



Routing & MPLS

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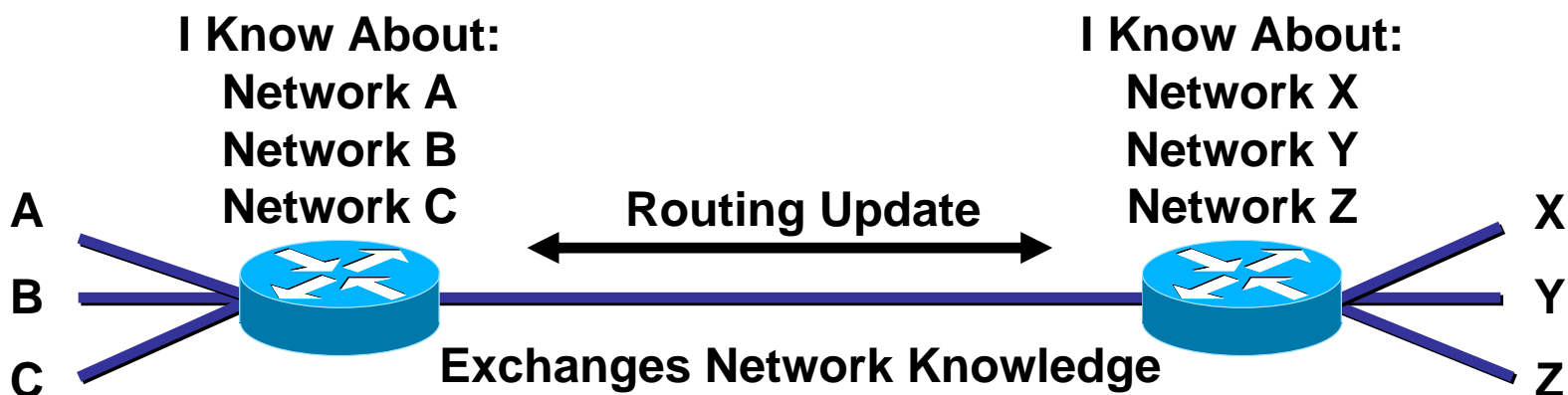
Orlando, Florida

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Routing Protocols with IPv6



- Routing protocols still:
- Exchange NLRI (Network Length Reachability Information)
- Optimal path selection
- Loop-free routing
- longest-prefix match routing algorithm

** Additional memory may be used to maintain two route tables...



Routing in IPv6

- As in IPv4, IPv6 has 2 families of routing protocols: IGP (Interior) and EGP (Exterior)
- IGP:
 - RIPng (RFC 2080)
 - EIGRP for IPv6
 - OSPFv3 (RFC 2740)
 - Integrated IS-ISv6 (draft-ietf-isis-ipv6-05.txt)
- EGP:
 - MP-BGP4 (RFC 2858 and RFC 2545)





A word on “static” routes

- It is not recommended to use a global unicast address as a next-hop address
- ICMPv6 redirect messages will not work if used

“RFC 2461: A router must be able to determine the link-local address of each of its neighboring routers in order to ensure that the target address of a Redirect message identifies the neighbor router by its link-local address.”



RIPng (RIP for IPv6)

- Same as IPv4:
 - Based on RIPv2
 - Distance-vector, radius of 15 hops, split-horizon, poison reverse etc.
- Updated features for IPv6 (RFC 2080)
 - IPv6 prefix, next-hop IPv6 address
 - Uses the multicast group FF02::9, the all-rip-routers multicast group, as the destination address for RIP updates on UDP port 521



OSPFv3 (RFC 2740)

- Link State Protocol
- Based on OSPFv2, with enhancements
 - Same basic packet types: Hello, DBD, LSR, LSA, LSU
 - Two new LSA types:
 - Link LSA (8) – provides a routers link local address and all IPv6 prefixes attached.
 - Intra-Area-Prefix-LSA (9) – carries the IPv6 prefixes of the router and network links
 - Runs over a link, not a subnet
 - Possible to have multiple instances per link
 - Uses link local addresses to identify adjacency neighbors
 - Uses AH/ESP IPsec for Security
 - Multicast Groups:FF02::5 (all SPF routers) & FF02::6 (all DR's)



