# Enterprise IPv6 Deployment

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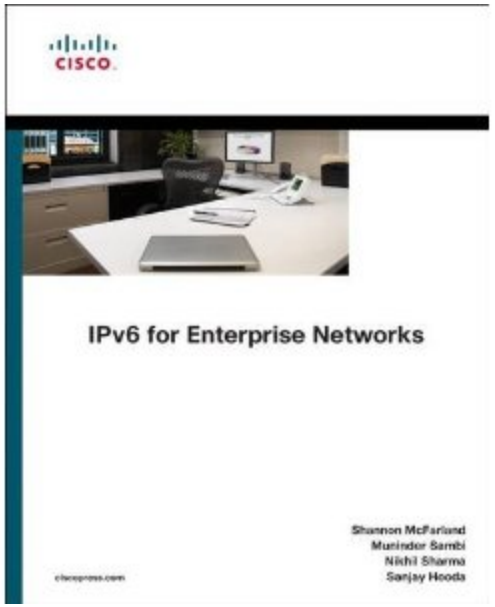
# Reference Materials

- Deploying IPv6 in Campus Networks: http://www.cisco.com/en/US/docs/solutions/Enterprise/Campus/CampIPv6.html
- Deploying IPv6 in Branch Networks: http://www.cisco.com/en/US/solutions/ns340/ns414/ns742/ns816/landing_br_ipv6.html
- CCO IPv6 Main Page: http://www.cisco.com/go/ipv6
- Cisco Network Designs: http://www.cisco.com/go/designzone

# Recommended Reading


Deploying IPv6 in Broadband Networks - Adeel Ahmed, Salman Asadullah ISBN0470193387, John Wiley & Sons Publications®

Coming Soon!!

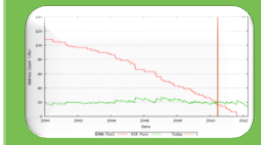
# Agenda

- The Need for IPv6
- Planning and Deployment Summary
- Address Considerations
- General Concepts
- Infrastructure Deployment
  - Campus/Data Center
  - WAN/Branch
  - Remote Access
- Provider Considerations

# The Need For IPv6

# Market Factors Driving IPv6 Deployment

**Address Issues**



2011

-Exhaustion
-M&A
-Business Development

**National IPv6 Strategies**

US DoD, China NGI, EU

**IPv6 OS, Content & Applications**

Google facebook Microsoft

**Infrastructure Evolution**

SmartGrid, SmartCities
DOCSIS 3.0, 4G/LTE ,IPSO

comcast verizon at&t

IPv6

CISCO

www.oecd.org: Measuring IPv6 adoption

# IPv6 Provides Benefits Across the Board

- Building sensors
- Media services
- Collaboration
- Mobility

**Higher Education/Research**

- Set-top boxes
- Internet gaming
- Appliances
- Voice/video
- Security monitoring

**Consumer**

**IPv6**

- Embedded devices
- Industrial Ethernet
- IP-enabled components

**Manufacturing**

- DoD
- WIN-T
- FCS
- JTRS
- GIG-BE

**Government (Federal/Public Sector)**

- Telematics
- Traffic control
- Hotspots
- Transit services

**Transportation**

- Animal tags
- Imagery
- Botanical
- Weather

**Agriculture/ Wildlife**

- Home care
- Wireless asset tracking
- Imaging
- Mobility

**Health Care**

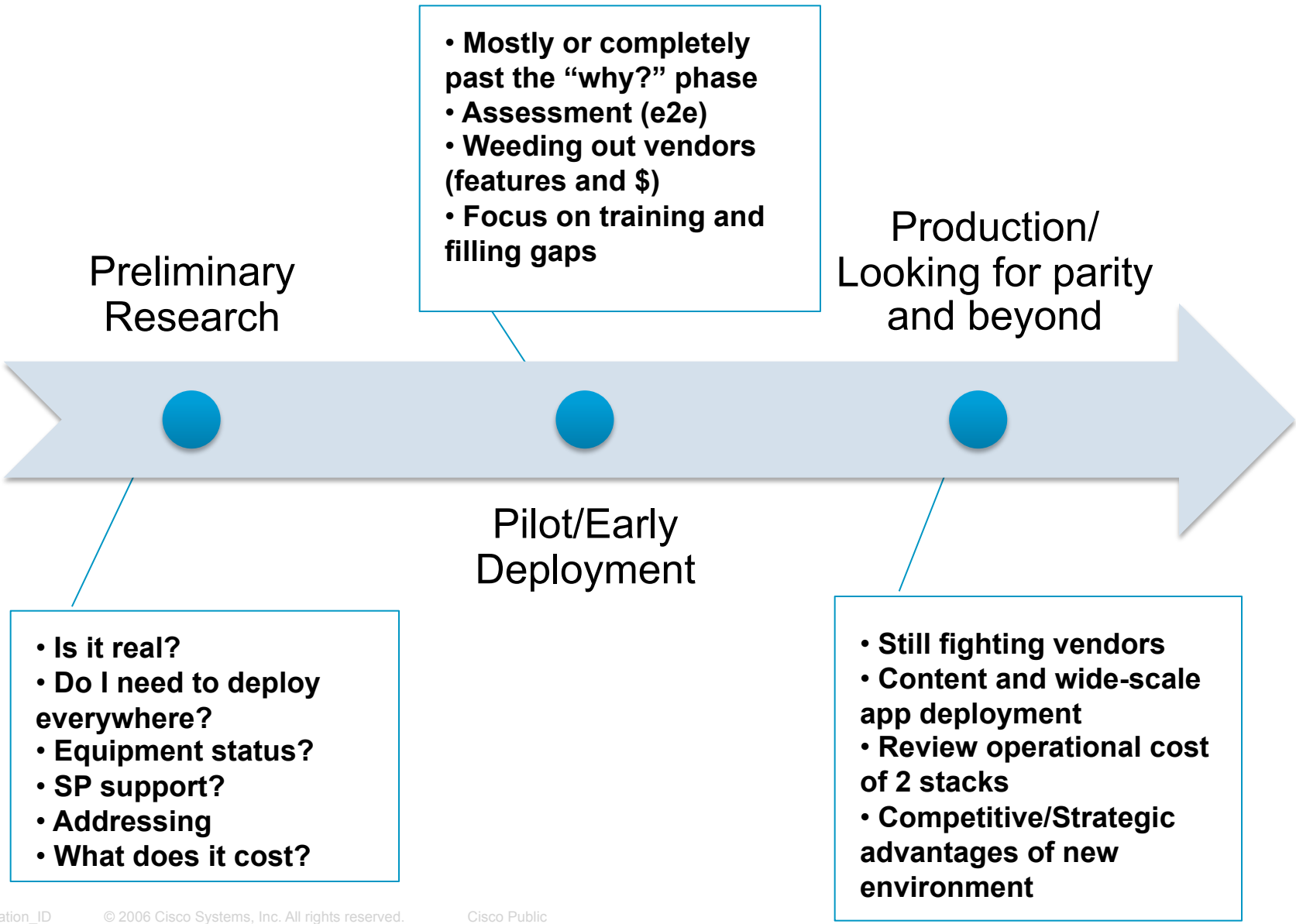
# Dramatic Increase in Enterprise Activity

## Why?

- Enterprise that is or will be expanding into emerging markets
- Enterprise that partners with other companies who may use IPv6 (larger enterprise, located in emerging markets, government, service providers)
- Adoption of Windows 7, Windows 2008, DirectAccess
- Frequent M&A activity
- Energy – High density IP-enabled endpoints (SmartGrid)

# Planning & Deployment Summary

# Enterprise Adoption Spectrum



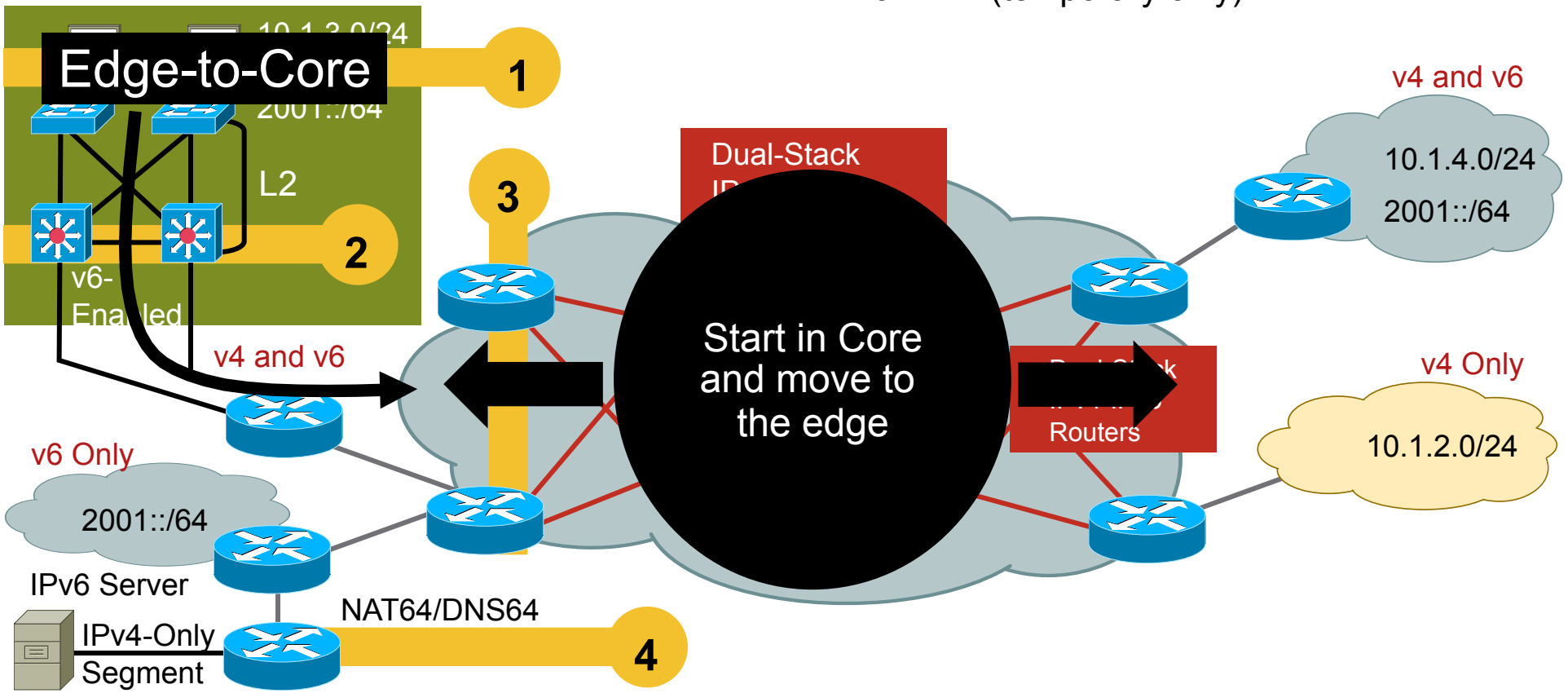
# IPv6 Integration Outline

| Pre-Deployment Phases | Deployment Phases |
| --- | --- |
| • Establish the network starting point<br>• Importance of a network assessment and available tools<br>• Defining early IPv6 security guidelines and requirements<br>• Additional IPv6 “pre-deployment” tasks needing consideration | • Transport considerations for integration<br>• Campus IPv6 integration options<br>• WAN IPv6 integration options<br>• Advanced IPv6 services options |

# Integration/Coexistence Starting Points

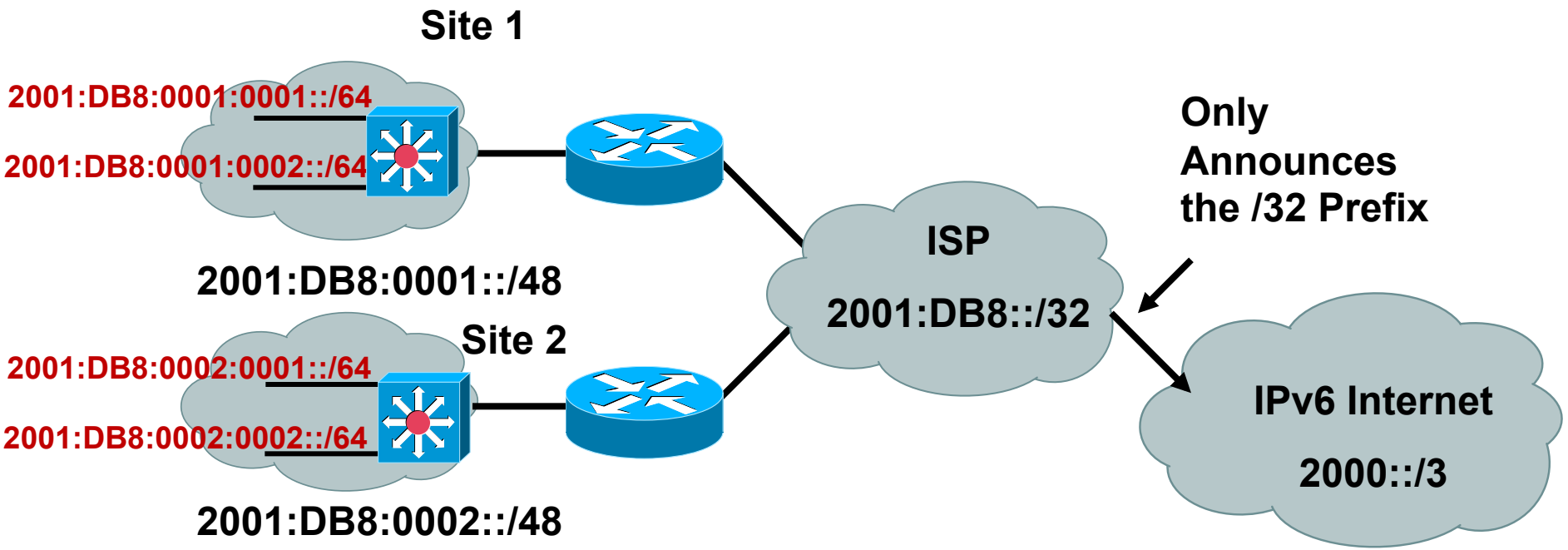
## Example: Integration Demarc/Start Points in Campus/WAN

1. Start dual-stack on hosts/OS
2. Start dual-stack in campus distribution layer (details follow)
3. Start dual-stack on the WAN/campus core/edge routers
4. NAT64 for servers/apps only capable of IPv4 (temporary only)



# Address Considerations

# Hierarchical Addressing and Aggregation




- Default is /48 – can be larger – “End-user Additional Assignment” https://www.arin.net/resources/request/ipv6_add_assign.html
- Provider independent – See Number Resource Policy Manual (NRPM) - https://www.arin.net/policy/nrpm.html

# Summary of Address Considerations

- Provider Independent and/or Provider Assigned
- ULA, ULA + Global, Global only
- Prefix-length allocation
  - /64 everywhere except loopbacks (/128)
  - /64 on host links, /126 on P2P links, /128 on loopbacks
  - Variable prefix-lengths on host links

# ULA, ULA + Global or Global

- What type of addressing should I deploy internal to my network? It depends:

  ULA-only—Today, no IPv6 NAT is useable in production so using ULA-only will not work externally to your network

  ULA + Global allows for the best of both worlds **but** at a price—much more address management with DHCP, DNS, routing and security—SAS does not always work as it should

  Global-only—Recommended approach but the old-school security folks that believe topology hiding is essential in security will bark at this option

- Let's explore these options…

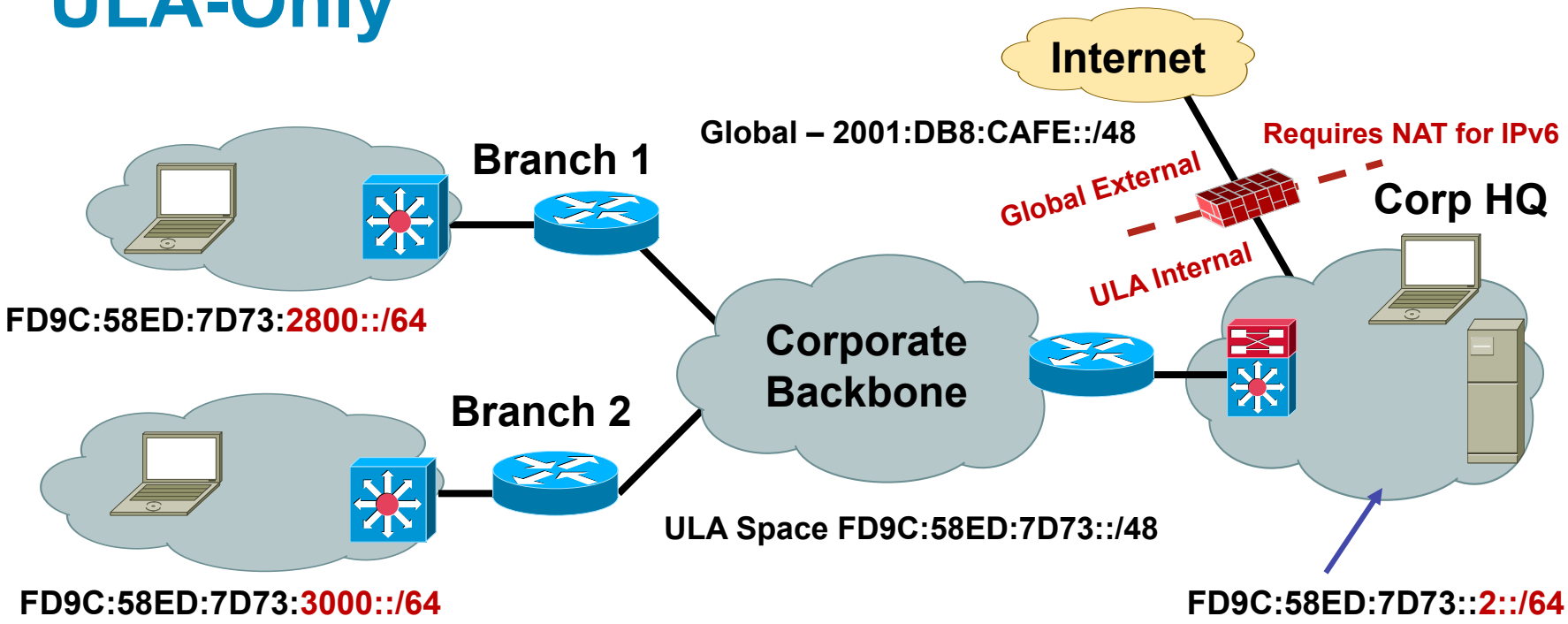
# Unique-Local Addressing (RFC4193)

- Used for internal communications, inter-site VPNs
  - Not routable on the internet—basically RFC1918 for IPv6 only better—less likelihood of collisions
- Default prefix is /48
  - /48 limits use in large organizations that will need more space
  - Semi-random generator prohibits generating sequentially 'useable' prefixes—no easy way to have aggregation when using multiple /48s
  - Why not hack the generator to produce something larger than a /48 or even sequential /48s?
  - Is it 'legal' to use something other than a /48? Perhaps the entire space? Forget legal, is it practical? Probably, but with dangers—remember the idea for ULA; internal addressing with a slim likelihood of address collisions with M&A. By consuming a larger space or the entire ULA space you will significantly increase the chances of pain in the future with M&A
- Routing/security control
  - You must always implement filters/ACLs to block any packets going in or out of your network (at the Internet perimeter) that contain a SA/DA that is in the ULA range—today this is the **only** way the ULA scope can be enforced
- Generate your own ULA: http://www.sixxs.net/tools/grh/ula/

```
Generated ULA= fd9c:58ed:7d73::/48

    * MAC address=00:0D:9D:93:A0:C3 (Hewlett Packard)
    * EUI64 address=020D9Dfffe93A0C3
    * NTP date=cc5ff71943807789 cc5ff71976b28d86
```

# ULA-Only

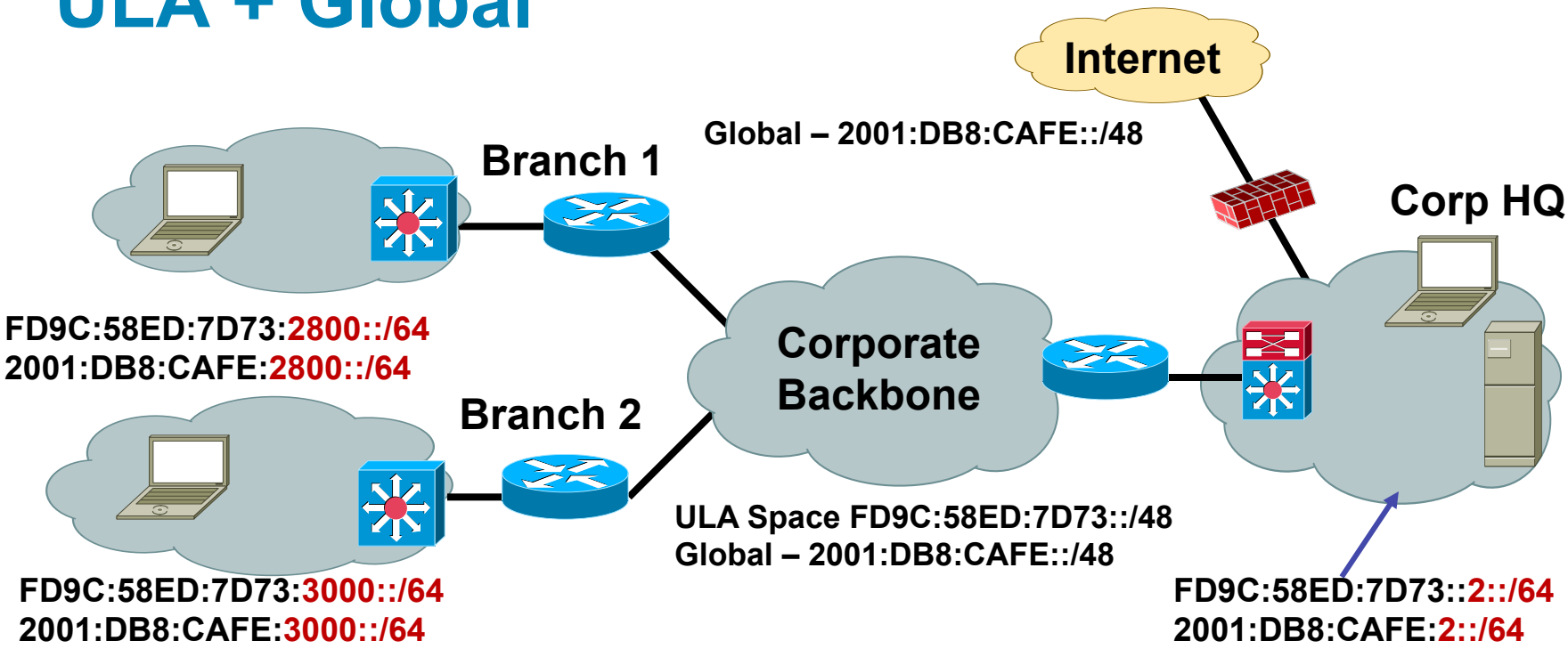
Not Recommended Today




- Everything internal runs the ULA space
- A NAT supporting IPv6 or a proxy is required to access IPv6 hosts on the internet — must run filters to prevent any SA/DA in ULA range from being forwarded
- Works as it does today with IPv4 except that today, there are no scalable NAT/Proxies for IPv6
- Removes the advantages of not having a NAT (i.e. application interoperability, global multicast, end-to-end connectivity)

Not Recommended

# ULA + Global




- Both ULA and Global are used internally except for internal-only hosts
- Source Address Selection (SAS) is used to determine which address to use when communicating with other nodes internally or externally
- In theory, ULA talks to ULA and Global talks to Global—SAS ‘should’ work this out
- ULA-only and Global-only hosts can talk to one another internal to the network
- Define a filter/policy that ensures your ULA prefix does not ‘leak’ out onto the Internet and ensure that no traffic can come in or out that has a ULA prefix in the SA/DA fields
- Management overhead for DHCP, DNS, routing, security, etc…

# Considerations—ULA + Global

- Use DHCPv6 for ULA and Global—apply different policies for both (lifetimes, options, etc..)
- Check routability for both—can you reach an AD/DNS server regardless of which address you have?
- Any policy using IPv6 addresses must be configured for the appropriate range (QoS, ACL, load-balancers, PBR, etc.)
- If using SLAAC for both—Microsoft Windows allows you to enable/disable privacy extensions globally—this means you are either using them for both or not at all!!!
- One option is to use SLAAC for the Global range and enable privacy extensions and then use DHCPv6 for ULA with another IID value (EUI-64, reserved/admin defined, etc.)

