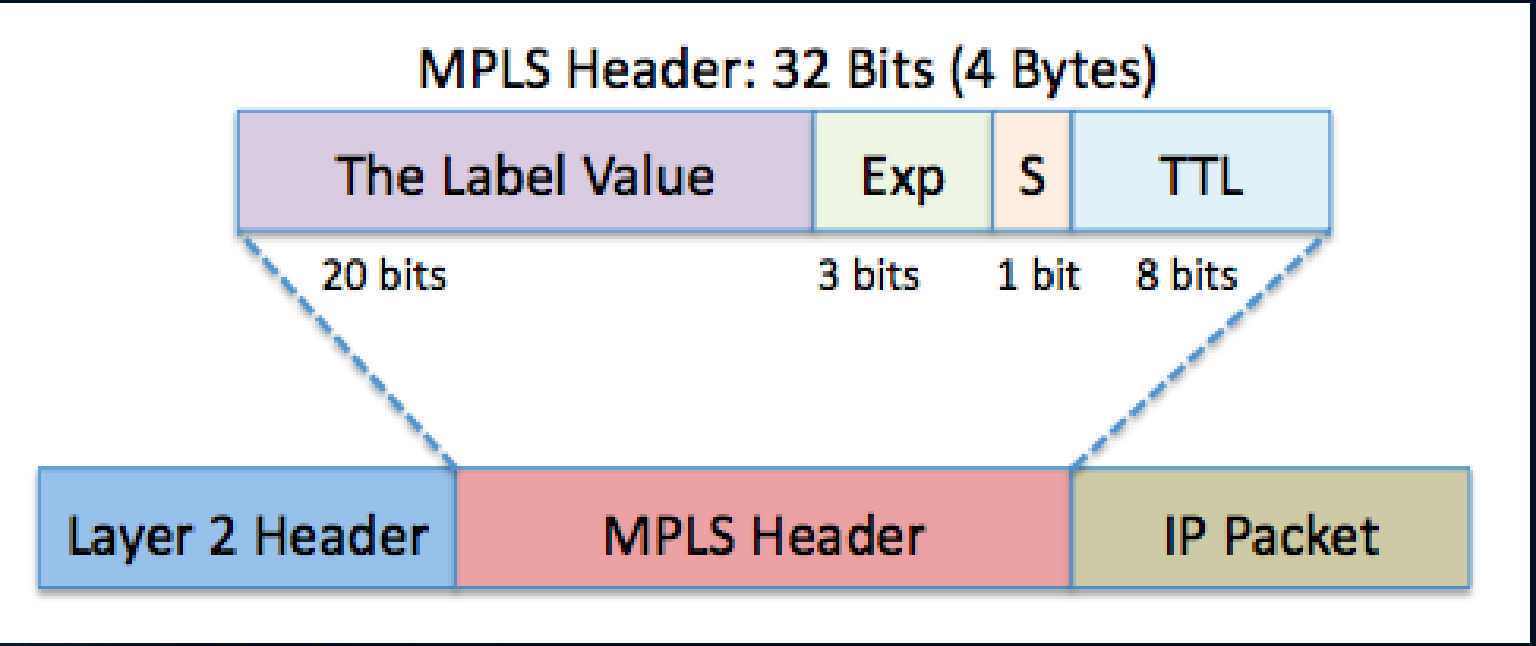
MPLS – What is it?

- **Theory:** Briefly introduce the MPLS protocol and how it works in conjunction with existing L2/L3 networks
- **Design:** Discuss an MPLS architecture and preparing your WISP for implementing MPLS.
- **Business Justification:** Identify the business and financial use case for implementing MPLS in a WISP.
- **Build:** Review and discuss examples of MPLS use cases and implementation in a WISP.

What problem are we trying to solve?

- **Isolation of traffic** – MPLS allows a network operator to isolate traffic between customers or segments of the WISP network. It also allows for the use of overlapping IP space which is useful when building private networks for customers. It is also useful when logical separation is needed for industry compliance standards like PCI or HIPAA.
- **Transporting other protocols over MPLS** – MPLS will transport a number of protocols by encapsulating it inside of an MPLS packet. Some of the more popular uses are: Ethernet, ATM and T1 (PPP and HDLC). Ethernet is probably the most popular and allows an L2 frame to be sent over an L3 network which creates a PtMP L2 domain over long distances if needed.
- **Reduce Complexity/Increase Flexibility** – Although MPLS does add complexity to the network, in the long run, it reduces complexity by allowing complex network problems to be solved in a practical and scalable way without a number of "one off" solutions. Being able to deploy Layer 2 or 3 overlays and isolation anywhere in the WISP make MPLS the Swiss Army Knife of protocols.

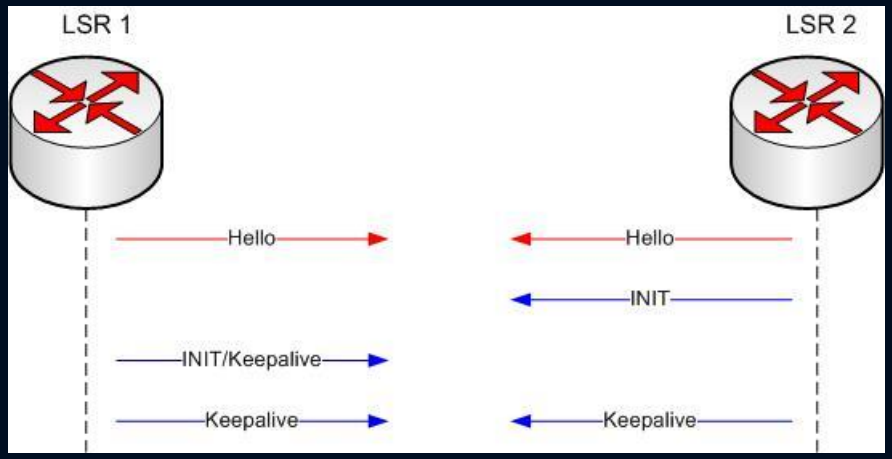
MPLS header – The Layer 2.5 protocol



- **Example of an IPv4 packet** – MPLS is commonly referred to as the layer 2.5 protocol because the MPLS header sits right between the Layer 2 and Layer 3 headers. This is also why MPLS networks require more MTU at Layer 2 so that MPLS labels can exist and a minimum of a 1500 byte packet can still be handed off.