IS-IS for IPv6

(Integrated Intermediate System-to-Intermediate System)

- Two new Type/Length/Values (TLV's) for IPv6:
 - IPv6 Reachability TLV (0xEC) - Describes network reach-ability, contains IPv6 routing prefix & Metric
 - IPv6 Interface Address TLV (0xE8)
 - Contains IPv6 interface address (128 bit vs.. 32)
 - For Hello PDUs, must contain the Link-Local address
 - For LSP, must only contain the non-Link Local address
- New Network Layer Protocol Identifier
 - IPv6 NLPID (0x8E) is advertised by IPv6 enabled routers
 - IPv4 is 0xCC
- Runs on data link. If tunneled, must be mode GRE not IPV6IP

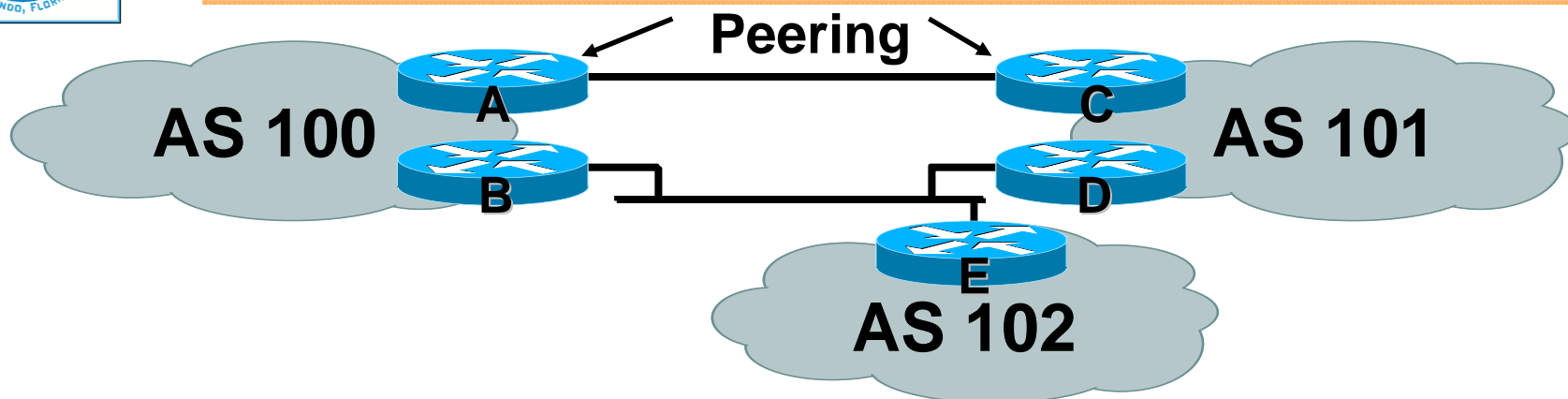


Single SPF IS-IS for IPv6 Restrictions

- IS-IS for IPv6 uses the same SPF for both IPv4 and IPv6 on each level
 - This means that all routers in an IS-IS area must run the same set of protocols!
- Therefore:
 - Not really suitable for an existing IPv4 IS-IS network where customer wants to turn on scattered IPv6 support.
- To allow more flexibility in the design of IS-IS networks the answer is Multi-Topology IS-IS.
 - Removes the limitation of having all IS-IS routers in a single area run all the same protocols
 - New TLVs added so each Multi-topology runs it's own SPF



Multi-Protocol BGP4 for IPv6 – RFC2545



- IPv6 attributes updated:
 - Next_HOP
 - IPv6 address of the router to be used as next hop
 - NLRI (Network Layer Reachability Information)
 - A set of destinations expressed as IPv6 prefix/length
- Address Family Information (AFI) = 2 (IPv6)
 - Sub-AFI = 1 (NLRI is used for unicast)
 - Sub-AFI = 2 (NLRI is used for multicast RPF check)
 - Sub-AFI = 128 (VPN)