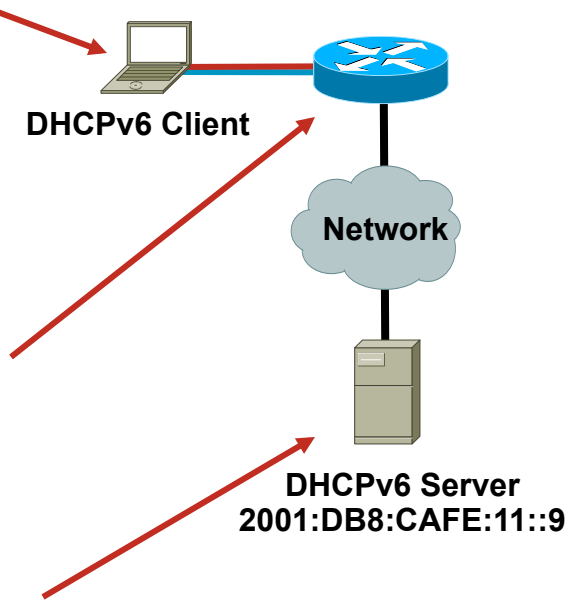
```
Temporary  Preferred  6d23h59m55s  23h59m55s 2001:db8:cafe:2:cd22:7629:f726:6a6b
Dhcp       Preferred  13d1h33m55s 6d1h33m55s fd9c:58ed:7d73:1002:8828:723c:275e:846d
Other      Preferred     infinite   infinite fe80::8828:723c:275e:846d%8
```

- Unlike Global and link-local scopes ULA is not automatically controlled at the appropriate boundary—you must prevent ULA prefix from going out or in at your perimeter
- SAS behavior is OS dependent and there have been issues with it working reliably

# ULA + Global Example

```
Addr Type   DAD State    Valid Life Pref. Life Address
---------   ----------- ---------- ---------- ------------------------
Dhcp        Preferred   13d23h48m24s 6d23h48m24s 2001:db8:cafe:2:c1b5:cc19:f87e:3c41
Dhcp        Preferred   13d23h48m24s 6d23h48m24s fd9c:58ed:7d73:1002:8828:723c:275e:846d
Other       Preferred      infinite   infinite fe80::8828:723c:275e:846d%8
```

```
interface Vlan2
 description ACCESS-DATA-2
 ipv6 address 2001:DB8:CAFE:2::D63/64
 ipv6 address FD9C:58ED:7D73:1002::D63/64
 ipv6 nd prefix 2001:DB8:CAFE:2::/64 no-advertise
 ipv6 nd prefix FD9C:58ED:7D73:1002::/64 no-advertise
 ipv6 nd managed-config-flag
 ipv6 dhcp relay destination 2001:DB8:CAFE:11::9
```




## List DHCP Leases for Prefix *VLAN2*

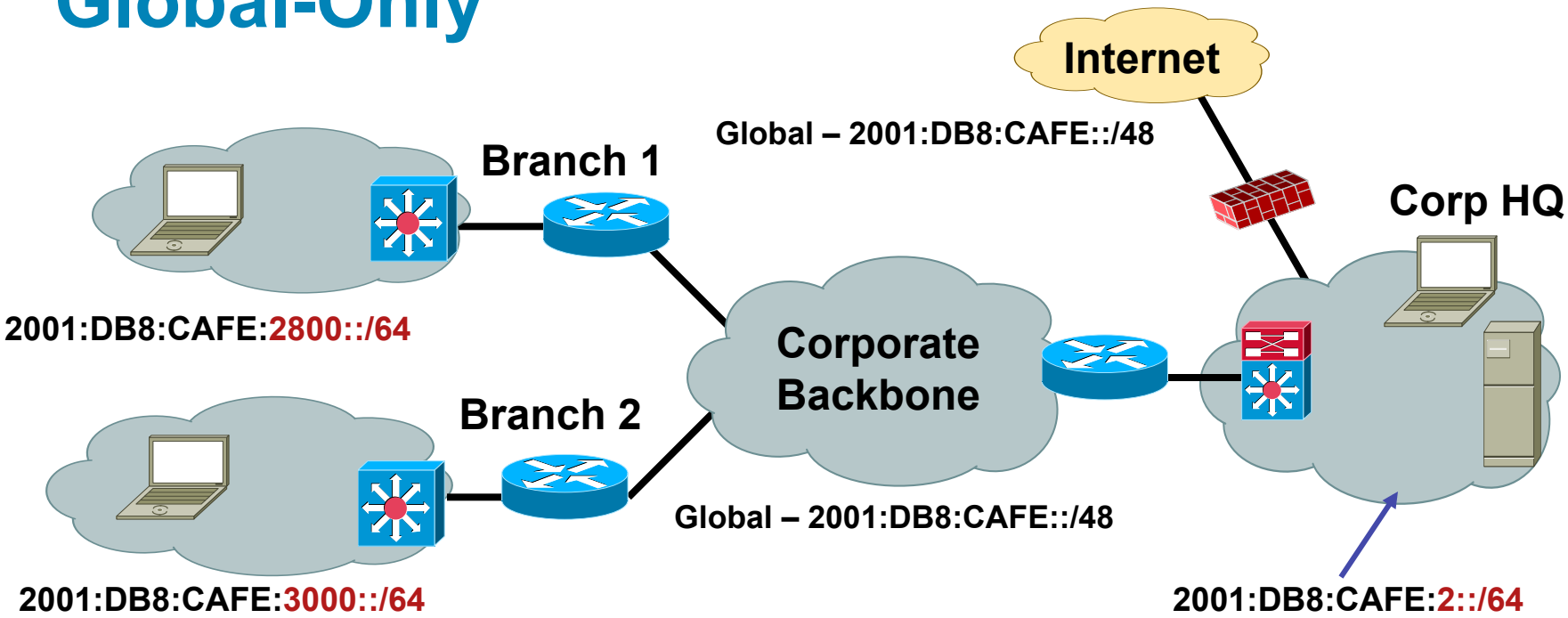
| Address | State | Lookup Key | Flags | State Expi |
|---|---|---|---|---|
| 2001:db8:cafe:2:c1b5:cc19:f87e:3c41 | leased | 00:01:00:01:0d:7f:9c:f8:00:0d:60:84:2c:7a | | Tue Sep 16 |

## List DHCP Leases for Prefix *VLAN2-ULA*

| Address | State | Lookup Key | Flags | State Expira |
|---|---|---|---|---|
| fd9c:58ed:7d73:1002:8828:723c:275e:846d | leased | 00:01:00:01:0d:7f:9c:f8:00:0d:60:84:2c:7a | | Tue Sep 16 1 |

Recommended

# Global-Only




- Global is used everywhere
- No issues with SAS
- No requirements to have NAT for ULA-to-Global translation—but, NAT may be used for other purposes
- Easier management of DHCP, DNS, security, etc.
- Only downside is breaking the habit of believing that topology hiding is a good security method ☺

# Randomized IID and Privacy Extensions

- Enabled by default on Microsoft Windows
- Enable/disable via GPO or CLI

```
netsh interface ipv6 set global randomizeidentifiers=disabled store=persistent
netsh interface ipv6 set privacy state=disabled store=persistent
```

- Alternatively, use DHCP (see later) to a specific pool
- Randomized address are generated for non-temporary autoconfigured addresses including public and link-local—used instead of EUI-64 addresses
- Randomized addresses engage Optimistic DAD—likelihood of duplicate LL address is rare so RS can be sent before full DAD completion
- Windows Vista/W7/2008 send RS while DAD is being performed to save time for interface initialization (read RFC4862 on why this is ok)
- Privacy extensions are used with SLAAC

# Link Level—Prefix Length Considerations

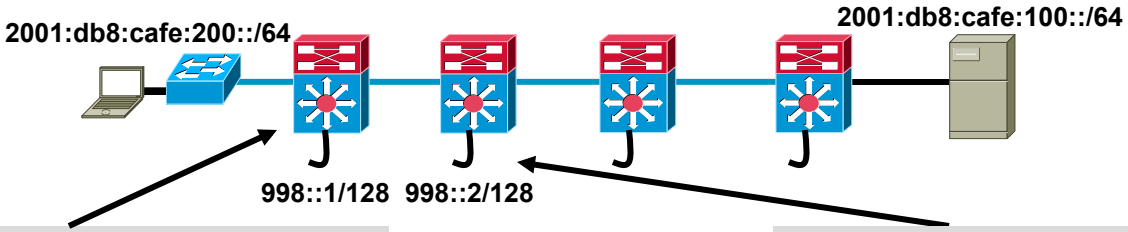
| 64 bits | < 64 bits | > 64 bits |
| --- | --- | --- |
| ▪ Recommended by RFC3177 and IAB/IESG<br>▪ Consistency makes management easy<br>▪ MUST for SLAAC (MSFT DHCPv6 also)<br>▪ Significant address space loss (18.466 Quintillion) | ▪ Enables more hosts per broadcast domain<br>▪ Considered bad practice<br>▪ 64 bits offers more space for hosts than the media can support efficiently | ▪ Address space conservation<br>▪ Special cases:<br>/126—valid for p2p<br>/127—not valid for p2p (RFC3627)<br>/128—loopback<br>▪ Complicates management<br>▪ Must avoid overlap with specific addresses:<br>Router Anycast (RFC3513)<br>Embedded RP (RFC3956)<br>ISATAP addresses |

# Using Link-Local for Non-Access Connections

## Under Research

- What if you did not have to worry about addressing the network infrastructure for the purpose of routing?
  - IPv6 IGPs use LL addressing
  - Only use Global or ULA addresses at the edges for host assignment
  - For IPv6 access to the network device itself use a loopback
- What happens to route filters? ACLs?—Nothing, unless you are blocking to/from the router itself
- Stuff to think about:
  - Always use a RID
  - Some Cisco devices require “ipv6 enable” on the interface in order to generate and use a link-local address
  - Enable the IGP on each interface used for routing or that requires its prefix to be advertised

# Using LL + Loopback Only




```
ipv6 unicast-routing
!
interface Loopback0
 ipv6 address 2001:DB8:CAFE:998::1/128
 ipv6 eigrp 10
!
interface Vlan200
 ipv6 address 2001:DB8:CAFE:200::1/64
 ipv6 eigrp 10
!
interface GigabitEthernet1/1
 ipv6 enable
 ipv6 eigrp 10
!
ipv6 router eigrp 10
 router-id 10.99.8.1
 no shutdown
```

```
ipv6 unicast-routing
!
interface Loopback0
 ipv6 address 2001:DB8:CAFE:998::2/128
 ipv6 eigrp 10
!
interface GigabitEthernet3/4
 ipv6 eigrp 10
!
interface GigabitEthernet1/2
 ipv6 eigrp 10
!
ipv6 router eigrp 10
 router-id 10.99.8.2
 no shutdown
```

```
IPv6-EIGRP neighbors for process 10
0   Link-local address:     Gi1/2
    FE80::212:D9FF:FE92:DE77
```

# Interface-ID Selection

## Network Devices

- Reconnaissance for network devices—the search for something to attack
- Use random 64-bit interface-IDs for network devices
  - 2001:DB8:CAFE:2::1/64—Common IID
  - 2001:DB8:CAFE:2::9A43:BC5D/64—Random IID
  - 2001:DB8:CAFE:2::A001:1010/64—Semi-random IID
- Operational management challenges with this type of numbering scheme

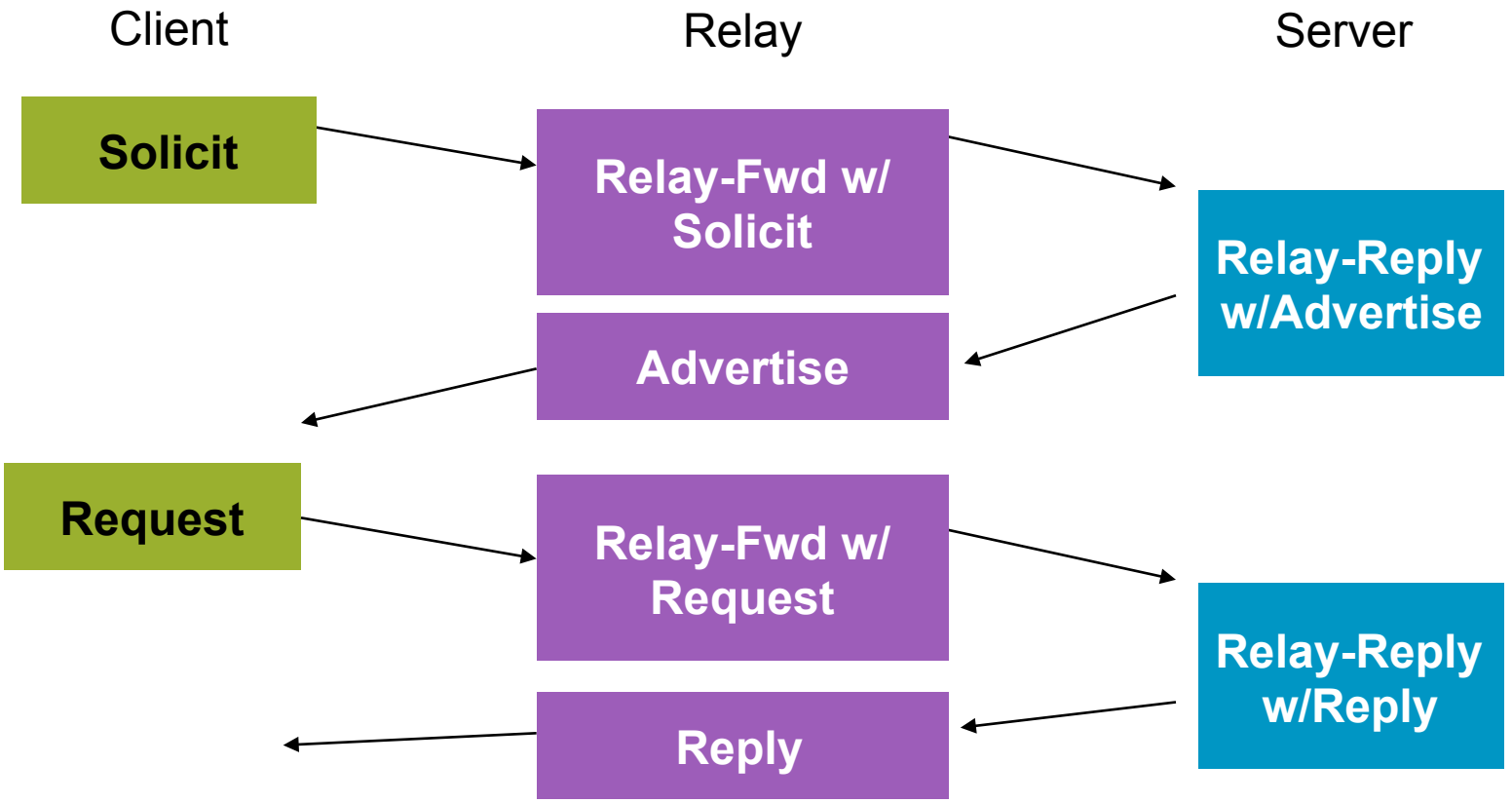
# DHCPv6

- Updated version of DHCP for IPv4
- Client detects the presence of routers on the link
- If found, then examines router advertisements to determine if DHCP can or should be used
- If no router found or if DHCP can be used, then

  DHCP Solicit message is sent to the All-DHCP-Agents multicast address

  Using the link-local address as the source address

# DHCPv6 Operation




- All_DHCP_Relay_Agents_and_Servers (FF02::1:2)
- All_DHCP_Servers (FF05::1:3)
- DHCP Messages: clients listen UDP port 546; servers and relay agents listen on UDP port 547

# Stateful/Stateless DHCPv6

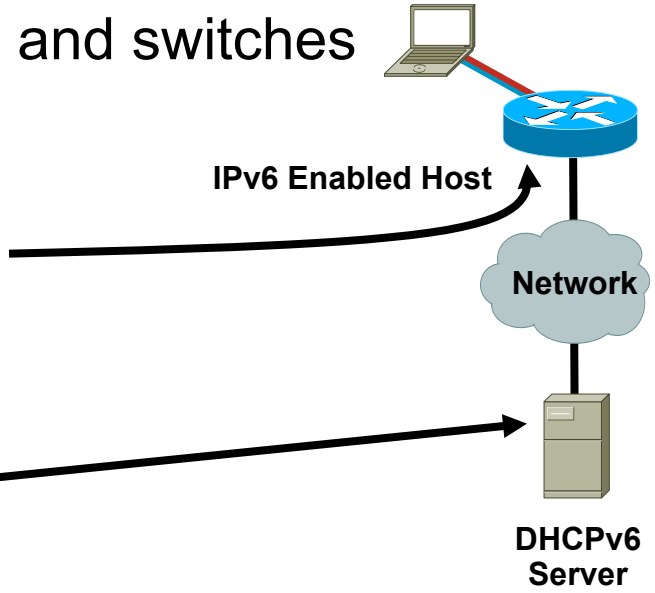
- Stateful and stateless DHCPv6 server

  Cisco Network Registrar:
  http://www.cisco.com/en/US/products/sw/netmgtsw/ps1982/

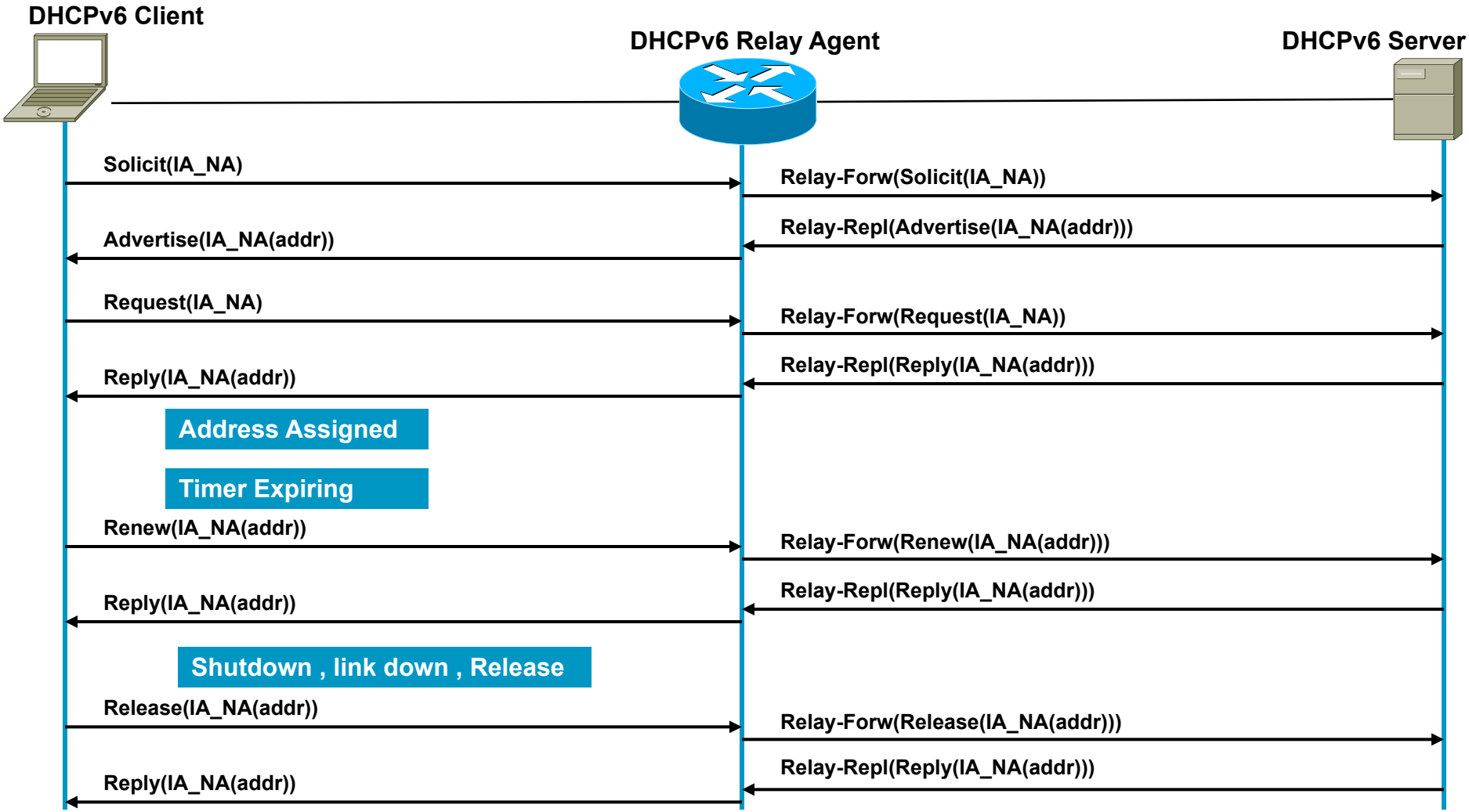
  Microsoft Windows Server 2008:
  http://technet2.microsoft.com/windowsserver2008/en/library/bab0f1a1-54aa-4cef-9164-139e8bcc44751033.mspx?mfr=true