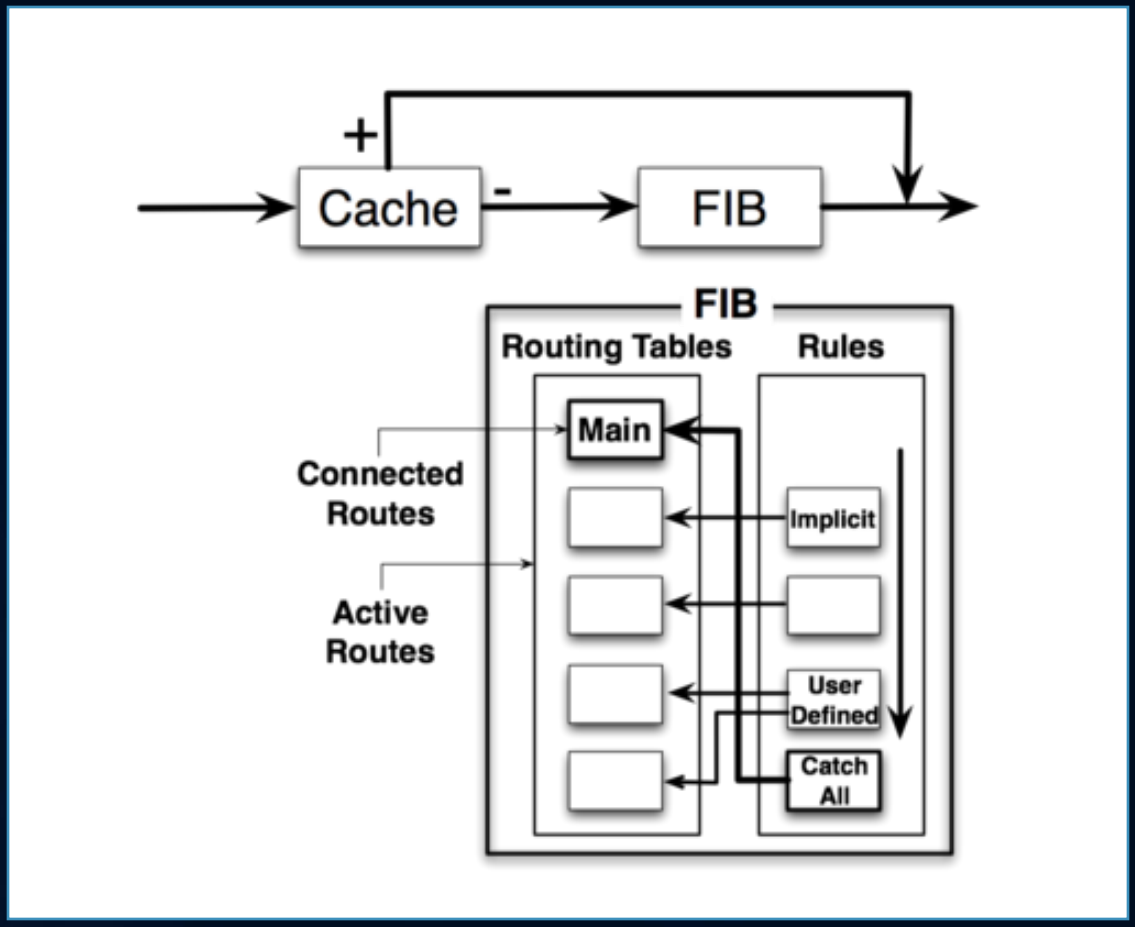
- Image source: blog.ine.com

MPLS Label Distribution Protocol – Assigning Labels



- **Label Distribution Protocol (LDP)** – Similar to a routing protocol, LDP maintains the database of MPLS labels and exchanges labels with other LDP neighbors. LDP relies on the underlying routing information provided by an IGP (OSPF, IS-IS, EIGRP) in order to forward label packets.