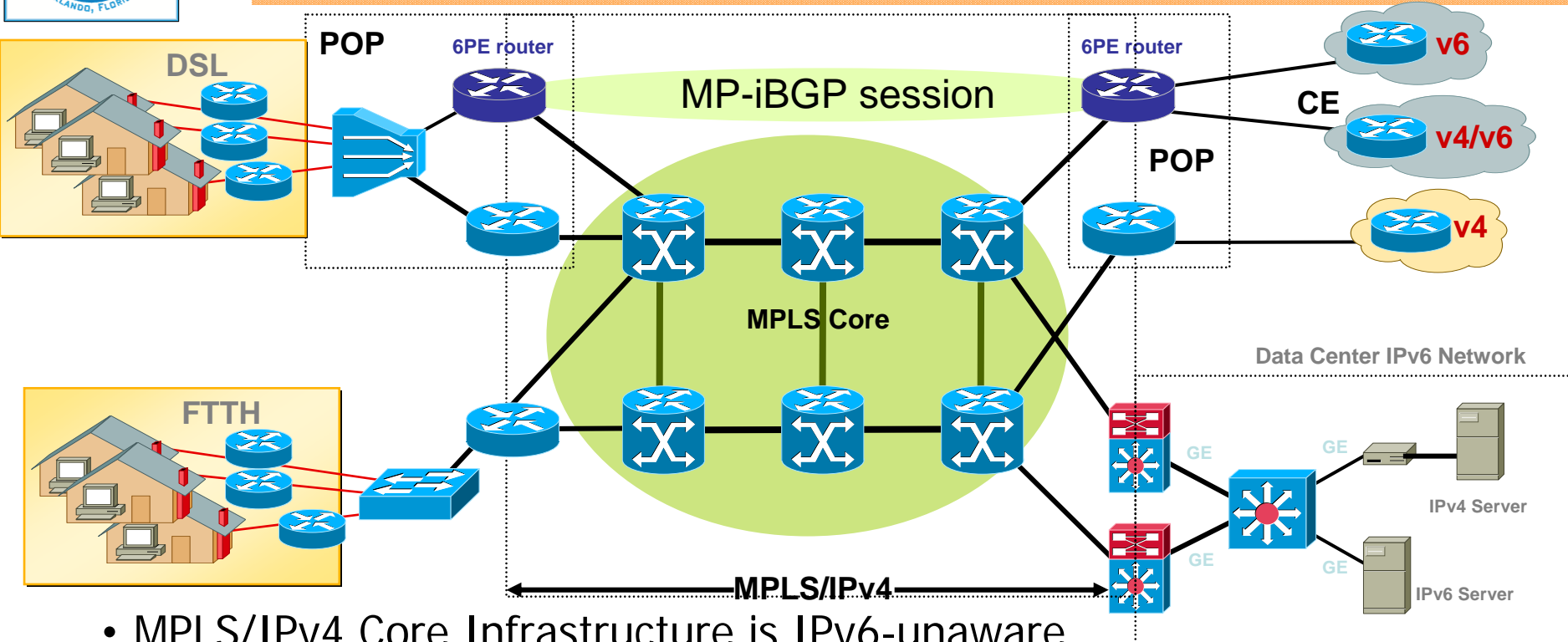


IPv6 over MPLS

- Many service providers have already deployed MPLS in their IPv4 backbone for various reasons
- MPLS can be used to facilitate IPv6 integration
- Multiple approaches for IPv6 over SP Core:
 - IPv6 over L2TPv3
 - IPv6 over EoMPLS/AToM
 - IPv6 CE-to-CE IPv6 over IPv4 Tunnels
 - IPv6 Provider Edge Router (6PE) over MPLS
 - IPv6 VPN Provider Edge (6VPE) over MPLS
 - Native IPv6 over MPLS
 - Dual-Stack SP Core



Minimal Infrastructure Upgrade for 6PE



- MPLS/IPv4 Core Infrastructure is IPv6-unaware
- PEs are updated to support Dual Stack/6PE
- IPv6 reachability exchanged among 6PEs via iBGP (MP-BGP)
 - Based on BGP Tunnelling - [<draft-ooms-v6ops-bgp-tunnel-04.txt>](#)
- IPv6 packets transported from 6PE to 6PE inside MPLS