- DHCPv6 Relay—supported on routers and switches

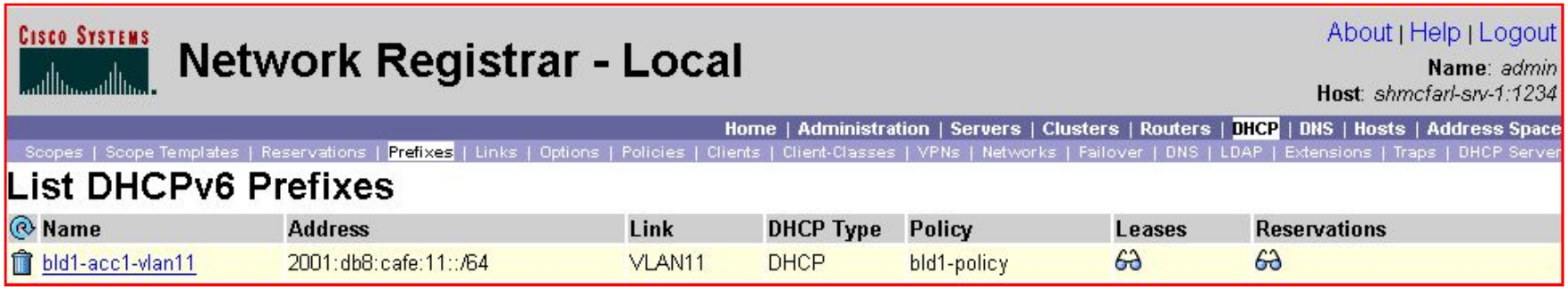
```
interface FastEthernet0/1
 description CLIENT LINK
 ipv6 address 2001:DB8:CAFE:11::1/64
 ipv6 nd prefix 2001:DB8:CAFE:11::/64 no-advertise
 ipv6 nd managed-config-flag
 ipv6 nd other-config-flag
 ipv6 dhcp relay destination 2001:DB8:CAFE:10::2
```

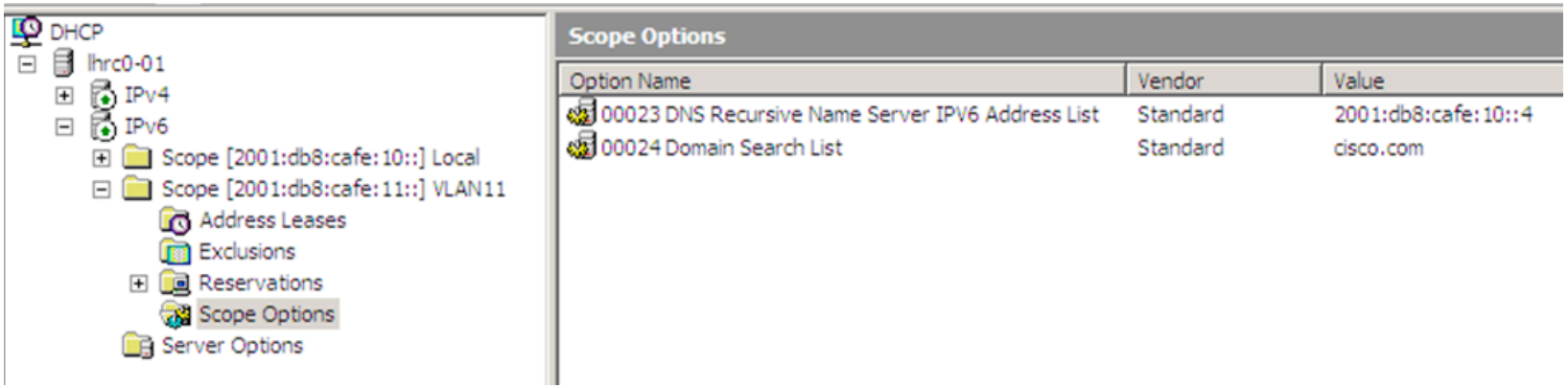


# Basic DHCPv6 Message Exchange



# CNR/W2K8—DHCPv6



# IPv6 General Prefix

- Provides an easy/fast way to deploy prefix changes
- Example:2001:db8:cafe::/48 = General Prefix
- Fill in interface specific fields after prefix

"ESE ::11:0:0:0:1" = 2001:db8:cafe:11::1/64

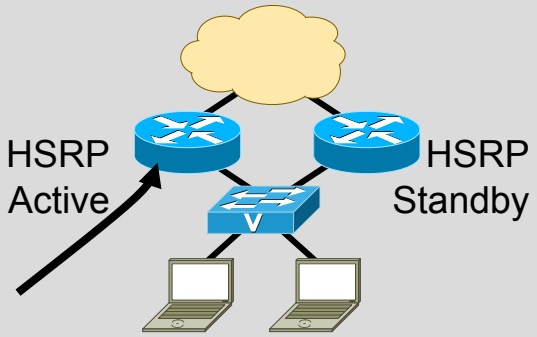
```
ipv6 unicast-routing
ipv6 cef
ipv6 general-prefix ESE 2001:DB8:CAFE::/48
!
interface GigabitEthernet3/2
ipv6 address ESE ::2/126
ipv6 cef
!
interface GigabitEthernet1/2
ipv6 address ESE ::E/126
ipv6 cef
```

```
interface Vlan11
 ipv6 address ESE ::11:0:0:0:1/64
 ipv6 cef
!
interface Vlan12
 ipv6 address ESE ::12:0:0:0:1/64
 ipv6 cef
```

```
Global unicast address(es):
  2001:DB8:CAFE:11::1, subnet is 2001:DB8:CAFE:11::/64
```

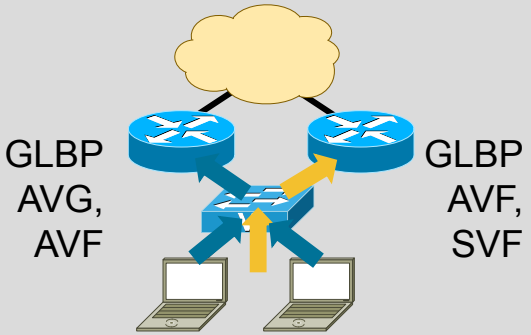
# General Concepts – FHRP, Multicast and QoS

# First Hop Router Redundancy



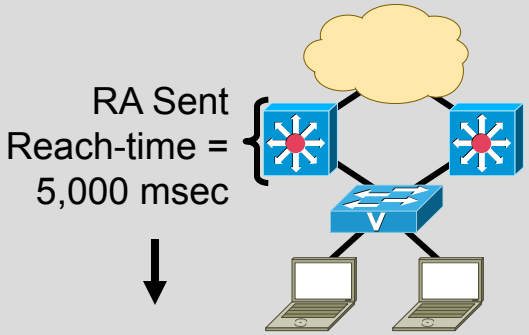

## HSRP for v6

- Modification to Neighbor Advertisement, router Advertisement, and ICMPv6 redirects
- Virtual MAC derived from HSRP group number and virtual IPv6 link-local address




## GLBP for v6

- Modification to Neighbor Advertisement, Router Advertisement—GW is announced via RAs
- Virtual MAC derived from GLBP group number and virtual IPv6 link-local address




## **N**eighbor **U**nreachability **D**etection

- For rudimentary HA at the first HOP
- Hosts use NUD “reachable time” to cycle to next known default gateway (30s by default)

No longer needed

# First-Hop Redundancy

- When HSRP,GLBP and VRRP for IPv6 are not available
- NUD can be used for rudimentary HA at the first-hop (today this only applies to the Campus/DC—HSRP is available on routers)

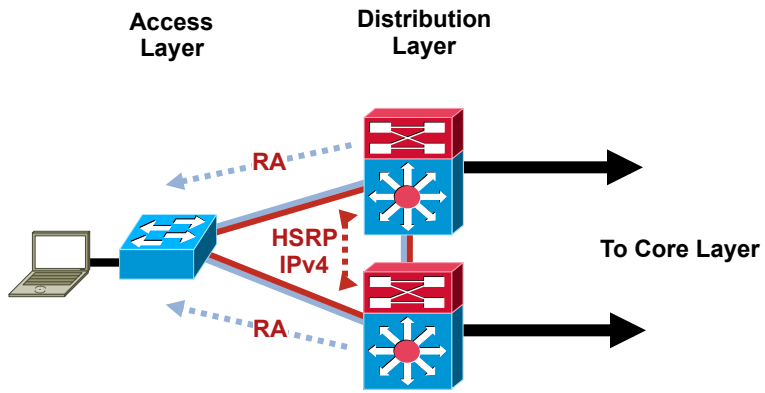
```
(config-if)#ipv6 nd reachable-time 5000
```

- Hosts use NUD “reachable time” to cycle to next known default gateway (30 seconds by default)
- Can be combined with default router preference to determine primary gw:

```
(config-if)#ipv6 nd router-preference {high | medium | low}
```

```
Default Gateway . . . . . . . . . . : 10.121.10.1
                                      fe80::211:bcff:fec0:d000%4
                                      fe80::211:bcff:fec0:c800%4
```

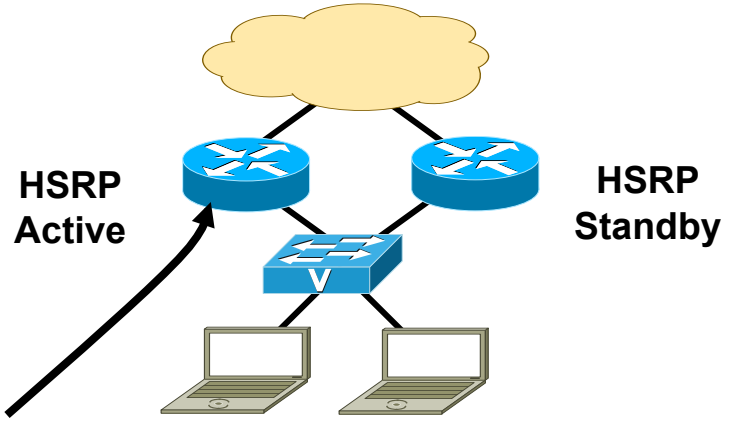
```
Reachable Time              : 6s
Base Reachable Time         : 5s
```




HSRP for IPv4
RA’s with adjusted reachable-time for IPv6

# HSRP for IPv6

- Many similarities with HSRP for IPv4
- Changes occur in Neighbor Advertisement, Router Advertisement, and ICMPv6 redirects
- No need to configure GW on hosts (RAs are sent from HSRP active router)
- Virtual MAC derived from HSRP group number and virtual IPv6 link-local address
- IPv6 Virtual MAC range:
  0005.73A0.0000 - 0005.73A0.0FFF (4096 addresses)
- HSRP IPv6 UDP Port Number 2029 (IANA Assigned)
- No HSRP IPv6 secondary address
- No HSRP IPv6 specific debug



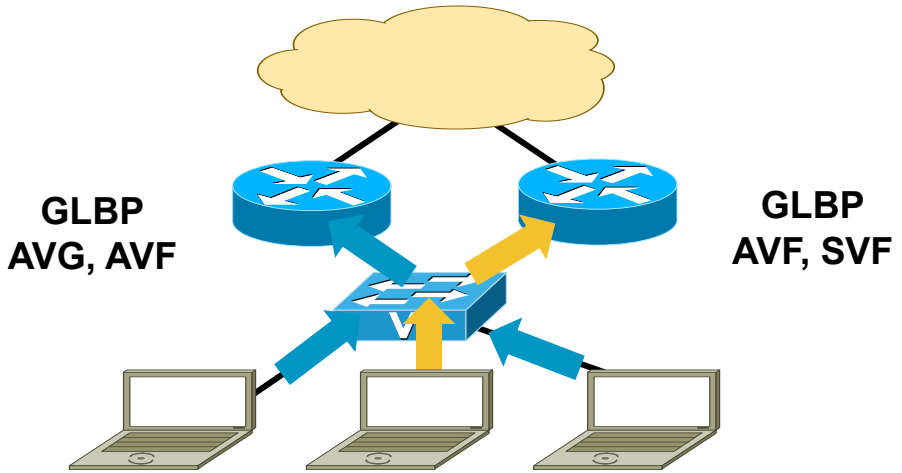

```
interface FastEthernet0/1
 ipv6 address 2001:DB8:66:67::2/64
 ipv6 cef
 standby version 2
 standby 1 ipv6 autoconfig
 standby 1 timers msec 250 msec 800
 standby 1 preempt
 standby 1 preempt delay minimum 180
 standby 1 authentication md5 key-string cisco
 standby 1 track FastEthernet0/0
```

**Host with GW of Virtual IP**

```
#route -A inet6 | grep ::/0 | grep eth2
::/0      fe80::5:73ff:fea0:1                    UGDA  1024   0        0 eth2
```

# GLBP for IPv6

- Many similarities with GLBP for IPv4 (CLI, load-balancing)
- Modification to Neighbor Advertisement, Router Advertisement
- GW is announced via RAs
- Virtual MAC derived from GLBP group number and virtual IPv6 link-local address




```
interface FastEthernet0/0
 ipv6 address 2001:DB8:1::1/64
 ipv6 cef
 glbp 1 ipv6 autoconfig
 glbp 1 timers msec 250 msec 750
 glbp 1 preempt delay minimum 180
 glbp 1 authentication md5 key-string cisco
```

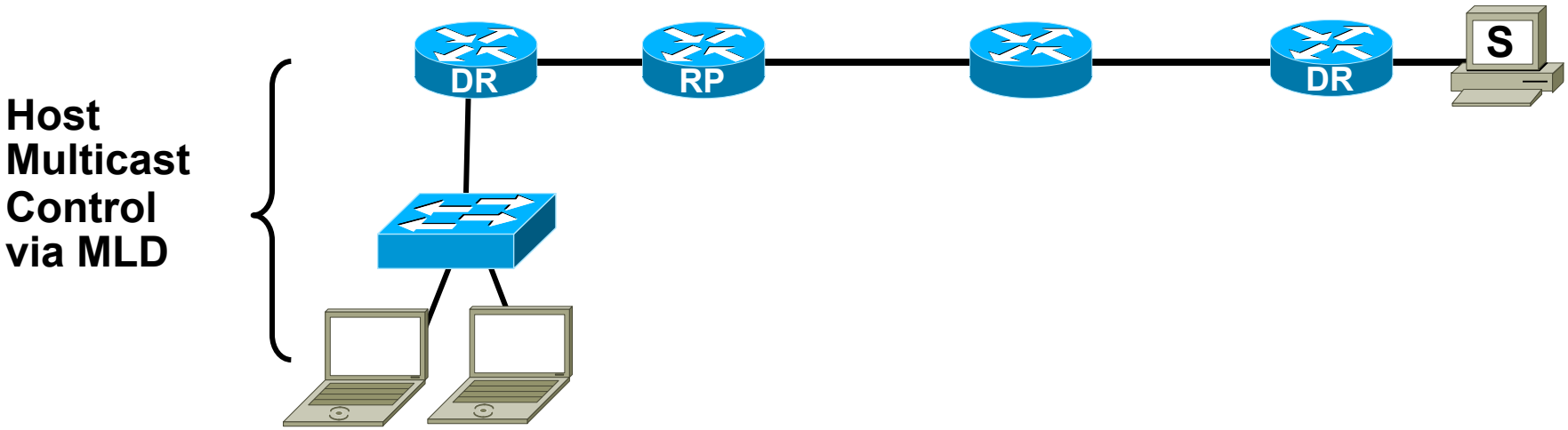
**AVG=Active Virtual Gateway**
**AVF=Active Virtual Forwarder**
**SVF=Standby Virtual Forwarder**

# IPv6 Multicast Availability

- Multicast Listener Discovery (MLD)

  Equivalent to IGMP

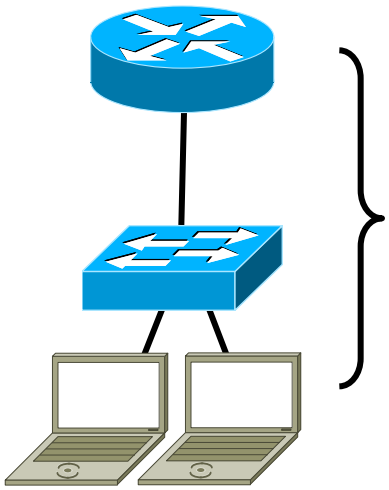
- PIM Group Modes: Sparse Mode, Bidirectional and Source Specific Multicast
- RP Deployment: Static, Embedded



# Multicast Listener Discovery: MLD

## Multicast Host Membership Control

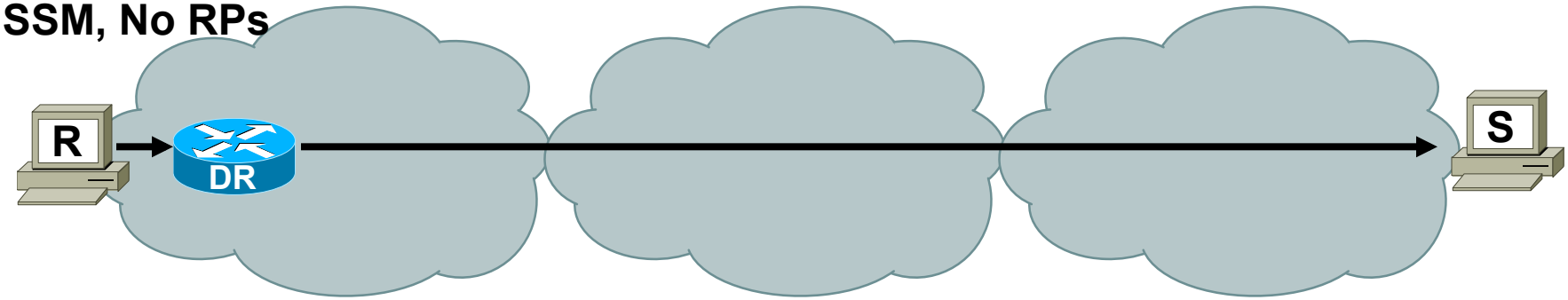
- MLD is equivalent to IGMP in IPv4
- MLD messages are transported over ICMPv6
- MLD uses link local source addresses
- MLD packets use “Router Alert” in extension header (RFC2711)
- Version number confusion:
  - MLDv1 (RFC2710) like IGMPv2 (RFC2236)
  - MLDv2 (RFC3810) like IGMPv3 (RFC3376)
- MLD snooping



# Multicast Deployment Options

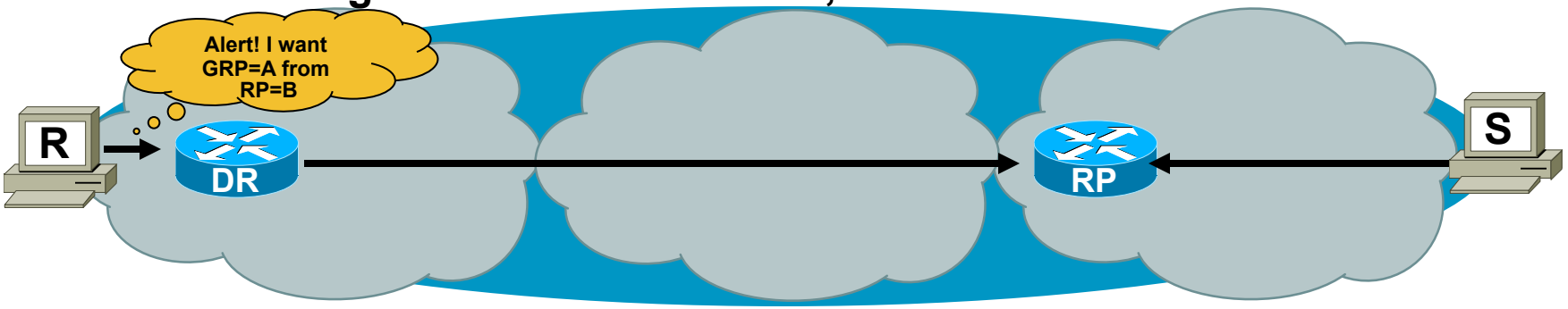
## With and Without Rendezvous Points (RP)

**SSM, No RPs**




**ASM Single RP—Static definitions**


**ASM Across Single Shared PIM Domain, One RP—Embedded-RP**



# IPv6 QoS Syntax Changes

- IPv4 syntax has used “ip” following match/set statements

  **Example:** `match ip dscp, set ip dscp`

- Modification in QoS syntax to support IPv6 and IPv4

```
New match criteria
   match dscp — Match DSCP in v4/v6
   match precedence — Match Precedence in v4/v6
New set criteria
   set dscp — Set DSCP in v4/v6
   set precedence — Set Precedence in v4/v6
```

- Additional support for IPv6 does not always require new Command Line Interface (CLI)

  **Example—WRED**

# Scalability and Performance

- IPv6 Neighbor Cache = ARP for IPv4

  In dual-stack networks the first hop routers/switches will now have more memory consumption due to IPv6 neighbor entries (can be multiple per host) + ARP entries

  ARP entry for host in the campus distribution layer:

```
Internet  10.120.2.200                          2   000d.6084.2c7a  ARPA  Vlan2
```

  IPv6 Neighbor Cache entry:

```
2001:DB8:CAFE:2:2891:1C0C:F52A:9DF1     4 000d.6084.2c7a  STALE Vl2
2001:DB8:CAFE:2:7DE5:E2B0:D4DF:97EC     16 000d.6084.2c7a  STALE Vl2

FE80::7DE5:E2B0:D4DF:97EC               16 000d.6084.2c7a  STALE Vl2
```

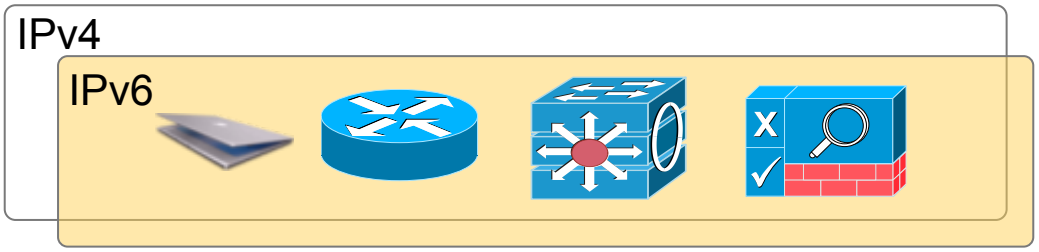
- Full internet route tables—ensure to account for TCAM/memory requirements for both IPv4/IPv6—not all vendors can properly support both
- Multiple routing protocols—IPv4 and IPv6 will have separate routing protocols. Ensure enough CPU/ Memory is present
- Control plane impact when using tunnels—terminate ISATAP/configured tunnels in HW platforms when attempting large scale deployments (hundreds/thousands of tunnels)

# Infrastructure Deployment

Start Here: Cisco IOS Software Release Specifics for IPv6 Features
http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123cgcr/ipv6_c/ftipv6s.htm