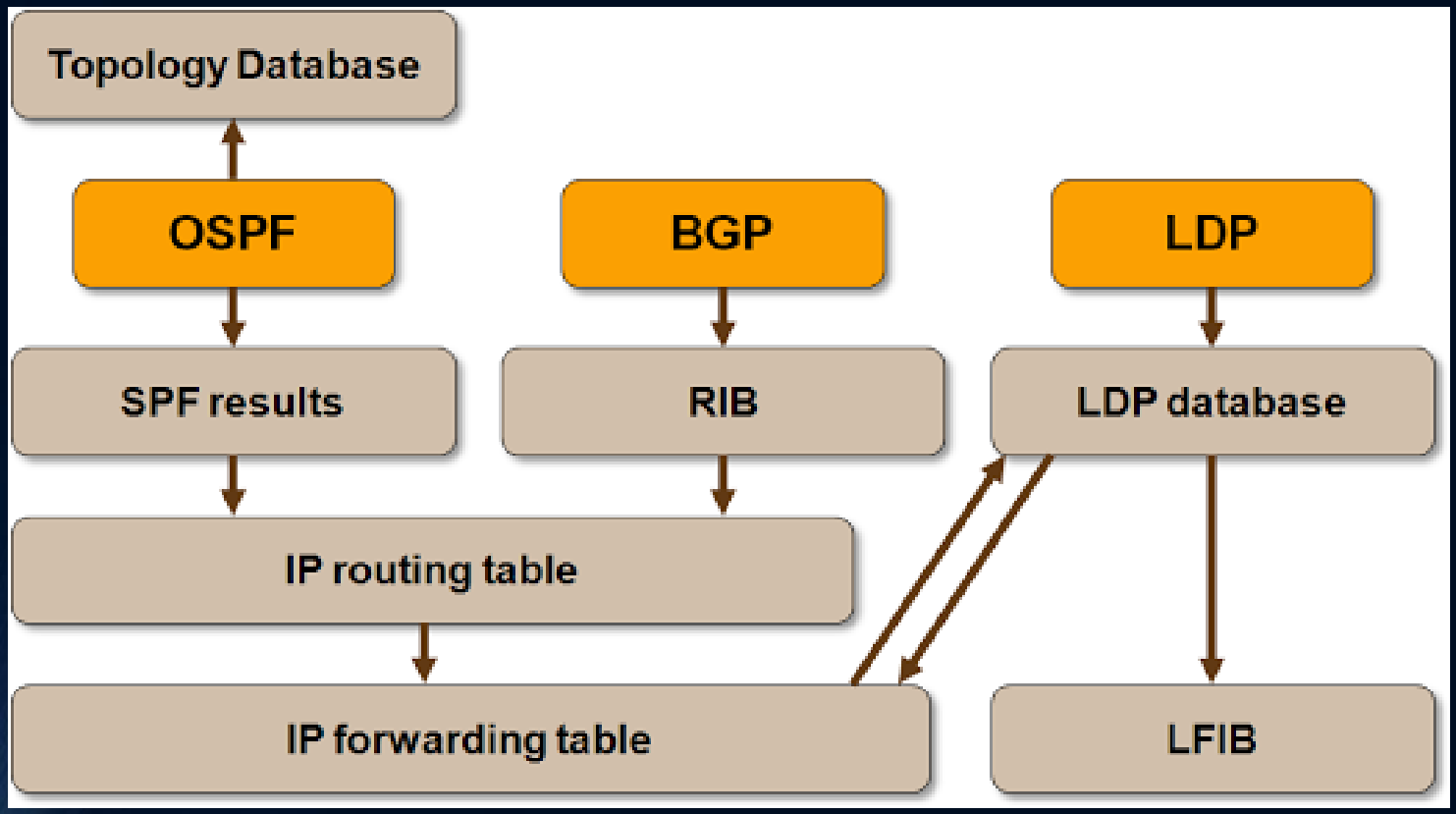
- **MPLS Forwarding – Routing FIB vs. MPLS FIB (or LFIB)**



- **MikroTik Routing Forwarding Information Base (FIB)** – When a Non-MPLS routed network needs to forward a packet, it does so via the FIB which is usually a mirror of the routing table.