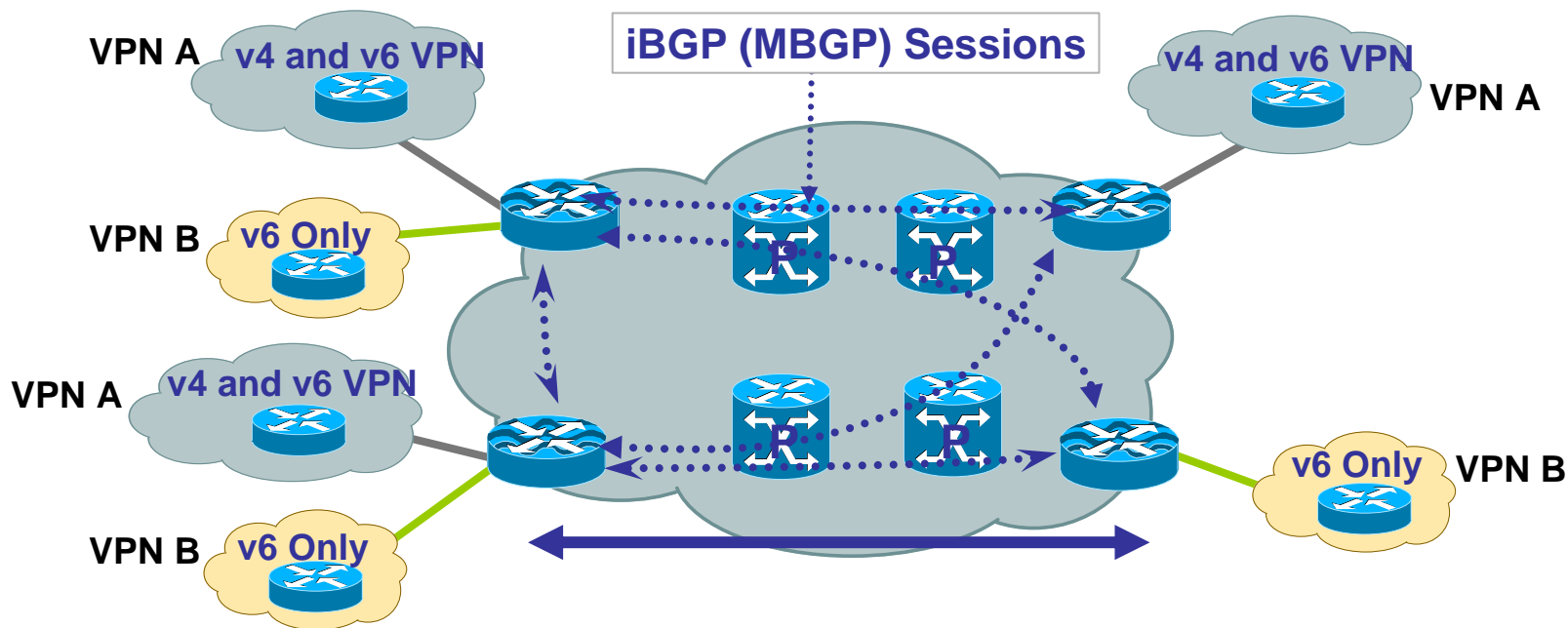


IPv6 VPN Provider Edge (6VPE)

- For VPN customers, IPv6 VPN service is exactly the same as IPv4 VPN service
- Current 6PE is “like VPN” but this is NOT VPN, i.e. global reachability
- For ISP offering MPLS/VPN for IPv4 that wish to add IPv6 services as well
 - No modification on the MPLS core
 - Support both IPv4 and IPv6 VPNs concurrently on the same interfaces
 - Configuration and operations of IPv6 VPNs exactly like IPv4 VPNs