# IPv6 Co-existence Solutions

## Dual Stack

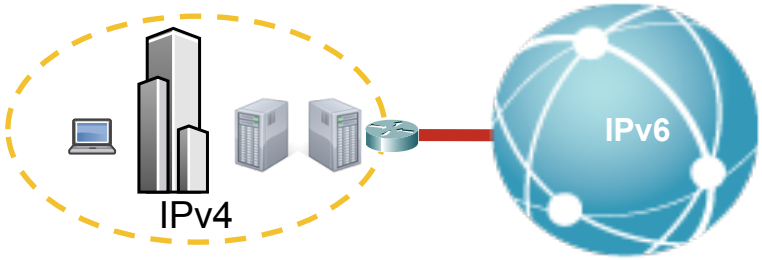



Recommended Enterprise Co-existence strategy

## Tunneling Services


Connect Islands of IPv6 or IPv4

## Translation Services




Connect to the IPv6 community

# Campus/Data Center

Deploying IPv6 in Campus Networks:
http://www.cisco.com/univercd/cc/td/doc/solution/campipv6.pdf

ESE Campus Design and Implementation Guides:
http://www.cisco.com/en/US/netsol/ns656/networking_solutions_design_guidances_list.html#anchor2

# Campus IPv6 Deployment

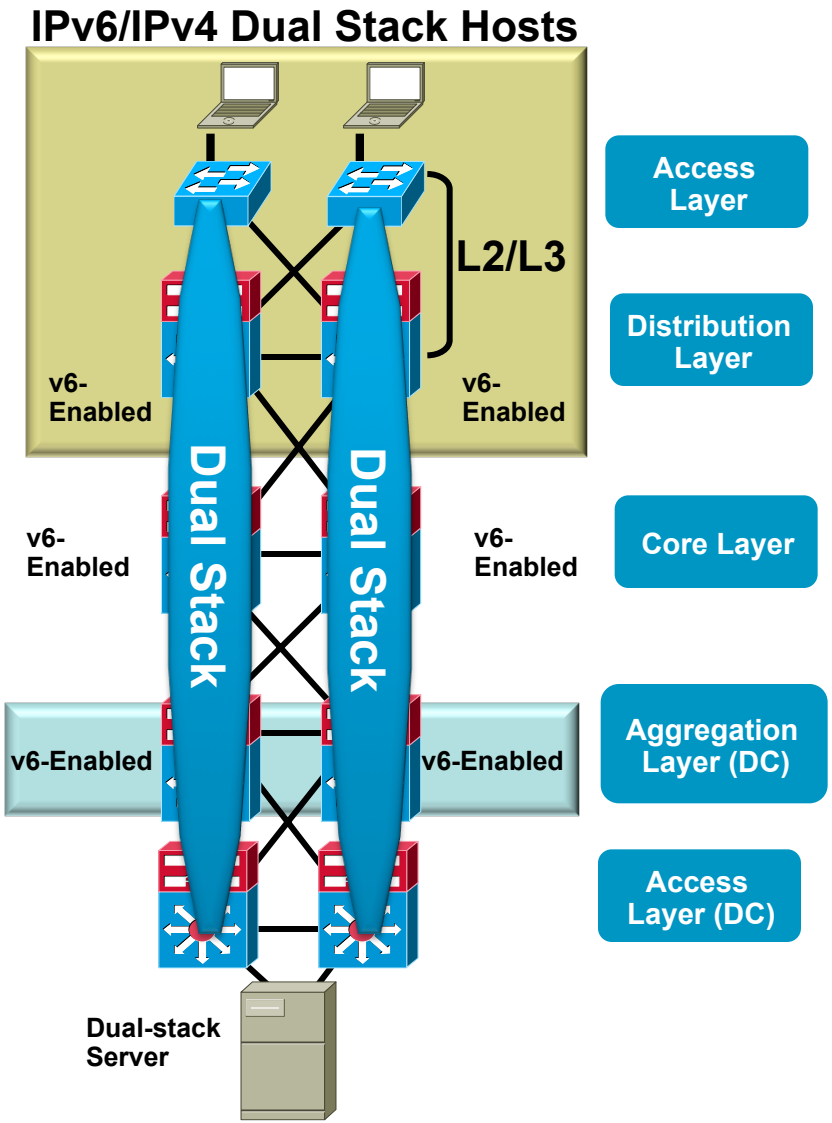
## Three Major Options

- Dual-stack—The way to go for obvious reasons: performance, security, QoS, multicast and management
  - Layer 3 switches should support IPv6 forwarding in hardware
- Hybrid—Dual-stack where possible, tunnels for the rest, but all leveraging the existing design/gear
  - Pro—Leverage existing gear and network design (traditional L2/L3 and routed access)
  - Con—Tunnels (especially ISATAP) cause unnatural things to be done to infrastructure (like core acting as access layer) and ISATAP does not support IPv6 multicast
- IPv6 Service Block—A new network block used for interim connectivity for IPv6 overlay network
  - Pro—Separation, control and flexibility (still supports traditional L2/L3 and routed access)
  - Con—Cost (more gear), does not fully leverage existing design, still have to plan for a real dual-stack deployment and ISATAP does not support IPv6 multicast

# Campus IPv6 Deployment Options

## Dual-Stack IPv4/IPv6

- #1 requirement—switching/ routing platforms must support hardware based forwarding for IPv6
- IPv6 is transparent on L2 switches but—
  - L2 multicast—MLD snooping
  - IPv6 management—Telnet/SSH/ HTTP/SNMP
  - Intelligent IP services on WLAN
- Expect to run the same IGPs as with IPv4
- VSS supports IPv6



# Access Layer: Dual Stack

- Catalyst 3560/3750—In order to enable IPv6 functionality the proper SDM template needs to be defined ( http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3750/12225see/scg/swsdm.htm# )

```
Switch(config)#sdm prefer dual-ipv4-and-ipv6 default
```

- If using a traditional Layer-2 access design, the only thing that needs to be enabled on the access switch (management/security discussed later) is MLD snooping:

```
Switch(config)#ipv6 mld snooping
```

- 3560/3750 non-E series cannot support both HSRP for IPv4 and HSRP for IPv6 on the same interface http://www.cisco.com/en/US/docs/switches/lan/catalyst3750/software/release/12.2_46_se/release/notes/OL16489.html#wp925898

# Distribution Layer: HSRP, EIGRP and DHCPv6-relay (Layer 2 Access)

```
ipv6 unicast-routing
!
interface GigabitEthernet1/0/1
 description To 6k-core-right
 ipv6 address 2001:DB8:CAFE:1105::A001:1010/64
 ipv6 eigrp 10
 ipv6 hello-interval eigrp 10 1
 ipv6 hold-time eigrp 10 3
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 eigrp
!
interface GigabitEthernet1/0/2
 description To 6k-core-left
 ipv6 address 2001:DB8:CAFE:1106::A001:1010/64
 ipv6 eigrp 10
 ipv6 hello-interval eigrp 10 1
 ipv6 hold-time eigrp 10 3
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 eigrp
```

```
interface Vlan4
 description Data VLAN for Access
 ipv6 address 2001:DB8:CAFE:4::2/64
 ipv6 nd prefix 2001:DB8:CAFE:4::/64 no-advertise
 ipv6 nd managed-config-flag
 ipv6 dhcp relay destination 2001:DB8:CAFE:10::2
 ipv6 eigrp 10
 standby version 2
 standby 2 ipv6 autoconfig
 standby 2 timers msec 250 msec 750
 standby 2 priority 110
 standby 2 preempt delay minimum 180
 standby 2 authentication ese
!
ipv6 router eigrp 10
 no shutdown
 router-id 10.122.10.10
 passive-interface Vlan4
 passive-interface Loopback0
```

Some OS/patches may need “no-autoconfig”

# Distribution Layer: Example with ULA and General Prefix feature

```
ipv6 general-prefix ULA-CORE FD9C:58ED:7D73::/53
ipv6 general-prefix ULA-ACC FD9C:58ED:7D73:1000::/53
ipv6 unicast-routing
!
interface GigabitEthernet1/0/1
 description To 6k-core-right
 ipv6 address ULA-CORE ::3:0:0:0:D63/64
 ipv6 eigrp 10
 ipv6 hello-interval eigrp 10 1
 ipv6 hold-time eigrp 10 3
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 eigrp
 ipv6 summary-address eigrp 10 FD9C:58ED:7D73:1000::/53
!
interface GigabitEthernet1/0/2
 description To 6k-core-left
 ipv6 address ULA-CORE ::C:0:0:0:D63/64
 ipv6 eigrp 10
 ipv6 hello-interval eigrp 10 1
 ipv6 hold-time eigrp 10 3
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 eigrp
 ipv6 summary-address eigrp 10 FD9C:58ED:7D73:1000::/53
```

```
interface Vlan4
 description Data VLAN for Access
 ipv6 address ULA-ACC ::D63/64
 ipv6 nd prefix FD9C:58ED:7D73:1002::/64
no-advertise
 ipv6 nd managed-config-flag
 ipv6 dhcp relay destination fd9c:58ed:
7d73:811::9
 ipv6 eigrp 10
 standby version 2
 standby 2 ipv6 autoconfig
 standby 2 timers msec 250 msec 750
 standby 2 priority 110
 standby 2 preempt delay minimum 180
 standby 2 authentication ese
!
ipv6 router eigrp 10
 no shutdown
 router-id 10.122.10.10
 passive-interface Vlan4
 passive-interface Loopback0
```

# Distribution Layer: OSPF with NUD (Layer 2 Access)

```
ipv6 unicast-routing
ipv6 multicast-routing
ipv6 cef distributed
!
interface GigabitEthernet1/1
 description To 6k-core-right
 ipv6 address 2001:DB8:CAFE:1105::A001:1010/64
 no ipv6 redirects
 ipv6 nd suppress-ra
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 0
 ipv6 ospf hello-interval 1
 ipv6 ospf dead-interval 3
!
interface GigabitEthernet1/2
 description To 6k-core-left
 ipv6 address 2001:DB8:CAFE:1106::A001:1010/64
 no ipv6 redirects
 ipv6 nd suppress-ra
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 0
 ipv6 ospf hello-interval 1
 ipv6 ospf dead-interval 3
```

```
interface Vlan2
 description Data VLAN for Access
 ipv6 address 2001:DB8:CAFE:2::A001:1010/64
 ipv6 nd reachable-time 5000
 ipv6 nd router-preference high
 no ipv6 redirects
 ipv6 ospf 1 area 1
!
ipv6 router ospf 1
 auto-cost reference-bandwidth 10000
 router-id 10.122.0.25
 log-adjacency-changes
 area 2 range 2001:DB8:CAFE:xxxx::/xx
 timers spf 1 5
```

# Access Layer: Dual Stack (Routed Access)

```
ipv6 unicast-routing
ipv6 cef
!
interface GigabitEthernet1/0/25
 description To 6k-dist-1
 ipv6 address 2001:DB8:CAFE:1100::CAC1:3750/64
 no ipv6 redirects
 ipv6 nd suppress-ra
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 2
 ipv6 ospf hello-interval 1
 ipv6 ospf dead-interval 3
 ipv6 cef
!
interface GigabitEthernet1/0/26
 description To 6k-dist-2
 ipv6 address 2001:DB8:CAFE:1101::CAC1:3750/64
 no ipv6 redirects
 ipv6 nd suppress-ra
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 2
 ipv6 ospf hello-interval 1
 ipv6 ospf dead-interval 3
 ipv6 cef
```

```
interface Vlan2
 description Data VLAN for Access
 ipv6 address 2001:DB8:CAFE:2::CAC1:3750/64
 ipv6 ospf 1 area 2
 ipv6 cef
!
ipv6 router ospf 1
 router-id 10.120.2.1
 log-adjacency-changes
 auto-cost reference-bandwidth 10000
 area 2 stub no-summary
 passive-interface Vlan2
 timers spf 1 5
```

# Distribution Layer: Dual Stack (Routed Access)

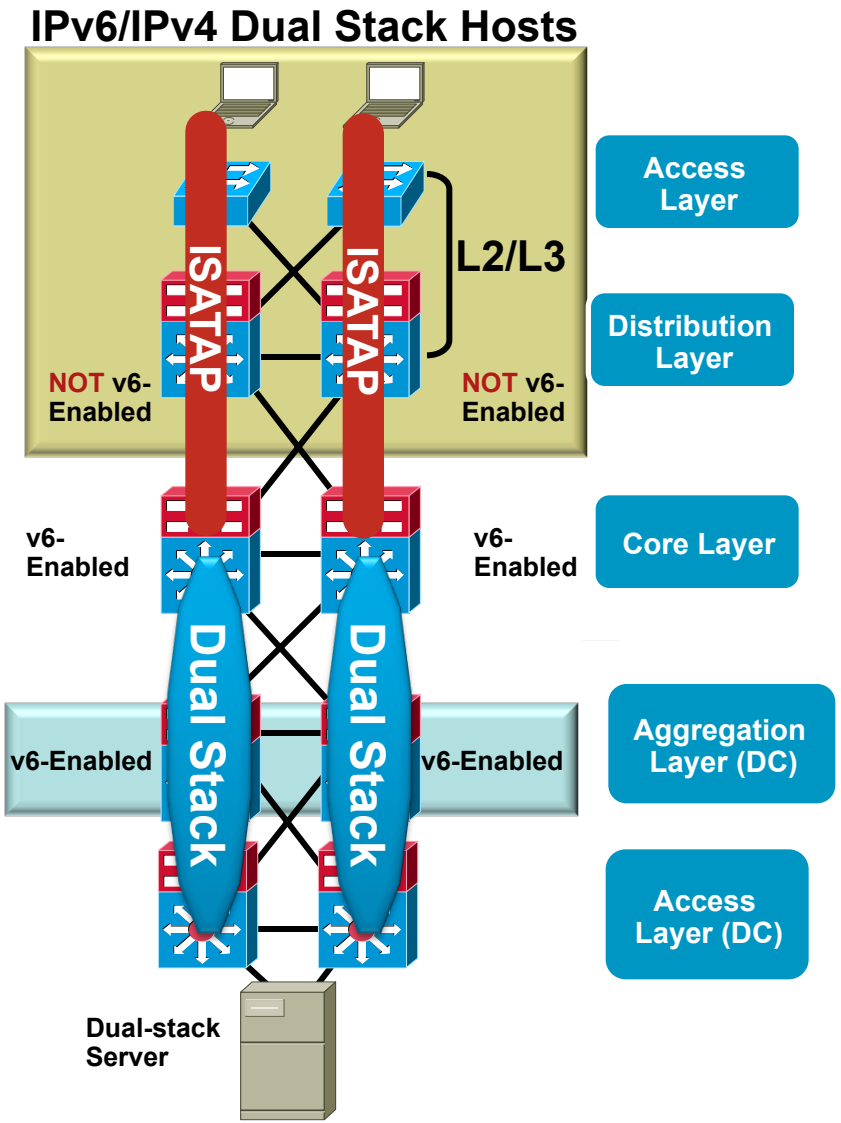
```
ipv6 unicast-routing
ipv6 multicast-routing
ipv6 cef distributed
!
interface GigabitEthernet3/1
 description To 3750-acc-1
 ipv6 address 2001:DB8:CAFE:1100::A001:1010/64
 no ipv6 redirects
 ipv6 nd suppress-ra
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 2
 ipv6 ospf hello-interval 1
 ipv6 ospf dead-interval 3
 ipv6 cef
!
interface GigabitEthernet1/2
 description To 3750-acc-2
 ipv6 address 2001:DB8:CAFE:1103::A001:1010/64
 no ipv6 redirects
 ipv6 nd suppress-ra
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 2
 ipv6 ospf hello-interval 1
 ipv6 ospf dead-interval 3
 ipv6 cef
```

```
ipv6 router ospf 1
 auto-cost reference-bandwidth 10000
 router-id 10.122.0.25
 log-adjacency-changes
 area 2 stub no-summary
 passive-interface Vlan2
 area 2 range 2001:DB8:CAFE:xxxx::/xx
 timers spf 1 5
```

# Campus IPv6 Deployment Options

## Hybrid Model

- Offers IPv6 connectivity via multiple options
  - Dual-stack
  - Configured tunnels—L3-to-L3
  - ISATAP—Host-to-L3
- Leverages existing network
- Offers natural progression to full dual-stack design
- May require tunneling to less-than-optimal layers (i.e. core layer)
- ISATAP creates a flat network (all hosts on same tunnel are peers)
  - Create tunnels per VLAN/subnet to keep same segregation as existing design (not clean today)
- Provides basic HA of ISATAP tunnels via old Anycast-RP idea



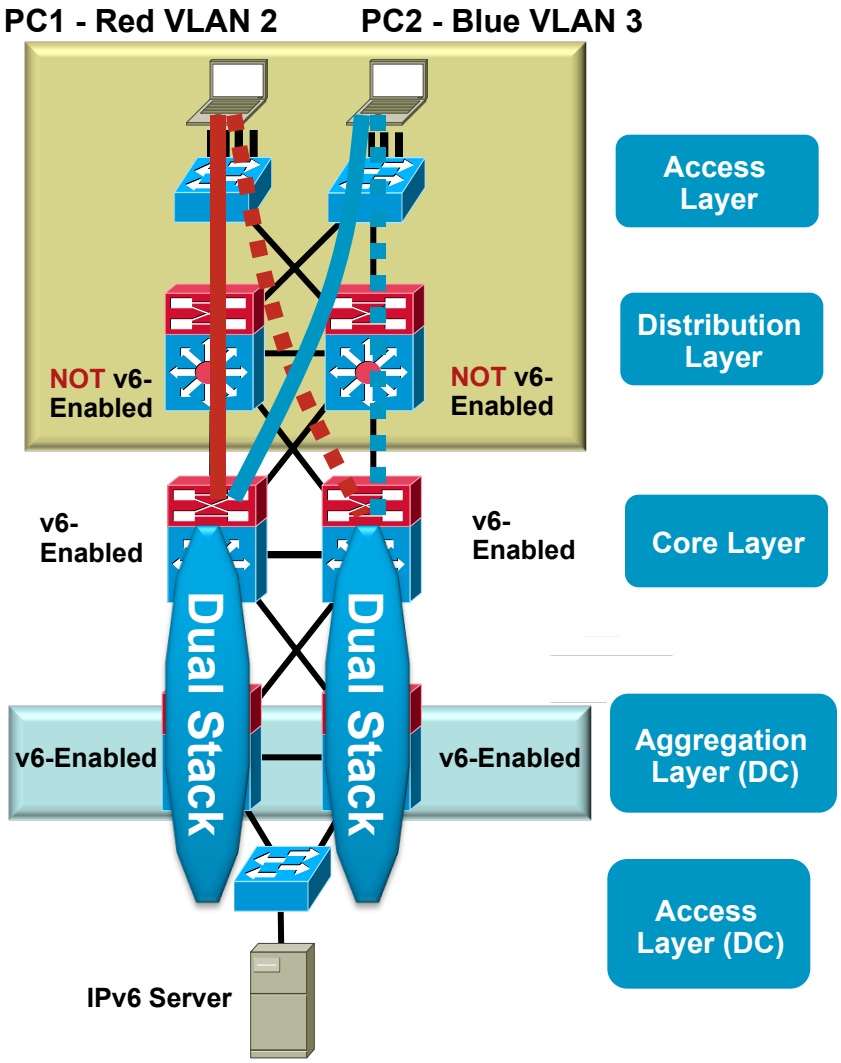
# IPv6 ISATAP Implementation

## ISATAP Host Considerations

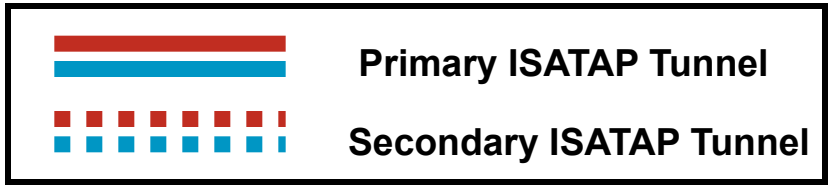
- ISATAP is available on Windows XP, Windows 2003, Vista/Server 2008, port for Linux
- If Windows host does not detect IPv6 capabilities on the physical interface then an effort to use ISATAP is started
- Can learn of ISATAP routers via DNS “A” record lookup “isatap” or via static configuration
  - If DNS is used then Host/Subnet mapping to certain tunnels cannot be accomplished due to the lack of naming flexibility in ISATAP
  - Two or more ISATAP routers can be added to DNS and ISATAP will determine which one to use and also fail to the other one upon failure of first entry
  - If DNS zoning is used within the enterprise then ISATAP entries for different routers can be used in each zone
- In the presented design the static configuration option is used to ensure each host is associated with the correct ISATAP tunnel
- Can conditionally set the ISATAP router per host based on subnet, userid, department and possibly other parameters such as role

# Highly Available ISATAP Design

## Topology




- ISATAP tunnels from PCs in access layer to core switches
- Redundant tunnels to core or service block
- Use IGP to prefer one core switch over another (both v4 and v6 routes) —deterministic
- Preference is important due to the requirement to have traffic (IPv4/ IPv6) route to the same interface (tunnel) where host is terminated on —Windows XP/2003
- Works like Anycast-RP with IPmc ☺



# IPv6 Campus ISATAP Configuration

## Redundant Tunnels

### ISATAP Primary

```
interface Tunnel2
 ipv6 address 2001:DB8:CAFE:2::/64 eui-64
 no ipv6 nd suppress-ra
 ipv6 ospf 1 area 2
 tunnel source Loopback2
 tunnel mode ipv6ip isatap
!
interface Tunnel3
 ipv6 address 2001:DB8:CAFE:3::/64 eui-64
 no ipv6 nd suppress-ra
 ipv6 ospf 1 area 2
 tunnel source Loopback3
 tunnel mode ipv6ip isatap
!
interface Loopback2
 description Tunnel source for ISATAP-VLAN2
 ip address 10.122.10.102 255.255.255.255
!
interface Loopback3
 description Tunnel source for ISATAP-VLAN3
 ip address 10.122.10.103 255.255.255.255
```

### ISATAP Secondary

```
interface Tunnel2
 ipv6 address 2001:DB8:CAFE:2::/64 eui-64
 no ipv6 nd suppress-ra
 ipv6 ospf 1 area 2
 ipv6 ospf cost 10
 tunnel source Loopback2
 tunnel mode ipv6ip isatap
!
interface Tunnel3
 ipv6 address 2001:DB8:CAFE:3::/64 eui-64
 no ipv6 nd suppress-ra
 ipv6 ospf 1 area 2
 ipv6 ospf cost 10
 tunnel source Loopback3
 tunnel mode ipv6ip isatap
!
interface Loopback2
 ip address 10.122.10.102 255.255.255.255
 delay 1000
!
interface Loopback3
 ip address 10.122.10.103 255.255.255.255
 delay 1000
```

# IPv6 Campus ISATAP Configuration

## IPv4 and IPv6 Routing—Options

**ISATAP Secondary—Bandwidth adjustment**

```
interface Loopback2
 ip address 10.122.10.102 255.255.255.255
 delay 1000
```

**ISATAP Primary—Longest-match adjustment**

```
interface Loopback2
 ip address 10.122.10.102 255.255.255.255
```

**ISATAP Secondary—Longest-match adjustment**

```
interface Loopback2
 ip address 10.122.10.102 255.255.255.254
```

- To influence IPv4 routing to prefer one ISATAP tunnel source over another—alter delay/cost or mask length
- Lower timers (timers spf, hello/hold, dead) to reduce convergence times
- Use recommended summarization and/or use of stubs to reduce routes and convergence times