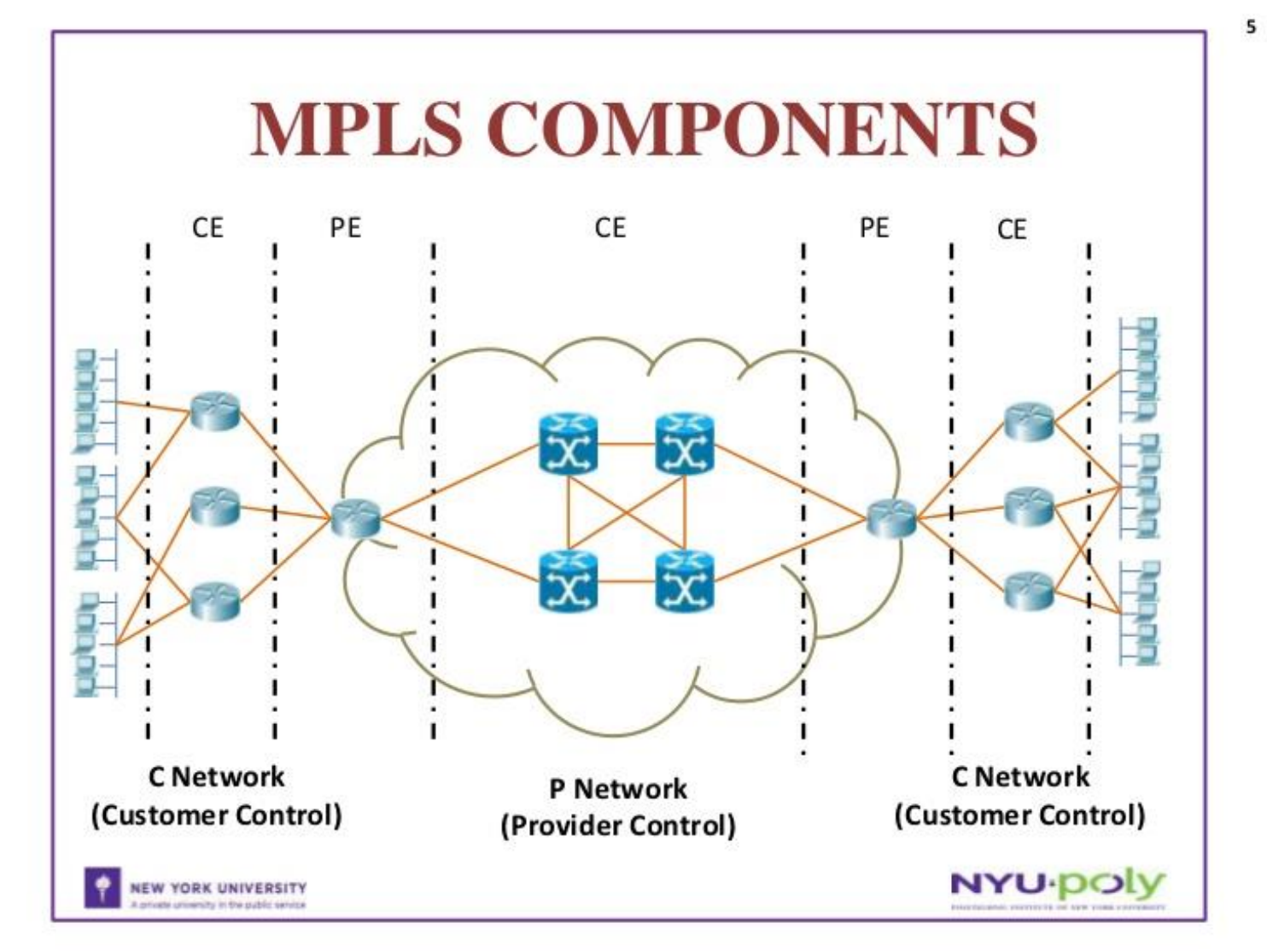
Image source: blog.ipspace.net

- **MPLS Forwarding – Routing FIB vs. MPLS FIB (or LFIB)**



- **MPLS (Label) Forwarding Information Base (LFIB/FIB generic)** – When an MPLS network needs to forward a packet, it does so via the MPLS FIB or LFIB which is drawn from the Routing table or Routing FIB depending on the vendor.

MPLS Architecture – PE, P and CE routers



MPLS Architecture – PE, P and CE routers

- **Provider Edge (PE) router** – also known as an Ingress/Egress Label Switch Router (LSR), is a router between one network service provider's area and areas administered by other network providers/ customers.
- **Provider (P) router** – is a Label Switch Router (LSR) that functions as a transit router of the core network. The P Router is typically connected to one or more PE Routers.
- **Customer Edge (CE) router** – The customer edge (CE) is the router at the customer premises that is connected to the provider edge of a service provider IP/MPLS network. CE peers with the Provider Edge (PE) and exchanges routes with the corresponding VRF inside the PE. The routing protocol used could be static or dynamic (an interior gateway protocol like OSPF or an exterior gateway protocol like BGP).

- **MPLS Architecture – MTU in the radios, copper and fiber**

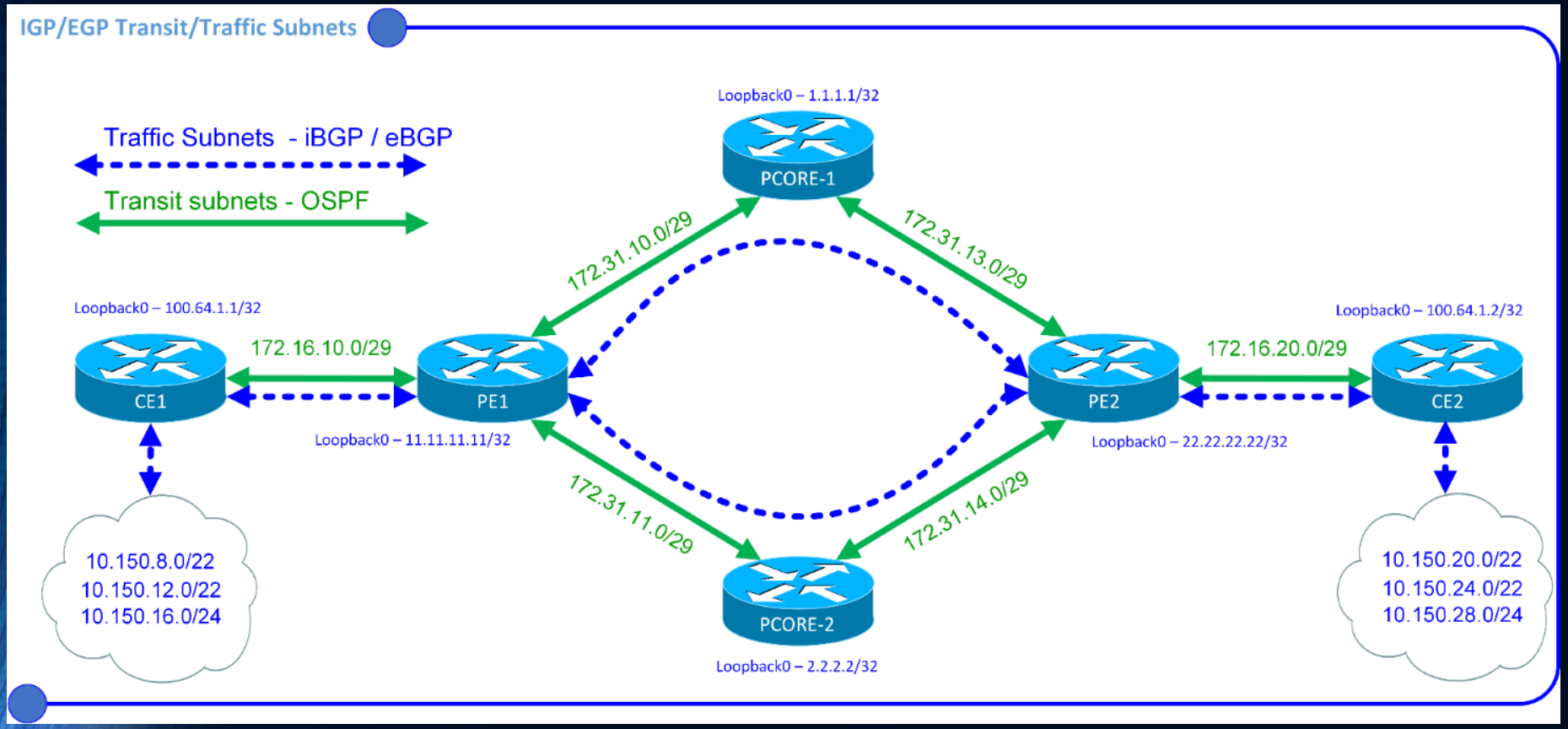
MPLS Basic	MPLS Untagged VPN	MPLS Tagged VPN
L2 MTU - **1522**	L2 MTU - **1526**	L2 MTU - **1530**
L3 MTU - **1500**	L3 MTU - **1500**	L3 MTU - **1500**
MPLS MTU - **1508**	MPLS MTU - **1526**	MPLS MTU – **1530**

- **MTU sizing is the most common MPLS mistake** – When building MPLS for a WISP, getting the minimum MTU to be standardized and supported is the most common mistake we see in real world operations. Many WISPs want to reuse radios that can't support MPLS minimum MTUs and end up wasting time/money in troubleshooting.