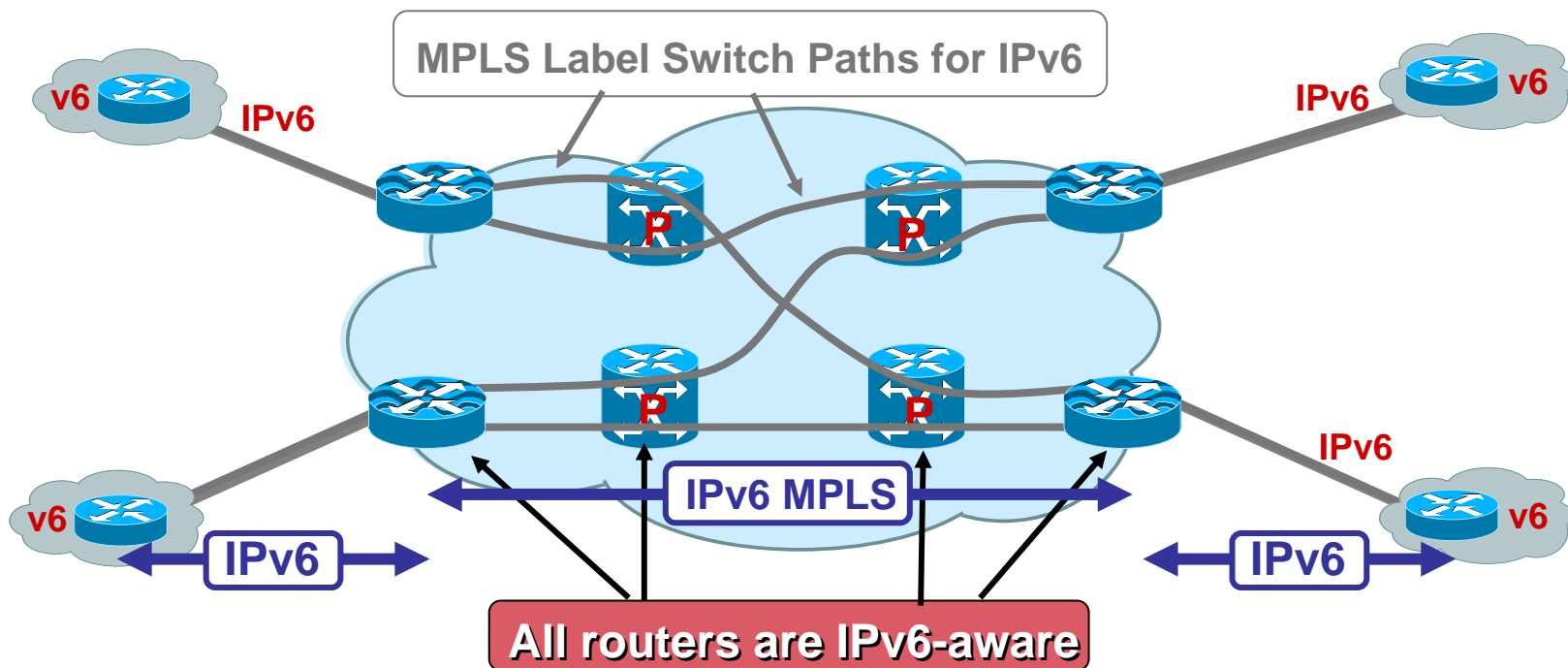
6VPE Deployment



- IPv6 VPN can coexist with IPv4 VPN—same coverage
- 6VPE is added only when and where the service is required
- 6VPE—A BGP-MPLS VPN extension for IPv6 VPN