**IPv4—EIGRP**

```
router eigrp 10
 eigrp router-id 10.122.10.3
```

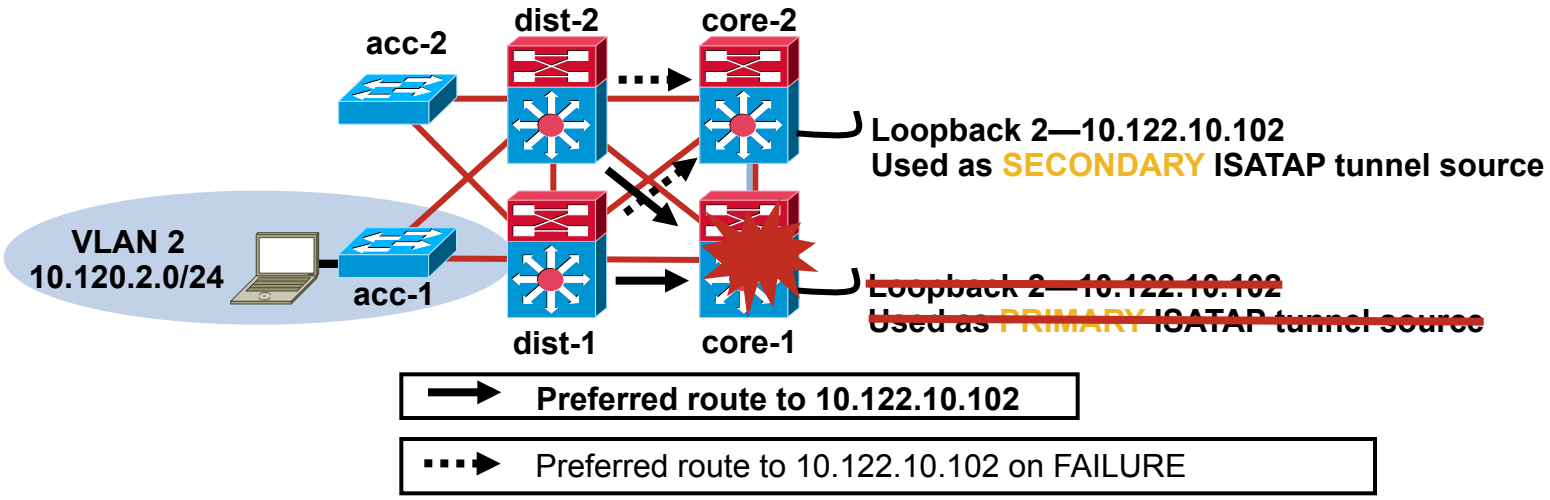
**IPv6—OSPFv3**

```
ipv6 router ospf 1
 router-id 10.122.10.3
```

**Set RID to ensure redundant loopback addresses do not cause duplicate RID issues**

# Distribution Layer Routes

## Primary/Secondary Paths to ISATAP Tunnel Sources




### Before Failure

```
dist-1#show ip route | b 10.122.10.102/32
D       10.122.10.102/32 [90/130816] via 10.122.0.41, 00:09:23, GigabitEthernet1/0/27
```

### After Failure

```
dist-1#show ip route | b 10.122.10.102/32
D       10.122.10.102/32 [90/258816] via 10.122.0.49, 00:00:08, GigabitEthernet1/0/28
```

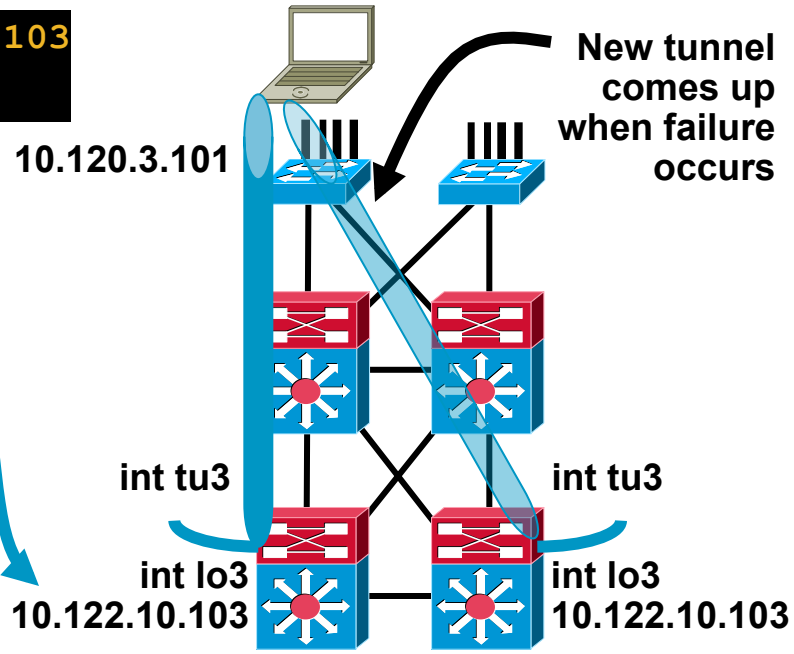
# IPv6 Campus ISATAP Configuration

## ISATAP Client Configuration

**Windows XP/Vista Host**

```
C:\>netsh int ipv6 isatap set router 10.122.10.103
Ok.
```

```
interface Tunnel3
 ipv6 address 2001:DB8:CAFE:3::/64 eui-64
 no ipv6 nd suppress-ra
 ipv6 eigrp 10
 tunnel source Loopback3
 tunnel mode ipv6ip isatap
!
interface Loopback3
 description Tunnel source for ISATAP-VLAN3
 ip address 10.122.10.103 255.255.255.255
```

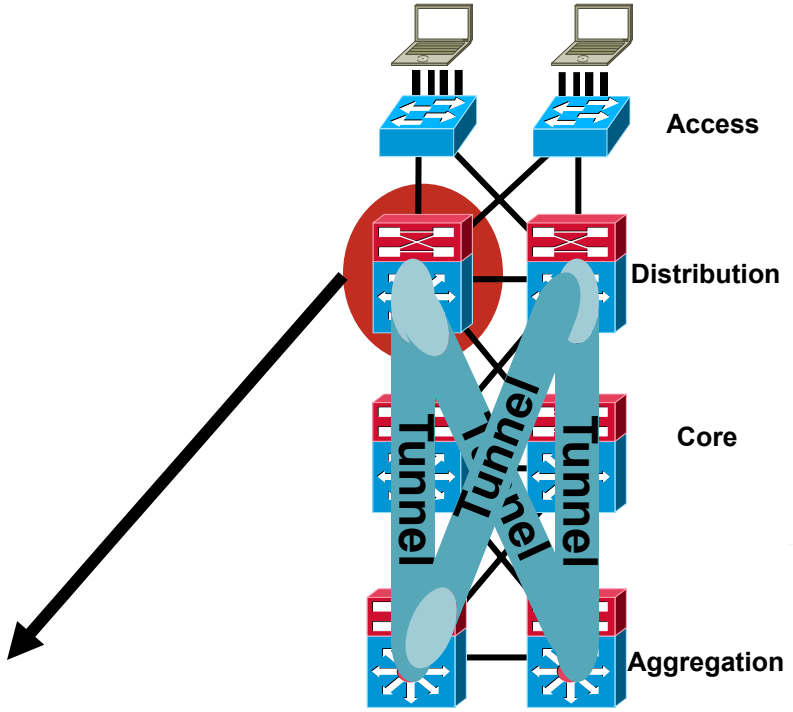



```
Tunnel adapter Automatic Tunneling Pseudo-Interface:
Connection-specific DNS Suffix  . :
IP Address. . . . . . . . . . . . : 2001:db8:cafe:3:0:5efe:10.120.3.101
IP Address. . . . . . . . . . . . : fe80::5efe:10.120.3.101%2
Default Gateway . . . . . . . . . : fe80::5efe:10.122.10.103%2
```

# IPv6 Configured Tunnels

## Think GRE or IP-in-IP Tunnels

- Encapsulating IPv6 into IPv4
- Used to traverse IPv4 only devices/links/networks
- Treat them just like standard IP links (only insure solid IPv4 routing/HA between tunnel interfaces)
- Provides for same routing, QoS, multicast as with dual-stack
- In HW, performance should be similar to standard tunnels

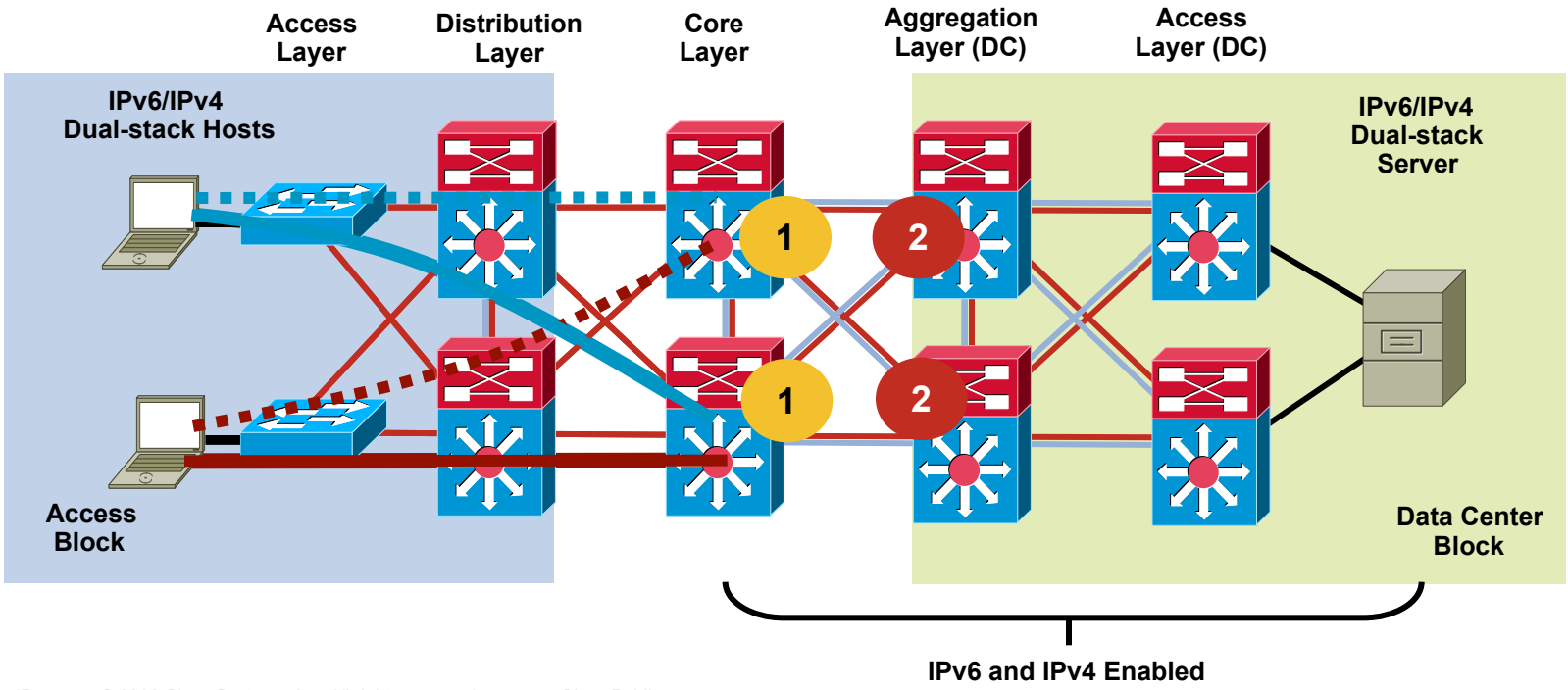



```
interface Tunnel0
 ipv6 cef
 ipv6 address 2001:DB8:CAFE:13::1/127
 ipv6 eigrp 10
 tunnel source Loopback3
 tunnel destination 172.16.2.1
 tunnel mode ipv6ip
```

```
interface GigabitEthernet1/1
 ipv6 address 2001:DB8:CAFE:13::4/127
 ipv6 eigrp 10
 ipv6 cef
!
interface Loopback3
 ip address 172.16.1.1 255.255.255.252
```

# Campus Hybrid Model 1
## QoS

1. Classification and marking of IPv6 is done on the egress interfaces on the core layer switches because packets have been tunneled until this point—QoS policies for classification and marking cannot be applied to the ISATAP tunnels on ingress
2. The classified and marked IPv6 packets can now be examined by upstream switches (e.g. aggregation layer switches) and the appropriate QoS policies can be applied on ingress. These polices may include trust (ingress), policing (ingress) and queuing (egress)



# Campus Hybrid Model 1

## QoS Configuration Sample—Core Layer

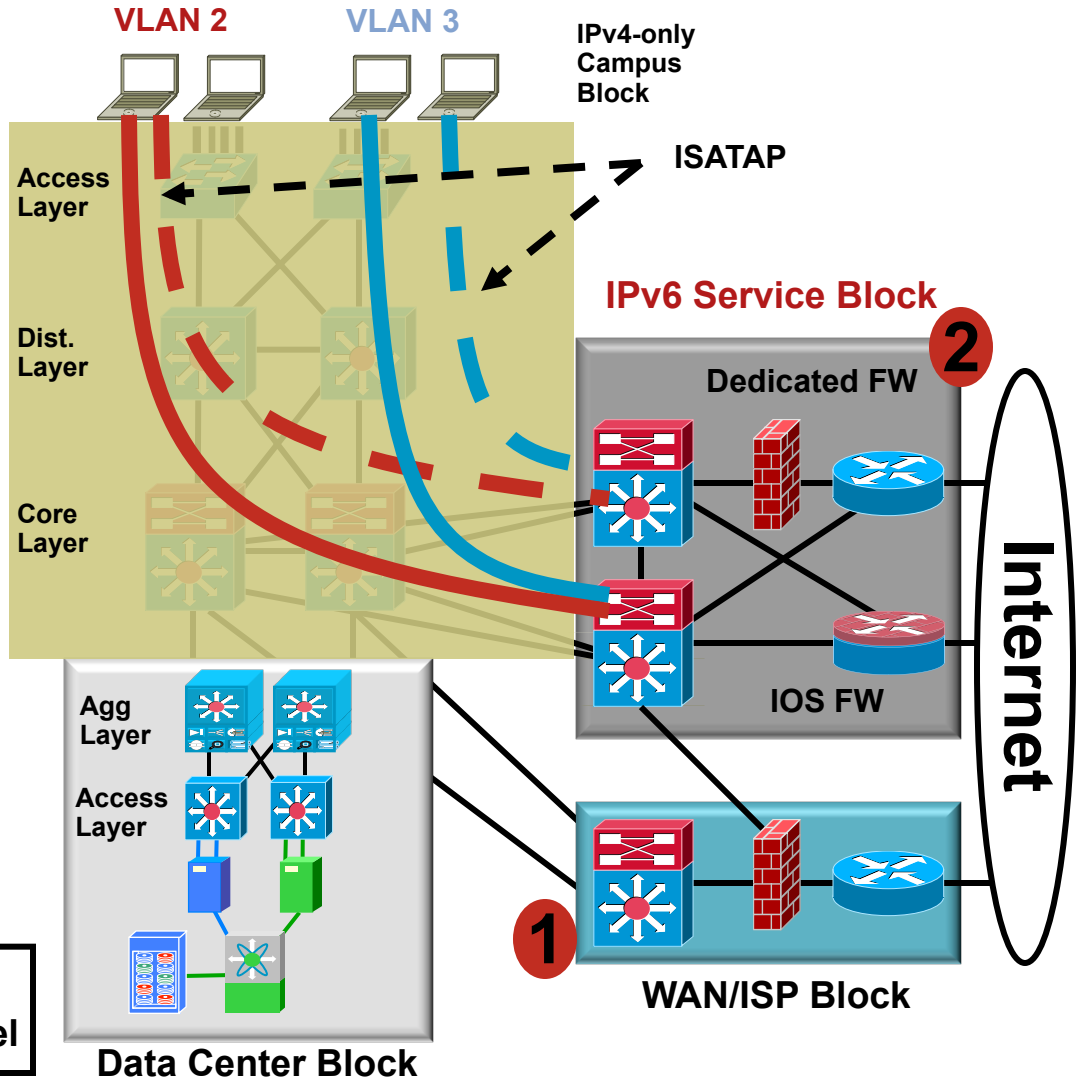
```
mls qos
!
class-map match-all CAMPUS-BULK-DATA
  match access-group name BULK-APPS
class-map match-all CAMPUS-TRANSACTIONAL-DATA
  match access-group name TRANSACTIONAL-APPS
!
policy-map IPv6-ISATAP-MARK
  class CAMPUS-BULK-DATA
   set dscp af11
  class CAMPUS-TRANSACTIONAL-DATA
   set dscp af21
  class class-default
   set dscp default
!
ipv6 access-list BULK-APPS
 permit tcp any any eq ftp
 permit tcp any any eq ftp-data
!
ipv6 access-list TRANSACTIONAL-APPS
 permit tcp any any eq telnet
 permit tcp any any eq 22
```

```
ipv6 access-list BULK-APPS
 permit tcp any any eq ftp
 permit tcp any any eq ftp-data
!
ipv6 access-list TRANSACTIONAL-APPS
 permit tcp any any eq telnet
 permit tcp any any eq 22
!
interface GigabitEthernet2/1
 description to 6k-agg-1
 mls qos trust dscp
 service-policy output IPv6-ISATAP-MARK
!
interface GigabitEthernet2/2
 description to 6k-agg-2
 mls qos trust dscp
 service-policy output IPv6-ISATAP-MARK
!
interface GigabitEthernet2/3
 description to 6k-core-1
 mls qos trust dscp
 service-policy output IPv6-ISATAP-MARK
```

# Campus IPv6 Deployment Options

## IPv6 Service Block—an Interim Approach

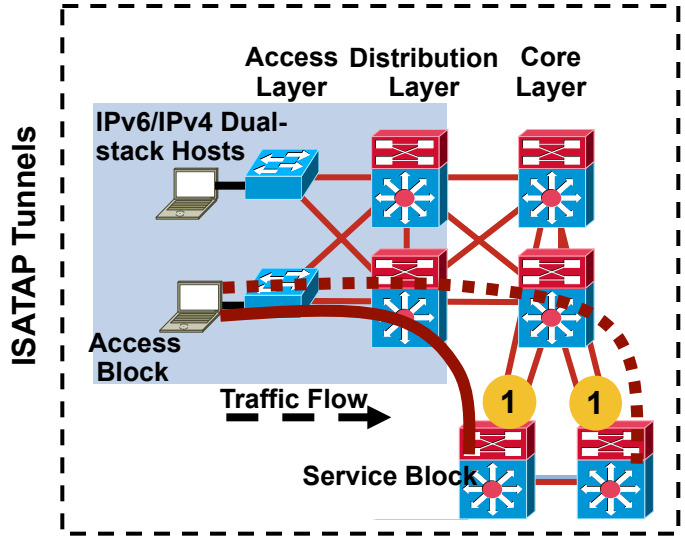
- Provides ability to rapidly deploy IPv6 services without touching existing network
- Provides tight control of where IPv6 is deployed and where the traffic flows (maintain separation of groups/ locations)
- Offers the same advantages as Hybrid Model without the alteration to existing code/configurations
- Configurations are very similar to the Hybrid Model
  - ISATAP tunnels from PCs in access layer to service block switches (instead of core layer—Hybrid)
- 1) Leverage existing ISP block for both IPv4 and IPv6 access
- 2) Use dedicated ISP connection just for IPv6—Can use IOS FW or PIX/ASA appliance

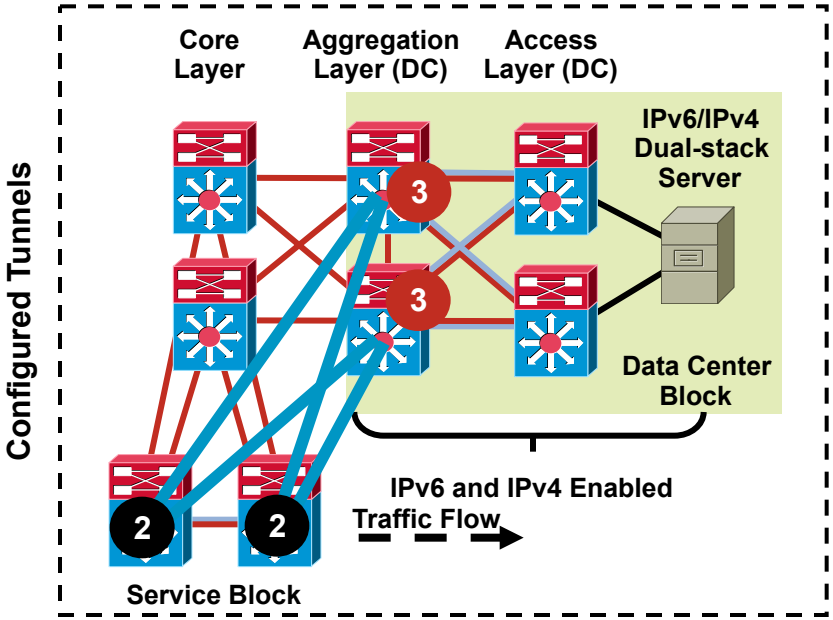


# Campus Service Block

## QoS from Access Layer

1. Same policy design as Hybrid Model—The first place to implement classification and marking from the access layer is after decapsulation (ISATAP) which is on the egress interfaces on the service block switches
2. IPv6 packets received from ISATAP interfaces will have egress policies (classification/ marking) applied on the configured tunnel interfaces
3. Aggregation/access switches can apply egress/ingress policies (trust, policing, queuing) to IPv6 packets headed for DC services