Preparing your WISP to support MPLS

- **CPU - Ensure that routers have sufficient CPU capacity for the control plane** – While MPLS was originally developed as a way to make routers more efficient, in today's MPLS network, more CPU is desirable to support a wide array of services and features as well as increased routing table size and number of routing adjacencies.
- **Memory** – If you have a need to take in large private or public routing tables, ensure the memory in your routers is sufficient. Memory consumption varies a bit by vendor for VRF usage and routing tables.
- **QoS** – MPLS changes QoS architectures as it has only a 3 bit field (EXP) to carry traffic markings vs an 8 bit DSCP field. Also, some network devices can't see a DSCP value once an MPLS label is applied so planning EXP to DSCP mapping is important as well as where and how to mark/shape traffic.
- **MTU** – In addition to radios and routers, it is important to ensure all switches are capable of supporting the minimum MPLS MTU for your use case.

Using BGP/OSPF to support MPLS



- BGP/OSPF – OSPF builds the topology of the network and provides loopback and next hop reachability for BGP and MPLS. BGP then utilizes MPLS to advertise customer VRF subnets and maintain logically separate routing tables in the VPNv4 community.

Implement MPLS carefully

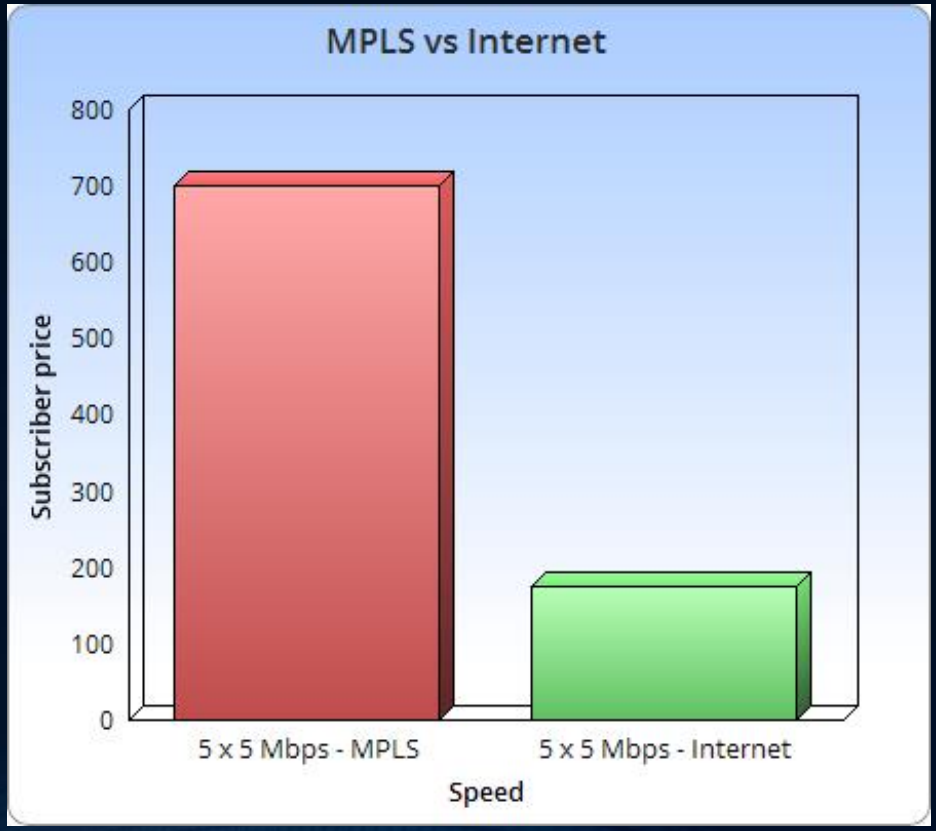
- **Build a lab for MPLS based on production** – This can be virtual or physical, but it's important to understand how MPLS will behave on your existing config and what changes will occur. The lab can be based on all or part of the existing network.

- **Implement on a low priority segment –** The very worst thing you can do is implement a complex protocol like MPLS for the first time using your highest priority subscribers as Guinea pigs. Pick a low impact segment of the network to attempt to take your lab into production. For a WISP this can be as simple as one tower router and one core router.

- **Don't be afraid to use new hardware –** We often see WISPs go to great lengths to try and convert an existing production router into an MPLS capable router. Sometimes this is feasible and sometimes it's actually less expensive to build MPLS for a small segment with new gear. Once everything is running and stable, a migration can be planned for the rest of the network. Adding a new tower can be a great opportunity to bring an MPLS trial online since new hardware is already required.

Business case for MPLS – part 1

- **Increase revenue using existing infrastructure** – MPLS enabled connections will sell for much more than an basic Internet pipe due to the provider offering managed routing and QoS. It is not uncommon for an MPLS circuit to sell for 4 times the cost of a non MPLS circuit at the same speeds.