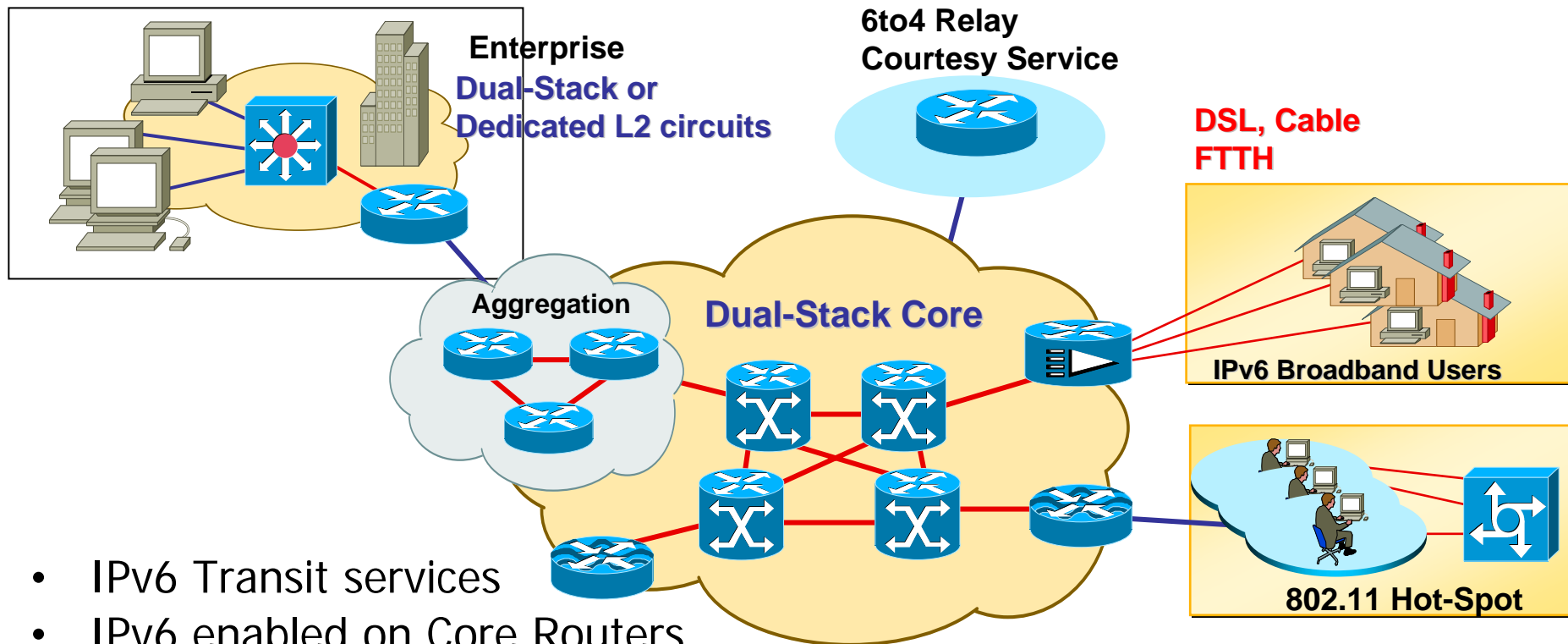
Native MPLS Support for IPv6



- Core Infrastructure requires full Control Plane upgrade to IPv6
 - IPv6 Routing in core
 - IPv6 Label Distribution Protocol in core
- Dual Control Plane management if IPv4 and IPv6 services



Dual Stack IPv4-IPv6



- IPv6 Transit services
- IPv6 enabled on Core Routers
- Enterprise and Consumer IPv6 Access
- Additional Services
 - IPv6 Multicast for streaming



Standards Status

- 6PE - [draft-ooms-v6ops-bgp-tunnel-04.txt](#)
- 6VPE - [draft-ietf-l3vpn-bgp-ipv6-06.txt](#)
- L2TPv3 - [RFC 3931](#)
- IPv6 Enterprise Network Scenarios [draft-ietf-v6ops-ent-scenarios-05.txt](#)
- ISP IPv6 Deployment Scenarios in Broadband Access Networks - [draft-ietf-v6ops-bb-deployment-scenarios-01.txt](#)
- Scenarios and Analysis for Introducing IPv6 into ISP Networks - [RFC 4029](#)
- Architectural Approaches to Multi-Homing for IPv6 - [draft-ietf-multi6-architecture-04.txt](#)
- Goals for IPv6 Site-Multihoming Architectures - [RFC 3582](#)



The Bottom Line

- Whether MPLS is used in the core or not:
 - There are solutions for IPv6 deployment
 - MPLS - 6PE/6VPE, CE-to-CE Tunnels
 - Native IPv6 forwarding via dual-stack or IPv6-only
- Things to consider with MPLS:
 - IPv6 Multicast
 - Perceived management and operation complexity
- Things to consider with native core:
 - IPv6 capable core (upgrades, performance, management)



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