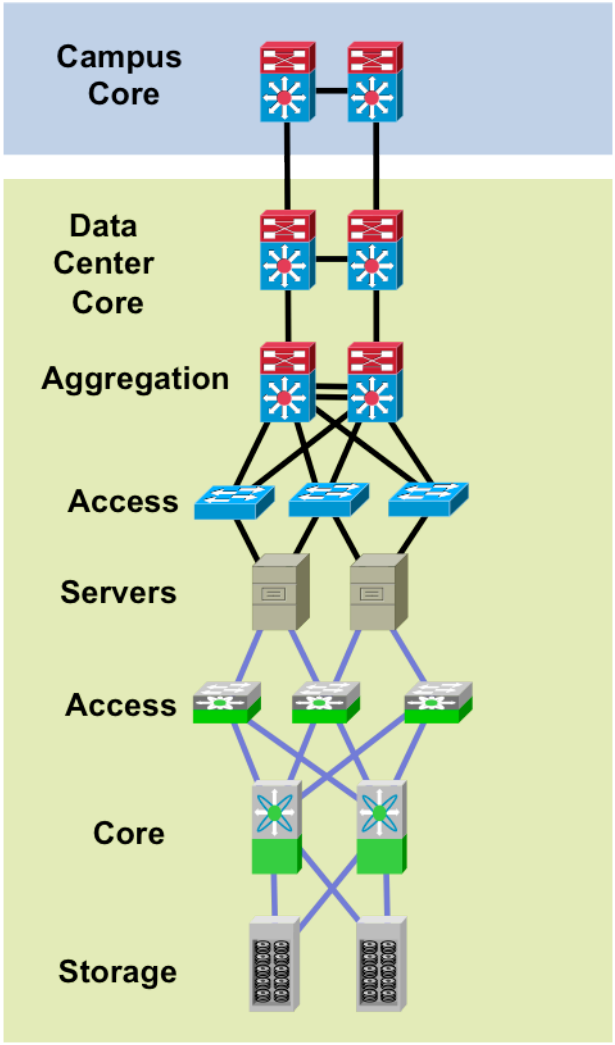


# Cisco VSS – DSM / Hybrid / Service Block

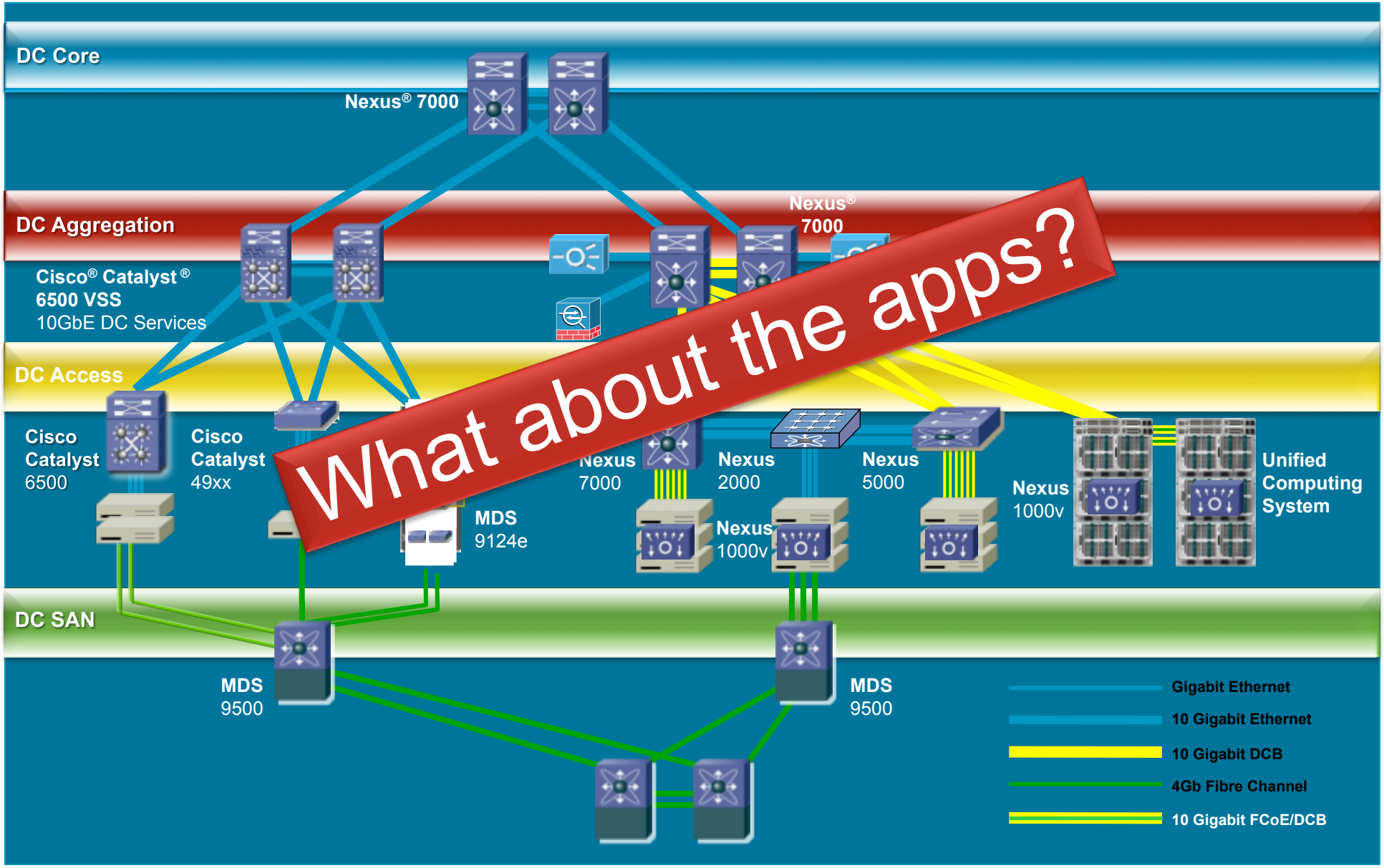
- Cisco VSS offers a greatly simplified configuration and extremely fast convergence for IPv6 deployment
- Dual stack – Place VSS pair in distribution and/or core layers – HA and simplified/reduced IPv6 configuration
- Hybrid model – If terminating tunnels against VSS (i.e. VSS at core layer), MUCH easier to configure tunnels for HA as only one tunnel configuration is needed
- Service Block – Use VSS as the SB pair – again, GREATLY simplified configuration and decrease convergence times!!

# IPv6 Data Center Integration




- Front-end design will be similar to campus based on feature, platform and connectivity similarities – Nexus, 6500 4900M
- The single most overlooked and potentially complicated area of IPv6 deployment
- IPv6 for SAN is supported in SAN-OS 3.0
- Stuff people don't think about:
  - NIC Teaming, iLO, DRAC, IP KVM, Clusters
  - Innocent looking Server OS upgrades – Windows Server 2008 - Impact on clusters – Microsoft Server 2008 Failover clusters full support IPv6 (and L3)
- Build an IPv6-only server farm?

# Virtualized DC Solutions



# IPv6 in the Enterprise Data Center
## Biggest Challenges Today

- Network services above L3
  - SLB, SSL-Offload, application monitoring (probes)
  - Application Optimization
  - High-speed security inspection/perimeter protection
- Application support for IPv6 – Know what you don't know
  - If an application is protocol centric (IPv4):
    - Needs to be rewritten
    - Needs to be translated until it is replaced
    - Wait and pressure vendors to move to protocol agnostic framework
- Virtualized and Consolidated Data Centers
  - Virtualization '*should*' make DCs simpler and more flexible
  - Lack of robust DC/Application management is often the root cause of all evil
  - Ensure management systems support IPv6 as well as the devices being managed

# Commonly Deployed IPv6-enabled OS/ Apps

**Operating Systems**

- Windows 7
- Windows Server 2008/R2
- SUSE
- Red Hat
- Ubuntu
- The list goes on

**Virtualization & Applications**

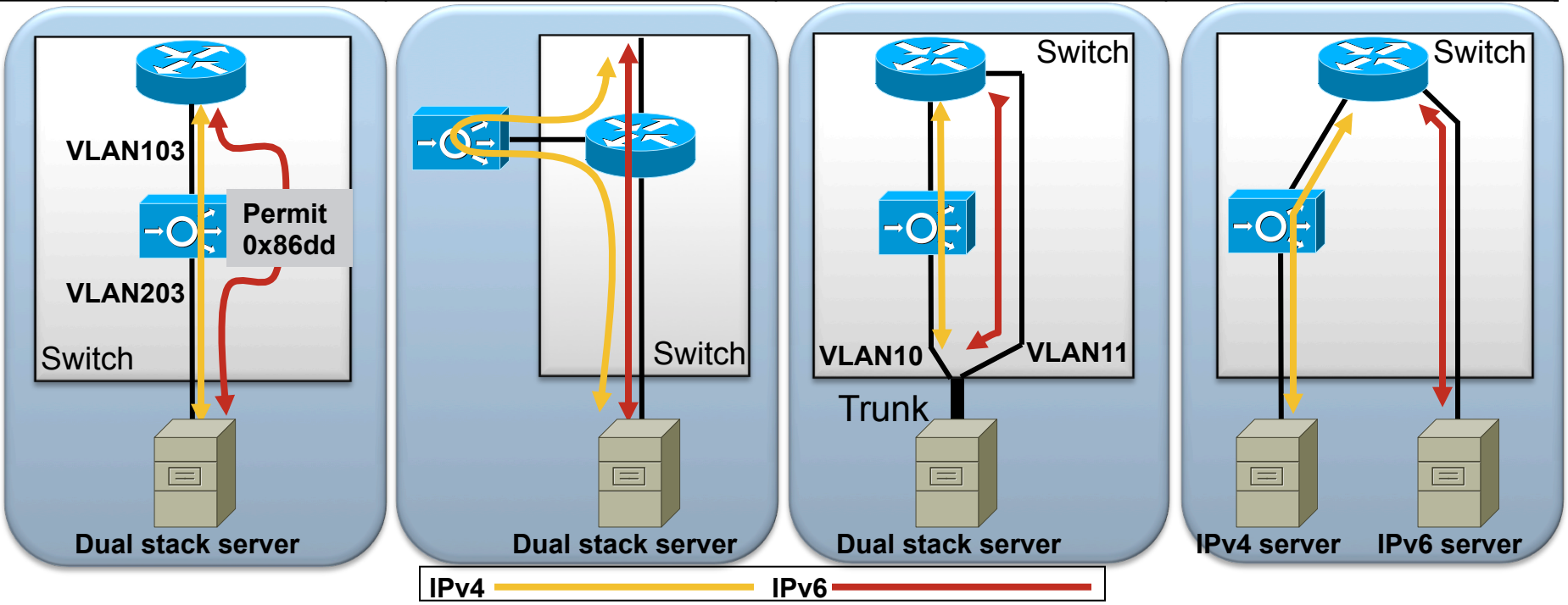
- VMware vSphere 4.1
- Microsoft Hyper-V
- Microsoft Exchange 2007 SP1/2010
- Apache/IIS Web Services
- Windows Media Services
- Multiple Line of Business apps

**Most commercial applications won't be your problem – it will be the custom/home-grown apps**

# IPv6 Deployment in the Data Center

## Services/Appliances Do Not Support IPv6

| Transparent | One-Armed | Routed | Dedicated Server Farm |
|---|---|---|---|
| ▪ IPv6 traffic is bridged between VLANs<br>▪ Permit Ethertype 0x86dd (IPv6) | ▪ IPv6 traffic bypasses services<br>▪ IPv4 traffic is sent to one-arm attached module/appliance | ▪ Create trunk between switch and server<br>▪ IPv4 has default gateway on service module<br>▪ IPv6 on separate VLAN to MSFC | ▪ New IPv6 only servers can be connected to existing access/agg pair on different VLANs<br>▪ New access/agg switches just for IPv6 servers |



# WAN/Branch

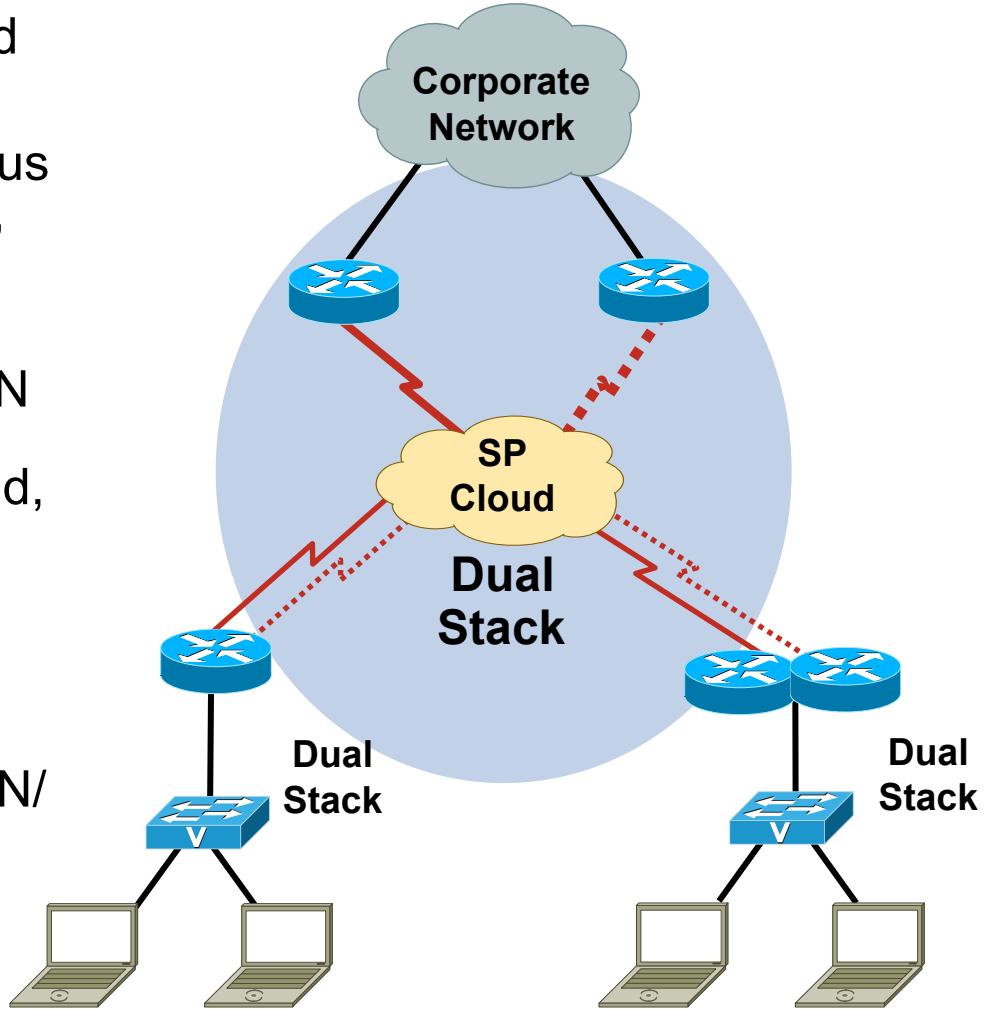
Deploying IPv6 in Branch Networks:
http://www.cisco.com/univercd/cc/td/doc/solution/brchipv6.pdf

ESE WAN/Branch Design and Implementation Guides:
http://www.cisco.com/en/US/netsol/ns656/networking_solutions_design_guidances_list.html#anchor1

http://www.cisco.com/en/US/netsol/ns656/networking_solutions_design_guidances_list.html#anchor10

# WAN/Branch Deployment

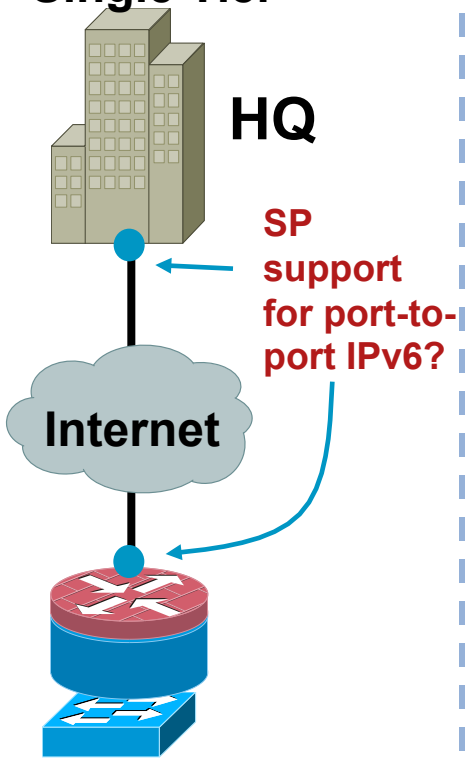
- Cisco routers have supported IPv6 for a long time
- Dual-stack should be the focus of your implementation—but, some situations still call for tunneling
- Support for every media/WAN type you want to use (Frame Relay, leased-line, broadband, MPLS, etc.)
- Don't assume all features for every technology are IPv6-enabled
- Better feature support in WAN/ branch than in campus/DC



# IPv6 Enabled Branch

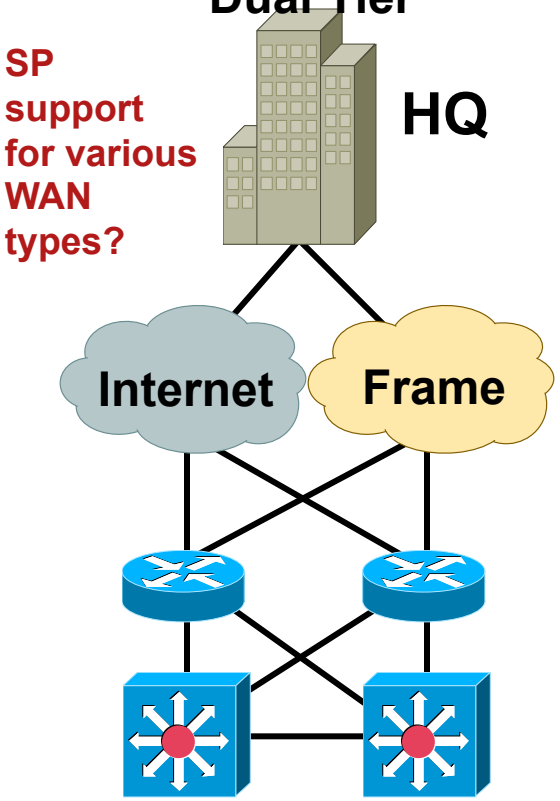
Focus more on the provider and less on the gear

**Branch Single Tier**



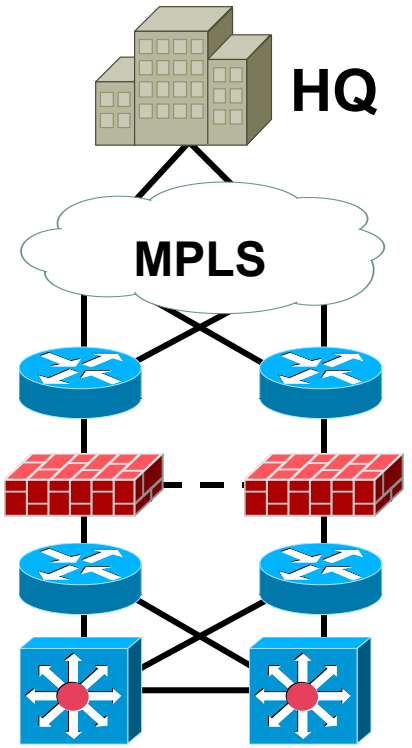

Dual-Stack
IPSec VPN (IPv4/IPv6)
Firewall (IPv4/IPv6)
Integrated Switch (MLD-snooping)

**Branch Dual Tier**




Dual-Stack
IPSec VPN or Frame Relay
Firewall (IPv4/IPv6)
Switches (MLD-snooping)

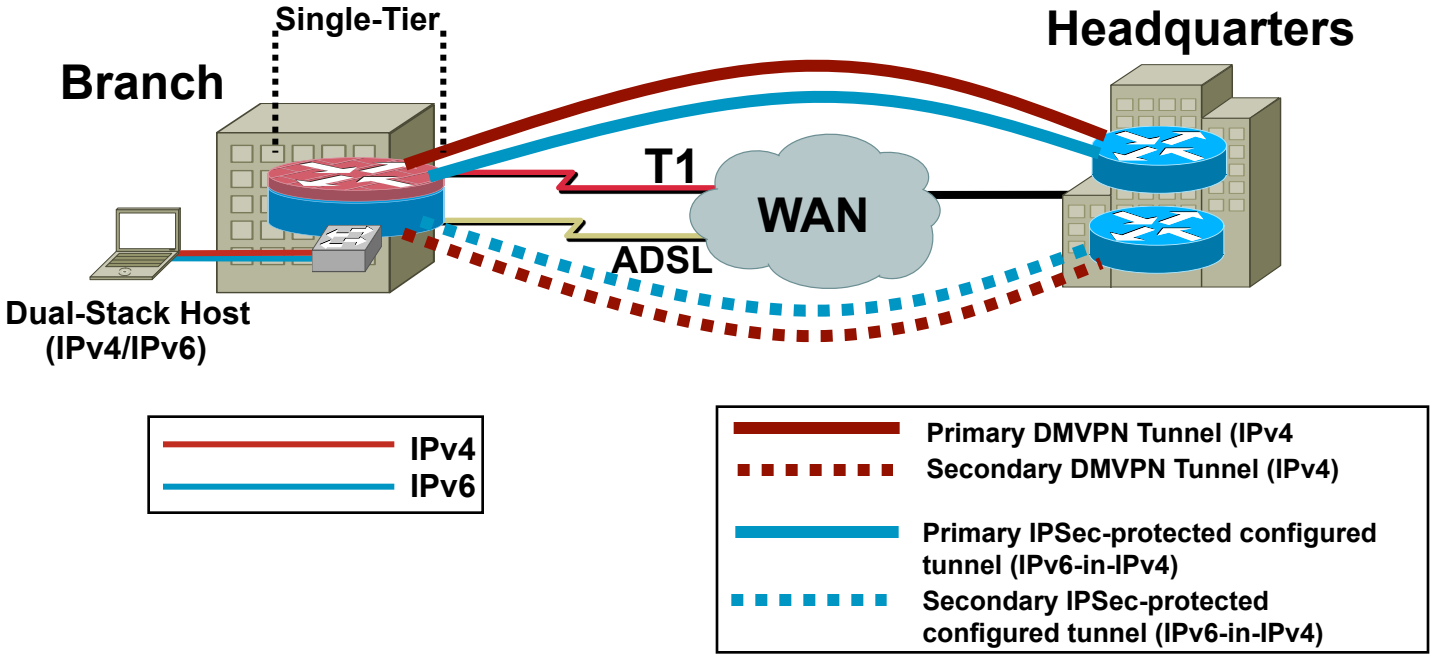
**Branch Multi-Tier**




Dual-Stack
IPSec VPN or
MPLS (6PE/6VPE)
Firewall (IPv4/IPv6)
Switches (MLD-snooping)

# Single-Tier Profile

- Totally integrated solution—Branch router and integrated EtherSwitch module—IOS FW and VPN for IPv6 and IPv4
- When SP does not offer IPv6 services, use IPv4 IPSec VPNs for manually configured tunnels (IPv6-in-IPv4) or DMVPN for IPv6
- When SP does offer IPv6 services, use IPv6 IPSec VPNs (latest AIM/VAM supports IPv6 IPSec)