Business case for MPLS – part 2

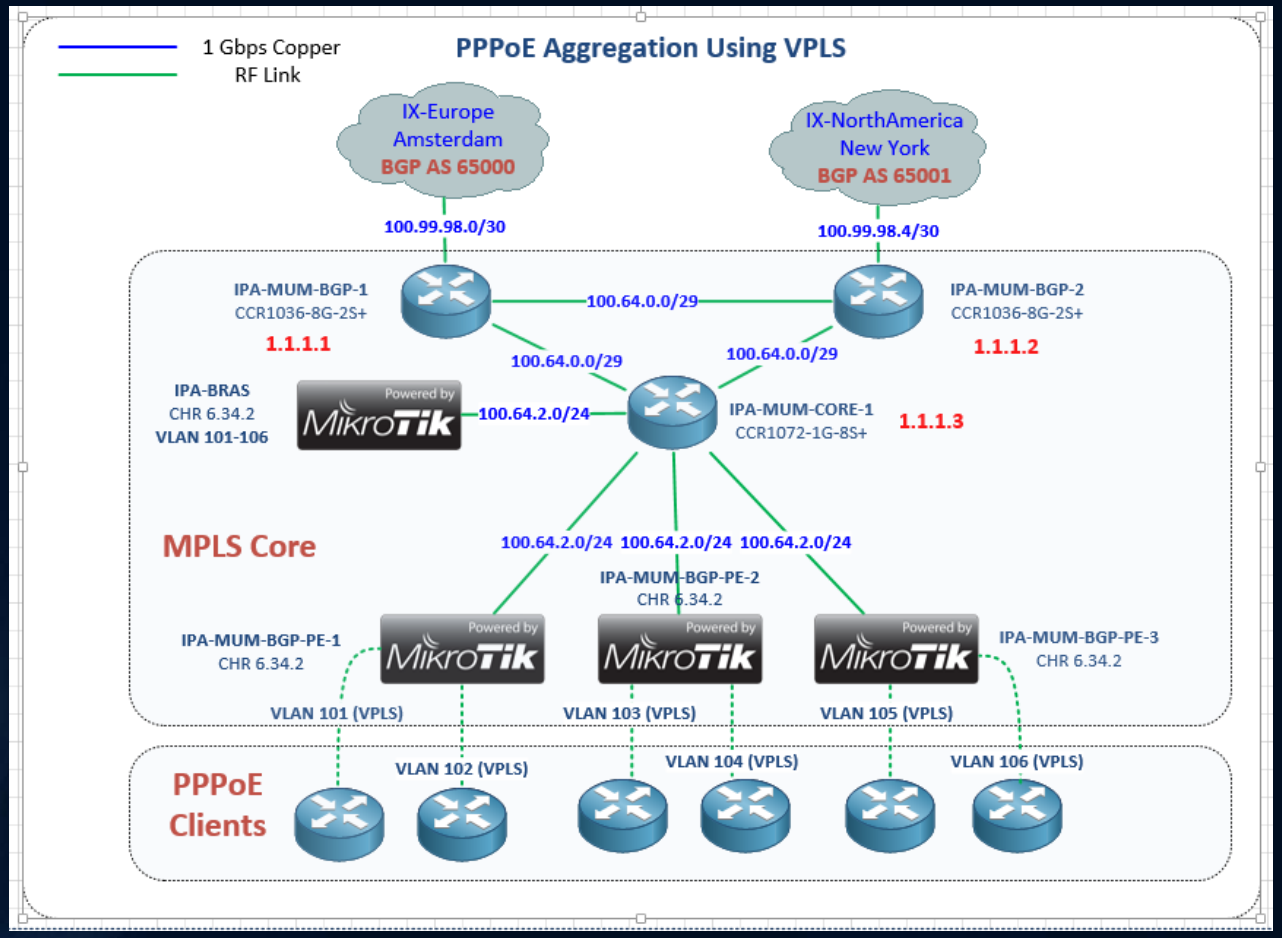
- **Lower OPEX cost by increasing agility** – MPLS enabled networks are more agile and can solve complex problems that a customer may require more efficiently than a non MPLS network.

- **Build private customer networks outside your service area** – If a business in your footprint has several locations in your service area, but one or more locations outside of the service area, you can still capture that sale and manage the entire private WAN infrastructure for that company. MPLS can be used to facilitate this.
  - Use MPLS over tunnels to extend the VRF over the Internet.
  - Purchase transit from the last mile provider and use MPLS to connect all the locations.
  - Manage the entire solution for a premium fee.
  - Customer gets a Tier 1 business class product with more personalized service.

- **Resell your network to Tier 1 and 2 providers –** with MPLS enabled, you can quickly hand off last mile Layer 2 or 3 circuits to other providers for redundancy or primary transit.

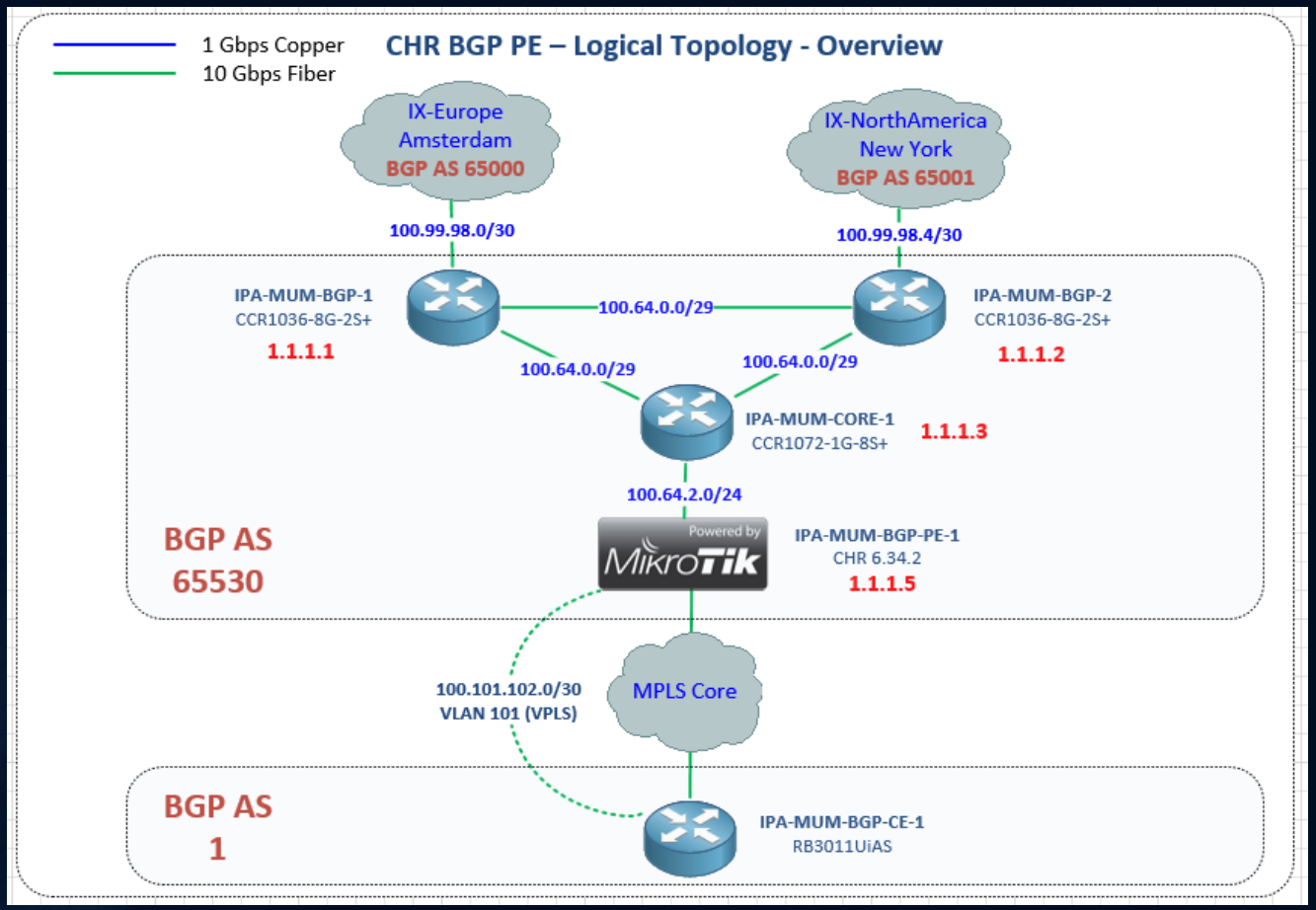
- **Transport legacy technologies –** MPLS can encapsulate legacy technologies like ATM, Frame Relay and PPP and deliver them with a much lower cost than traditional legacy end to end service.

MPLS WISP Use case #1 – PPPoE aggregation with VPLS



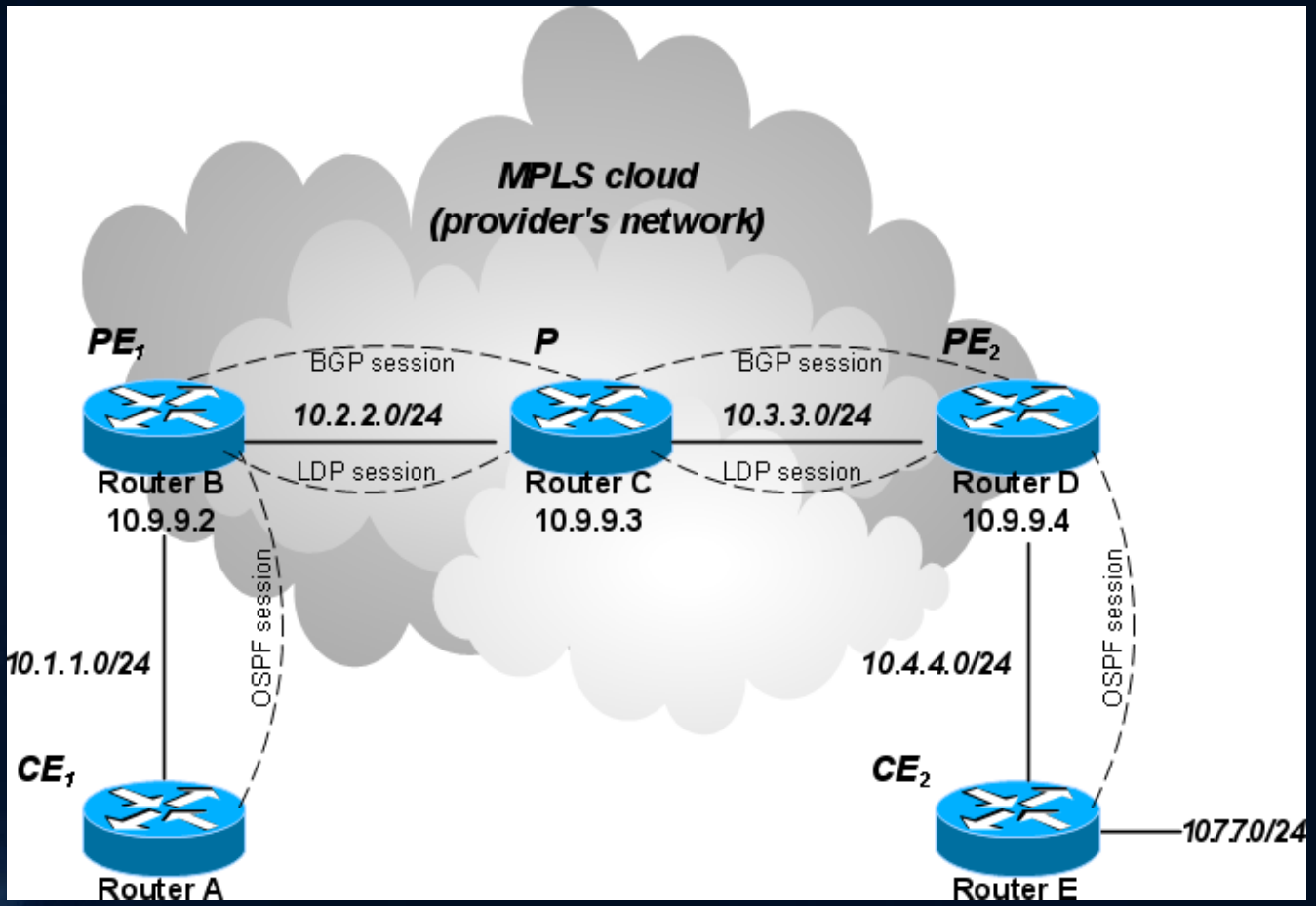
- **Problem** – Need multiple L2 domains aggregated over a routed network for PPPoE
- **Solution** – Use VPLS to extend L2 from the BRAS to the last mile.