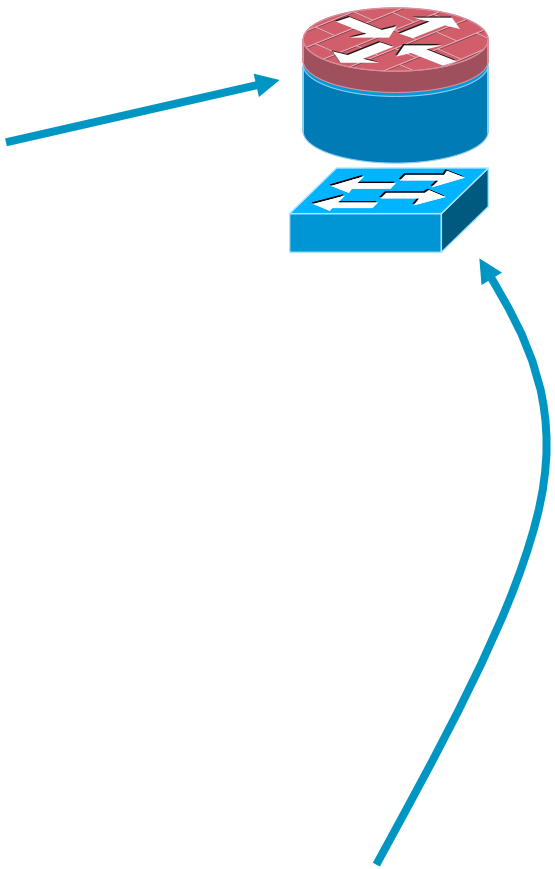


# Single-Tier Profile

## LAN Configuration—DHCPv6

```
ipv6 unicast-routing
ipv6 multicast-routing
ipv6 cef
!
ipv6 dhcp pool DATA_VISTA
 address prefix 2001:DB8:CAFE:1100::/64
 dns-server 2001:DB8:CAFE:10:20D:9DFF:FE93:B25D
 domain-name cisco.com
!
interface GigabitEthernet1/0.100
 description DATA VLAN for Computers
 encapsulation dot1Q 100
 ipv6 address 2001:DB8:CAFE:1100::BAD1:A001/64
 ipv6 nd prefix 2001:DB8:CAFE:1100::/64 no-advertise
 ipv6 nd managed-config-flag
 ipv6 dhcp server DATA_VISTA
```

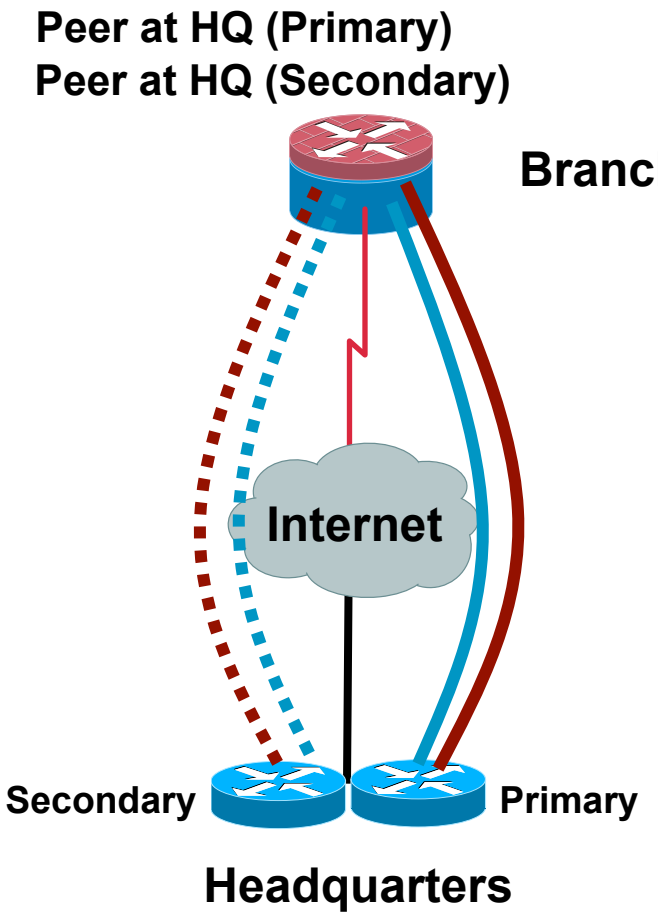
```
ipv6 mld snooping
!
interface Vlan100
 description VLAN100 for PCs and Switch management
 ipv6 address 2001:DB8:CAFE:1100::BAD2:F126/64
```



# Single-Tier Profile

## IPSec Configuration—1

```
crypto isakmp policy 1
 encr 3des
 authentication pre-share
crypto isakmp key CISCO address 172.17.1.3
crypto isakmp key SYSTEMS address 172.17.1.4
crypto isakmp keepalive 10
!
crypto ipsec transform-set HE1 esp-3des esp-sha-hmac
crypto ipsec transform-set HE2 esp-3des esp-sha-hmac
!
crypto map IPv6-HE1 local-address Serial0/0/0
crypto map IPv6-HE1 1 ipsec-isakmp
 set peer 172.17.1.3
 set transform-set HE1
 match address VPN-TO-HE1
!
crypto map IPv6-HE2 local-address Loopback0
crypto map IPv6-HE2 1 ipsec-isakmp
 set peer 172.17.1.4
 set transform-set HE2
 match address VPN-TO-HE2
```



# Single-Tier Profile

## IPSec Configuration—2

```
interface Tunnel3
 description IPv6 tunnel to HQ Head-end 1
 delay 500
 ipv6 address 2001:DB8:CAFE:1261::BAD1:A001/64
 ipv6 mtu 1400
 tunnel source Serial0/0/0
 tunnel destination 172.17.1.3
 tunnel mode ipv6ip
!
interface Tunnel4
 description IPv6 tunnel to HQ Head-end 2
 delay 2000
 ipv6 address 2001:DB8:CAFE:1271::BAD1:A001/64
 ipv6 mtu 1400
 tunnel source Loopback0
 tunnel destination 172.17.1.4
 tunnel mode ipv6ip
!
interface Serial0/0/0
 description to T1 Link Provider (PRIMARY)
 crypto map IPv6-HE1
```

```
interface Dialer1
 description PPPoE to BB provider
 crypto map IPv6-HE2
!
ip access-list extended VPN-TO-HE1
 permit 41 host 172.16.1.2 host 172.17.1.3
ip access-list extended VPN-TO-HE2
 permit 41 host 10.124.100.1 host 172.17.1.4
```

- Adjust delay to prefer Tunnel3
- Adjust MTU to avoid fragmentation on router (PMTUD on client will not account for IPSec/Tunnel overheard)
- Permit “41” (IPv6) instead of “gre”

# Single-Tier Profile
## Routing

```
ipv6 unicast-routing
ipv6 cef
!
key chain ESE
 key 1
  key-string 7 111B180B101719
!
interface Tunnel3
 description IPv6 tunnel to HQ Head-end 1
 delay 500
 ipv6 eigrp 10
 ipv6 hold-time eigrp 10 35
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 ESE
!
interface Tunnel4
 description IPv6 tunnel to HQ Head-end 2
 delay 2000
 ipv6 eigrp 10
 ipv6 hold-time eigrp 10 35
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 ESE
```

```
interface Loopback0
 ipv6 eigrp 10
!
interface GigabitEthernet1/0.100
 description DATA VLAN for Computers
 ipv6 eigrp 10
!
ipv6 router eigrp 10
 router-id 10.124.100.1
 stub connected summary
 no shutdown
 passive-interface GigabitEthernet1/0.100
 passive-interface GigabitEthernet1/0.200
 passive-interface GigabitEthernet1/0.300
 passive-interface Loopback0
```

## EtherSwitch Module

```
ipv6 route ::/0 Vlan100 FE80::217:94FF:FE90:2829
```

# Single-Tier Profile

## Security—1

```
ipv6 inspect name v6FW tcp
ipv6 inspect name v6FW icmp
ipv6 inspect name v6FW ftp
ipv6 inspect name v6FW udp
!
interface Tunnel3
 ipv6 traffic-filter INET-WAN-v6 in
 no ipv6 redirects
 no ipv6 unreachables
 ipv6 inspect v6FW out
 ipv6 virtual-reassembly
!
interface GigabitEthernet1/0.100
ipv6 traffic-filter DATA_LAN-v6 in
!
line vty 0 4
ipv6 access-class MGMT-IN in
```

**Inspection profile for TCP, ICMP, FTP and UDP**

**ACL used by IOS FW for dynamic entries**

**Apply firewall inspection For egress traffic**

**Used by firewall to create dynamic ACLs and protect against various fragmentation attacks**

**Apply LAN ACL (next slide)**

**ACL used to restrict management access**

# Single-Tier Profile

Sample Only

## Security—2

```
ipv6 access-list MGMT-IN
 remark permit mgmt only to loopback
 permit tcp 2001:DB8:CAFE::/48 host 2001:DB8:CAFE:1000::BAD1:A001
 deny ipv6 any any log-input
!
ipv6 access-list DATA_LAN-v6
remark PERMIT ICMPv6 PACKETS FROM HOSTS WITH PREFIX CAFE:1100::/64
permit icmp 2001:DB8:CAFE:1100::/64 any
remark PERMIT IPv6 PACKETS FROM HOSTS WITH PREFIX CAFE:1100::64
permit ipv6 2001:DB8:CAFE:1100::/64 any
remark PERMIT ALL ICMPv6 PACKETS SOURCED BY HOSTS USING THE LINK-LOCAL PREFIX
permit icmp FE80::/10 any
remark PERMIT DHCPv6 ALL-DHCP-AGENTS REQUESTS FROM HOSTS
permit udp any eq 546 any eq 547
remark DENY ALL OTHER IPv6 PACKETS AND LOG
deny ipv6 any any log-input
```

# Single-Tier Profile

## Security—3

Sample Only

```
ipv6 access-list INET-WAN-v6
 remark PERMIT EIGRP for IPv6
 permit 88 any any
 remark PERMIT PIM for IPv6
 permit 103 any any
 remark PERMIT ALL ICMPv6 PACKETS SOURCED USING THE LINK-LOCAL PREFIX
 permit icmp FE80::/10 any
 remark PERMIT SSH TO LOCAL LOOPBACK
 permit tcp any host 2001:DB8:CAFE:1000::BAD1:A001 eq 22
 remark PERMIT ALL ICMPv6 PACKETS TO LOCAL LOOPBACK,VPN tunnels,VLANs
 permit icmp any host 2001:DB8:CAFE:1000::BAD1:A001
 permit icmp any host 2001:DB8:CAFE:1261::BAD1:A001
 permit icmp any host 2001:DB8:CAFE:1271::BAD1:A001
 permit icmp any 2001:DB8:CAFE:1100::/64
 permit icmp any 2001:DB8:CAFE:1200::/64
 permit icmp any 2001:DB8:CAFE:1300::/64
 remark PERMIT ALL IPv6 PACKETS TO VLANs
 permit ipv6 any 2001:DB8:CAFE:1100::/64
 permit ipv6 any 2001:DB8:CAFE:1200::/64
 permit ipv6 any 2001:DB8:CAFE:1300::/64
 deny ipv6 any any log
```

# Single-Tier Profile
## QoS

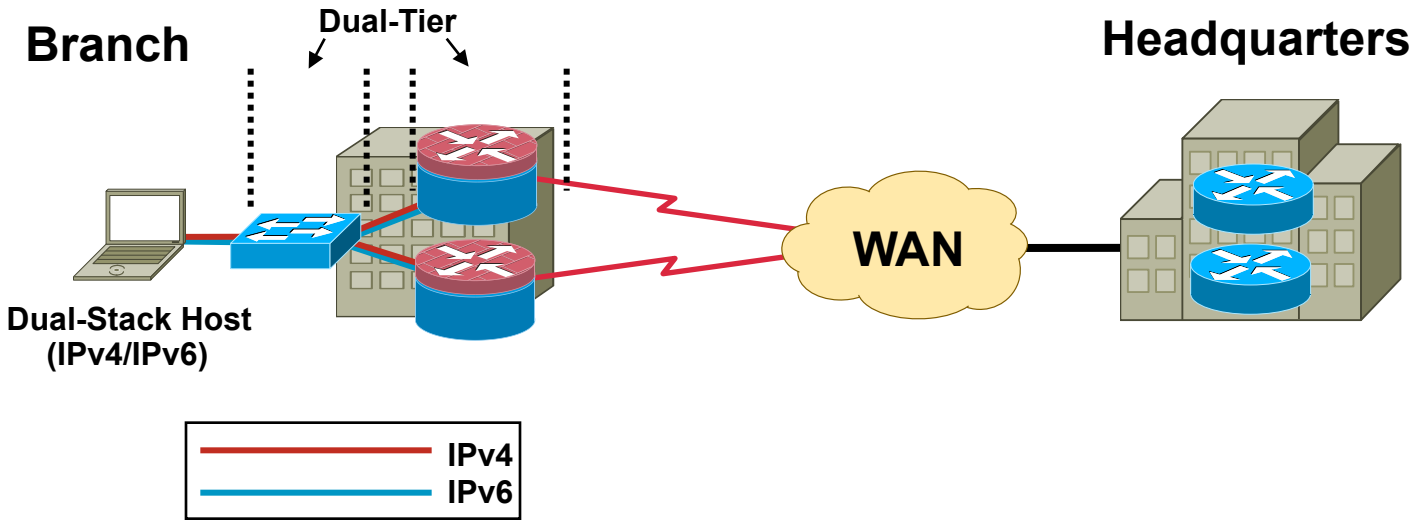
```
class-map match-any BRANCH-TRANSACTIONAL-DATA
 match protocol citrix
 match protocol ldap
 match protocol sqlnet
 match protocol http url "*cisco.com"
 match access-group name BRANCH-TRANSACTIONAL-V6
!
policy-map BRANCH-WAN-EDGE
 class TRANSACTIONAL-DATA
  bandwidth percent 12
  random-detect dscp-based
!
policy-map BRANCH-LAN-EDGE-IN
 class BRANCH-TRANSACTIONAL-DATA
  set dscp af21
!
ipv6 access-list BRANCH-TRANSACTIONAL-V6
 remark Microsoft RDP traffic-mark dscp af21
 permit tcp any any eq 3389
 permit udp any any eq 3389
```

```
interface GigabitEthernet1/0.100
 description DATA VLAN for Computers
 service-policy input BRANCH-LAN-EDGE-IN
!
interface Serial0/0/0
 description to T1 Link Provider
 max-reserved-bandwidth 100
 service-policy output BRANCH-WAN-EDGE
```

- Some features of QoS do not yet support IPv6
- NBAR is used for IPv4, but ACLs must be used for IPv6 (until NBAR supports IPv6)
- Match/Set v4/v6 packets in same policy

# Dual-Tier Profile

- Redundant set of branch routers—separate branch switch (multiple switches can use StackWise technology)
- Can be dual-stack if using Frame Relay or other L2 WAN type



# Dual-Tier Profile

## Configuration

### Branch Router 1

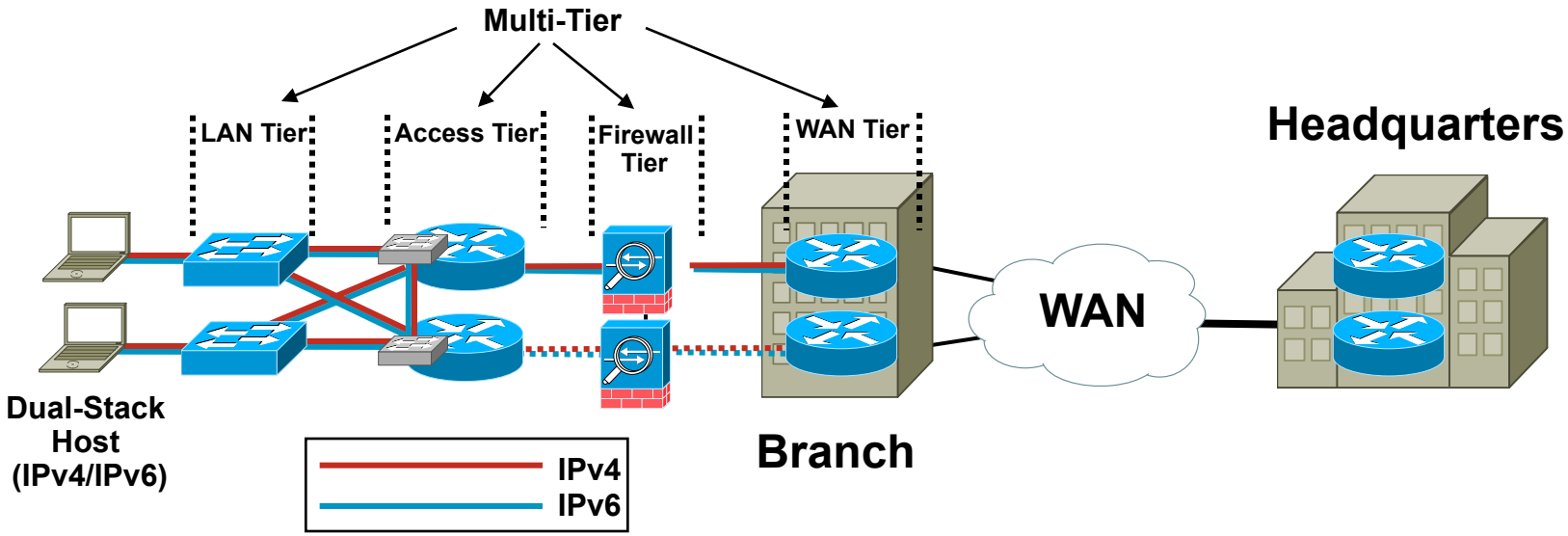
```
interface Serial0/1/0.17 point-to-point
 description TO FRAME-RELAY PROVIDER
 ipv6 address 2001:DB8:CAFE:1262::BAD1:1010/64
 ipv6 eigrp 10
 ipv6 hold-time eigrp 10 35
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 ESE
 frame-relay interface-dlci 17
  class QOS-BR2-MAP
!
interface FastEthernet0/0.100
 ipv6 address 2001:DB8:CAFE:2100::BAD1:1010/64
 ipv6 traffic-filter DATA_LAN-v6 in
 ipv6 nd other-config-flag
 ipv6 dhcp server DATA_VISTA
 ipv6 eigrp 10
 standby version 2
 standby 201 ipv6 autoconfig
 standby 201 priority 120
 standby 201 preempt delay minimum 30
 standby 201 authentication ese
 standby 201 track Serial0/1/0.17 90
```

### Branch Router 2

```
interface Serial0/2/0.18 point-to-point
 description TO FRAME-RELAY PROVIDER
 ipv6 address 2001:DB8:CAFE:1272::BAD1:1020/64
 ipv6 eigrp 10
 ipv6 hold-time eigrp 10 35
 ipv6 authentication mode eigrp 10 md5
 ipv6 authentication key-chain eigrp 10 ESE
 frame-relay interface-dlci 18
  class QOS-BR2-MAP
!
interface FastEthernet0/0.100
 ipv6 address 2001:DB8:CAFE:2100::BAD1:1020/64
 ipv6 traffic-filter DATA_LAN-v6 in
 ipv6 nd other-config-flag
 ipv6 eigrp 10
 standby version 2
 standby 201 ipv6 autoconfig
 standby 201 preempt
 standby 201 authentication ese
```

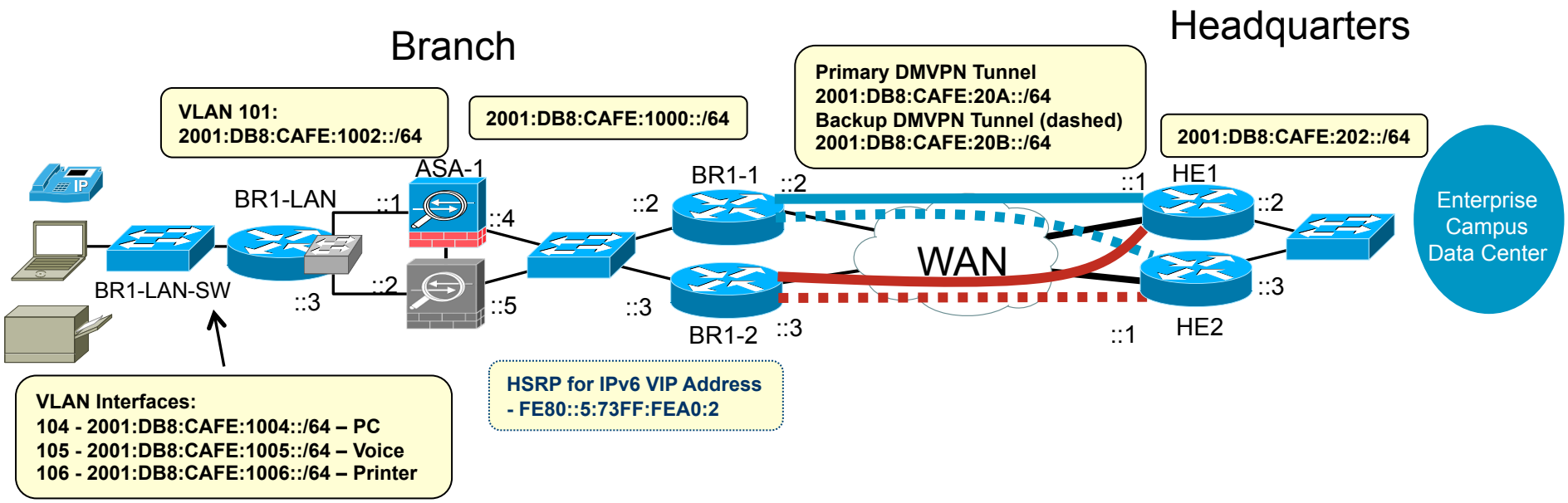
# Multi-Tier Profile

- All branch elements are redundant and separate
  - WAN tier—WAN connections—can be anything (frame/IPSec)—MPLS shown here
  - Firewall tier—redundant ASA firewalls
  - Access tier—internal services routers (like a campus distribution layer)
  - LAN tier—access switches (like a campus access layer
- Dual-stack is used on every tier—If SP provides IPv6 services via MPLS. If not, tunnels can be used from WAN tier to HQ site



# Hybrid Branch Example

- Mixture of attributes from each profile
- An example to show configuration for different tiers
- Basic HA in critical roles is the goal

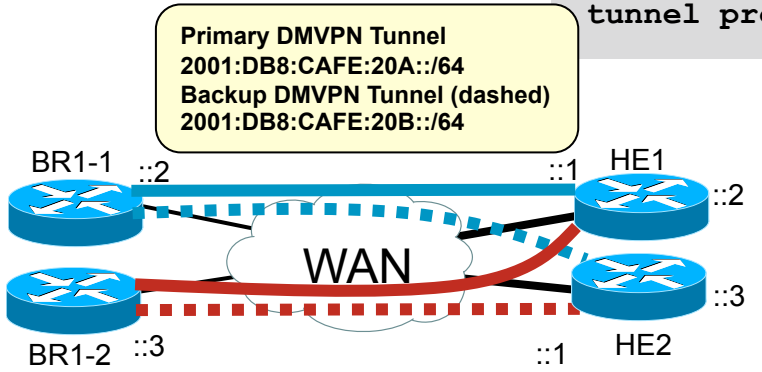


# DMVPN with IPv6

## Hub Configuration Example

```
crypto isakmp policy 1
 encr aes 256
 authentication pre-share
 group 2
!
crypto isakmp key CISCO address 0.0.0.0 0.0.0.0
crypto isakmp key CISCO address ipv6 ::/0
!
crypto ipsec transform-set HUB esp-aes 256 esp-sha-hmac
!
crypto ipsec profile HUB
 set transform-set HUB
```