MPLS WISP Use case #2 – BGP Peering with a full table



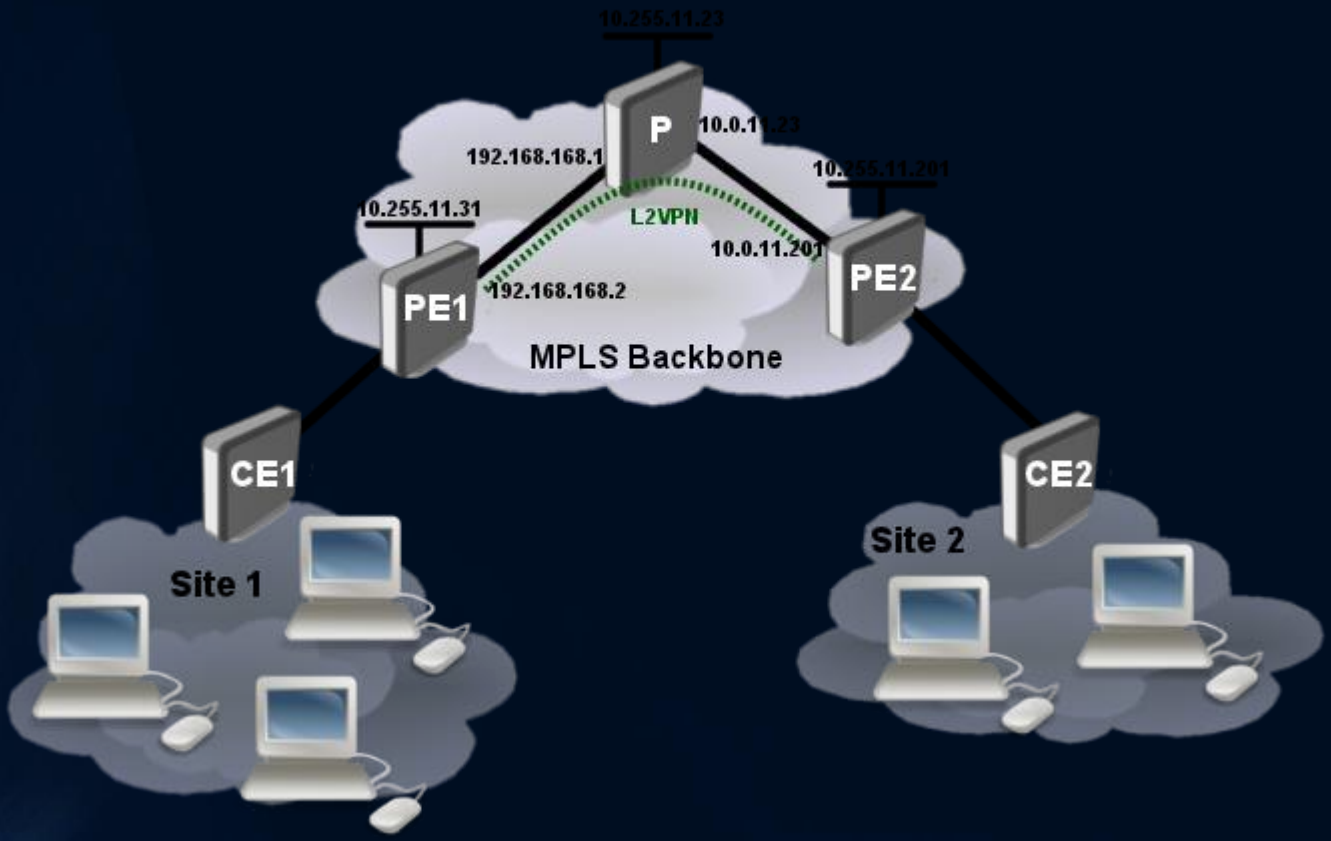
- **Problem** – Need to sell public BGP transit to multiple customers without impacting BGP edge performance
- **Solution** – Use VPLS to hand off a /30 that directly connects the CE and PE routers without the need for a full table in the core

MPLS WISP Use case #3 – Private L3 Transit (L3VPN)



- **Problem** – Need to sell private transit to multiple customers and keep them isolated
- **Solution** – Use L3VPN to build private VRF segment for each customer.

MPLS WISP Use case #4 – Private L2 Transit (L2VPN)



- **Problem** – Need to sell private L2 transit to multiple customers over an L3 networks
- **Solution** – Use L2VPN to build private L2 pseudowire for each customer.

Questions?

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