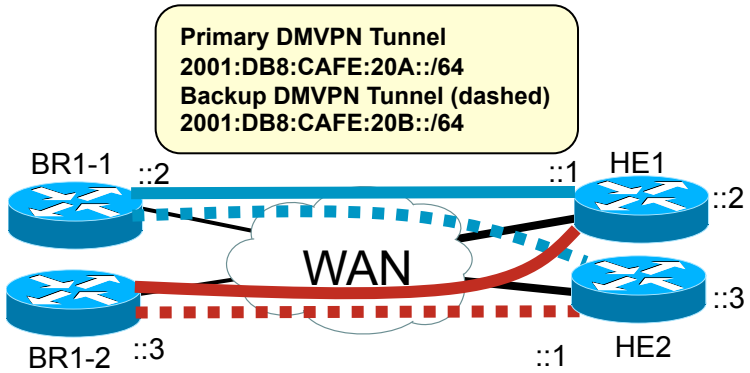
```
interface Tunnel0
 description DMVPN Tunnel 1
 ip address 10.126.1.1 255.255.255.0
 ipv6 address 2001:DB8:CAFE:20A::1/64
 ipv6 mtu 1416
 ipv6 eigrp 10
 ipv6 hold-time eigrp 10 35
 no ipv6 next-hop-self eigrp 10
 no ipv6 split-horizon eigrp 10
 ipv6 nhrp authentication CISCO
 ipv6 nhrp map multicast dynamic
 ipv6 nhrp network-id 10
 ipv6 nhrp holdtime 600
 ipv6 nhrp redirect
 tunnel source Serial1/0
 tunnel mode gre multipoint
 tunnel key 10
 tunnel protection ipsec profile HUB
```



# DMVPN with IPv6

## Spoke Configuration Example

```
crypto isakmp policy 1
 encr aes 256
 authentication pre-share
 group 2
!
crypto isakmp key CISCO address 0.0.0.0 0.0.0.0
crypto isakmp key CISCO address ipv6 ::/0
!
crypto ipsec transform-set SPOKE esp-aes 256 esp-sha-hmac
!
crypto ipsec profile SPOKE
 set transform-set SPOKE
```




```
interface Tunnel0
 description to HUB
 ip address 10.126.1.2 255.255.255.0
 ipv6 address 2001:DB8:CAFE:20A::2/64
 ipv6 mtu 1416
 ipv6 eigrp 10
 ipv6 hold-time eigrp 10 35
 no ipv6 next-hop-self eigrp 10
 no ipv6 split-horizon eigrp 10
 ipv6 nhrp authentication CISCO
 ipv6 nhrp map 2001:DB8:CAFE:20A::1/64 172.16.1.1
 ipv6 nhrp map multicast 172.16.1.1
 ipv6 nhrp network-id 10
 ipv6 nhrp holdtime 600
 ipv6 nhrp nhs 2001:DB8:CAFE:20A::1
 ipv6 nhrp shortcut
 tunnel source Serial1/0
 tunnel mode gre multipoint
 tunnel key 10
 tunnel protection ipsec profile SPOKE
```

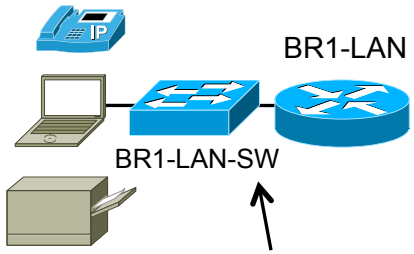
# ASA with IPv6

## Snippet of full config – examples of IPv6 usage

```
name 2001:db8:cafe:1003:: BR1-LAN description VLAN on EtherSwitch
name 2001:db8:cafe:1004:9db8:3df1:814c:d3bc Br1-v6-Server
!
interface GigabitEthernet0/0
 description TO WAN
 nameif outside
 security-level 0
 ip address 10.124.1.4 255.255.255.0 standby 10.124.1.5
 ipv6 address 2001:db8:cafe:1000::4/64 standby 2001:db8:cafe:1000::5
!
interface GigabitEthernet0/1
 description TO BRANCH LAN
 nameif inside
 security-level 100
 ip address 10.124.3.1 255.255.255.0 standby 10.124.3.2
 ipv6 address 2001:db8:cafe:1002::1/64 standby 2001:db8:cafe:1002::2
!
ipv6 route inside BR1-LAN/64 2001:db8:cafe:1002::3
ipv6 route outside ::/0 fe80::5:73ff:fea0:2
!
ipv6 access-list v6-ALLOW permit icmp6 any any
ipv6 access-list v6-ALLOW permit tcp 2001:db8:cafe::/48 host Br1-v6-Server object-group RDP
!
failover
failover lan unit primary
failover lan interface FO-LINK GigabitEthernet0/3
failover interface ip FO-LINK 2001:db8:cafe:1001::1/64 standby 2001:db8:cafe:1001::2
access-group v6-ALLOW in interface outside
```

# Branch LAN
## Connecting Hosts

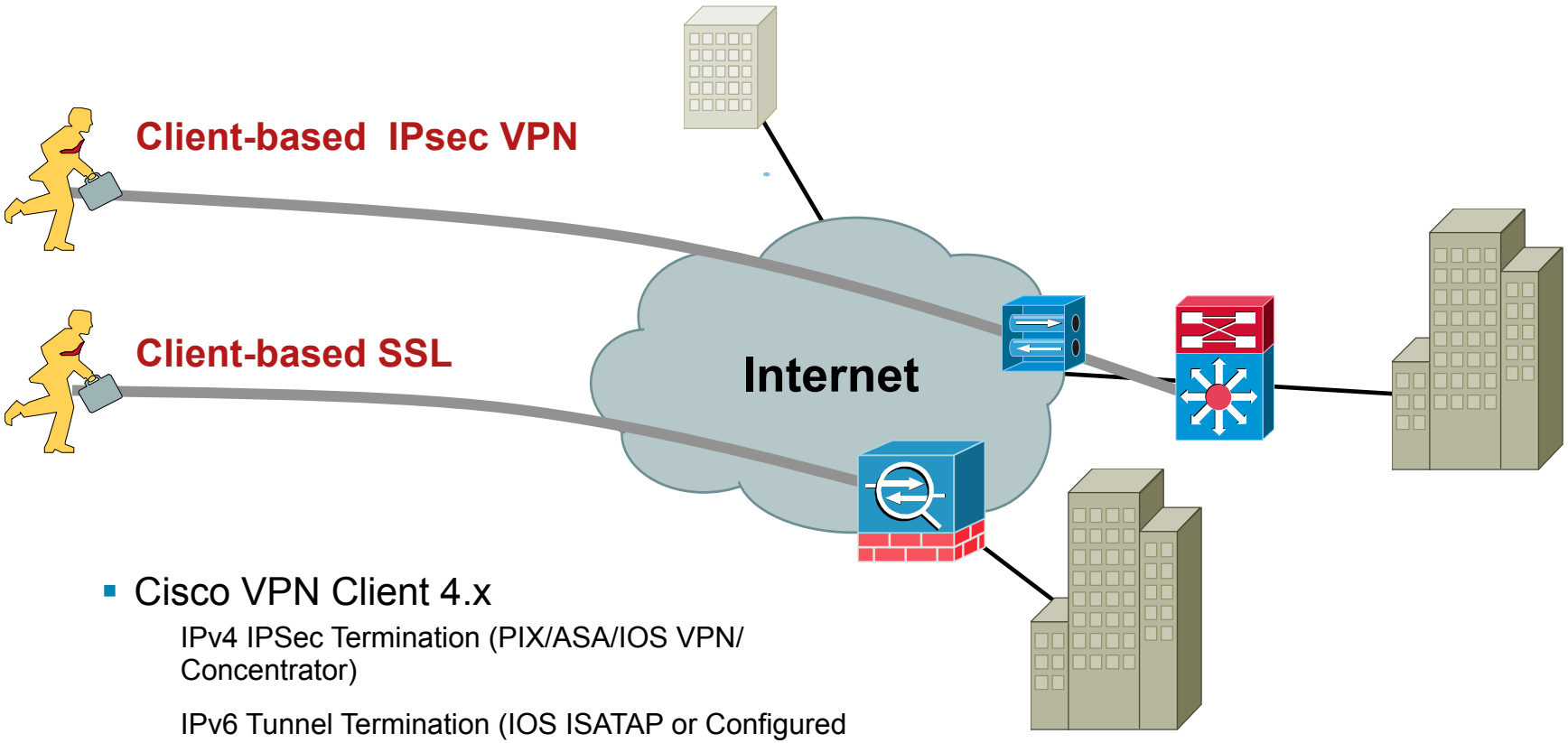
```
ipv6 dhcp pool DATA_W7
 dns-server 2001:DB8:CAFE:102::8
 domain-name cisco.com
!
interface GigabitEthernet0/0
 description to BR1-LAN-SW
 no ip address
 duplex auto
 speed auto
!
interface GigabitEthernet0/0.104
 description VLAN-PC
 encapsulation dot1Q 104
 ip address 10.124.104.1 255.255.255.0
 ipv6 address 2001:DB8:CAFE:1004::1/64
 ipv6 nd other-config-flag
 ipv6 dhcp server DATA_W7
 ipv6 eigrp 10
!
interface GigabitEthernet0/0.105
 description VLAN-PHONE
 encapsulation dot1Q 105
 ip address 10.124.105.1 255.255.255.0
 ipv6 address 2001:DB8:CAFE:1005::1/64
 ipv6 nd prefix 2001:DB8:CAFE:1005::/64 0 0 no-autoconfig
 ipv6 nd managed-config-flag
 ipv6 dhcp relay destination 2001:DB8:CAFE:102::9
 ipv6 eigrp 10
```




**VLAN Interfaces:**
**104 - 2001:DB8:CAFE:1004::/64 – PC**
**105 - 2001:DB8:CAFE:1005::/64 – Voice**
**106 - 2001:DB8:CAFE:1006::/64 – Printer**

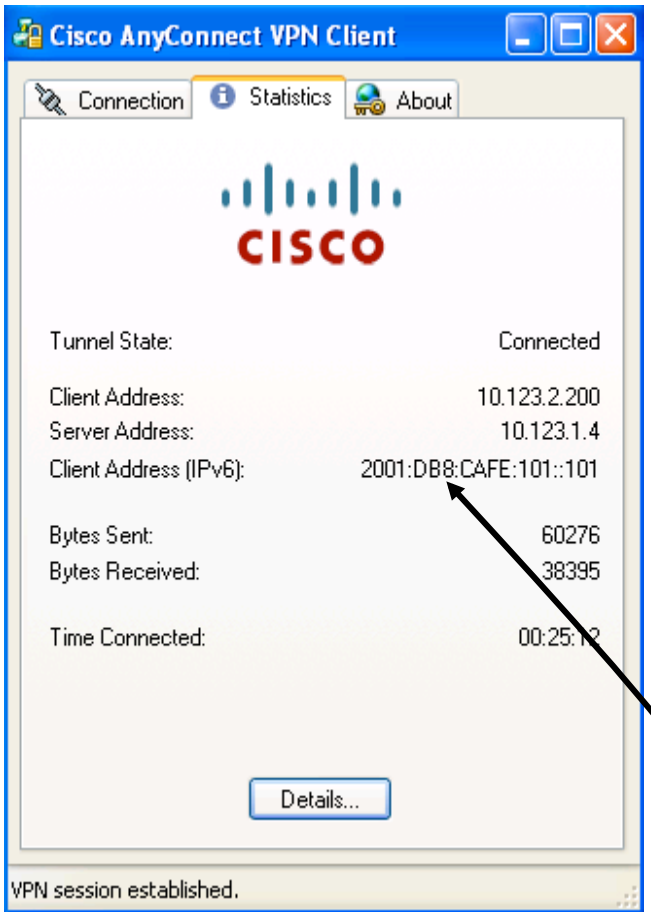
# Remote Access

# Cisco Remote VPN – IPv6

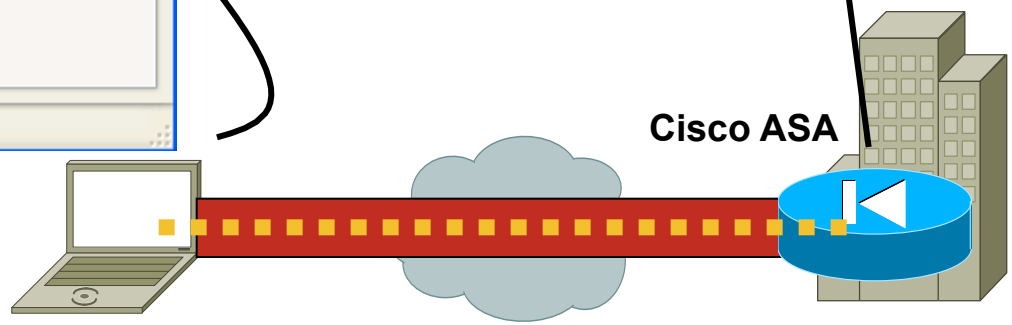



- Cisco VPN Client 4.x
  - IPv4 IPSec Termination (PIX/ASA/IOS VPN/ Concentrator)
  - IPv6 Tunnel Termination (IOS ISATAP or Configured Tunnels)
- AnyConnect Client 2.x
  - SSL/TLS or DTLS (datagram TLS = TLS over UDP)
  - Tunnel transports both IPv4 and IPv6 and the packets exit the tunnel at the hub ASA as native IPv4 and IPv6.

# AnyConnect 2.x—SSL VPN



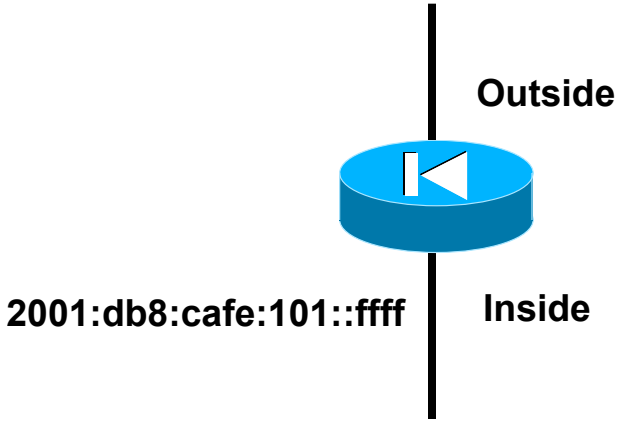

```
asa-edge-1#show vpn-sessiondb svc
Session Type: SVC
Username     : ciscoese                Index        : 14
Assigned IP  : 10.123.2.200            Public IP    : 10.124.2.18
Assigned IPv6: 2001:db8:cafe:101::101
Protocol     : Clientless SSL-Tunnel DTLS-Tunnel
License      : SSL VPN
Encryption   : RC4 AES128              Hashing      : SHA1
Bytes Tx     : 79763                   Bytes Rx     : 176080
Group Policy : AnyGrpPolicy            Tunnel Group: ANYCONNECT
Login Time   : 14:09:25 MST Mon Dec 17 2007
Duration     : 0h:47m:48s
NAC Result   : Unknown
VLAN Mapping : N/A                     VLAN         : none
```




**Dual-Stack Host**
**AnyConnect Client**

# AnyConnect 2.x—Summary Configuration

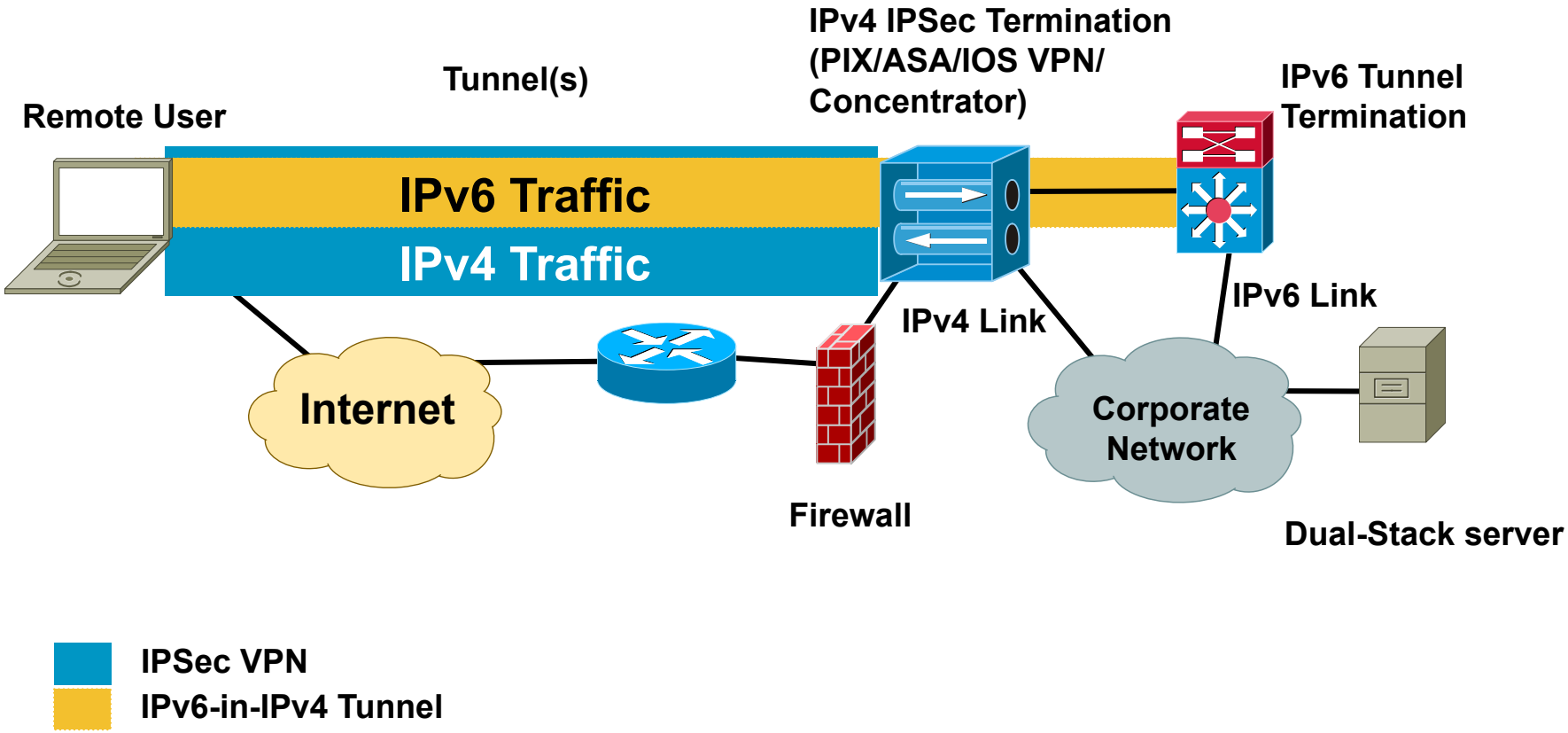
```
interface GigabitEthernet0/0
 nameif outside
 security-level 0
 ip address 10.123.1.4 255.255.255.0
 ipv6 enable
!
interface GigabitEthernet0/1
 nameif inside
 security-level 100
 ip address 10.123.2.4 255.255.255.0
 ipv6 address 2001:db8:cafe:101::ffff/64
!
ipv6 local pool ANYv6POOL 2001:db8:cafe:101::101/64 200
```




```
webvpn
 enable outside
 svc enable
 tunnel-group-list enable
group-policy AnyGrpPolicy internal
group-policy AnyGrpPolicy attributes
 vpn-tunnel-protocol svc
 default-domain value cisco.com
 address-pools value AnyPool
tunnel-group ANYCONNECT type remote-access
tunnel-group ANYCONNECT general-attributes
 address-pool AnyPool
 ipv6-address-pool ANYv6POOL
 default-group-policy AnyGrpPolicy
tunnel-group ANYCONNECT webvpn-attributes
 group-alias ANYCONNECT enable
```

http://www.cisco.com/en/US/docs/security/vpn_client/anyconnect/anyconnect20/administrative/guide/admin6.html#wp1002258

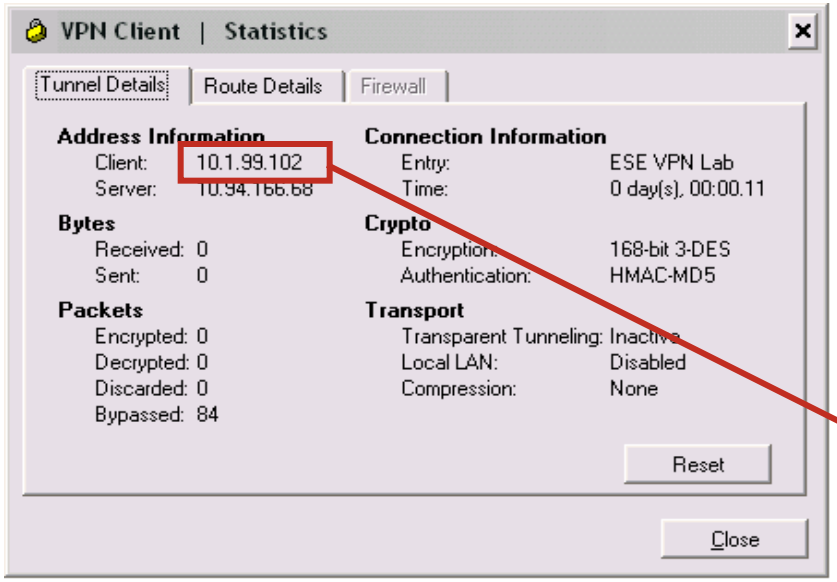
# IPv6-in-IPv4 Tunnel Example—Cisco VPN Client

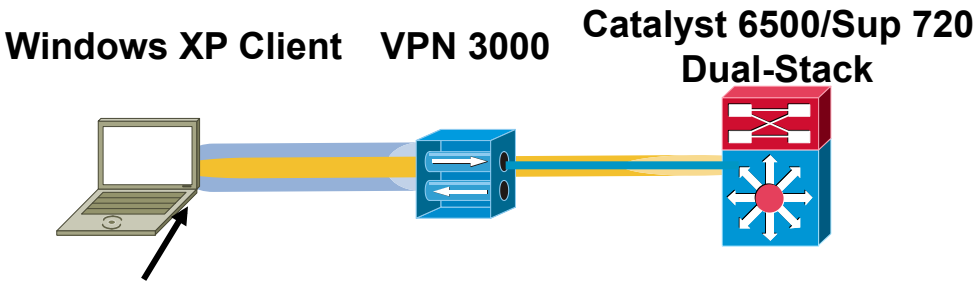


# Considerations

- Cisco IOS® version supporting IPv6 configured/ ISATAP tunnels
  - Configured—12.3(1)M/12.3(2)T/12.2(14)S and above (12.4M/12.4T)
  - ISATAP—12.3(1)M, 12.3(2)T, 12.2(14)S and above (12.4M/12.4T)
  - Catalyst® 6500 with Sup720/32—12.2(17a)SX1—HW forwarding
- Be aware of the security issues if split-tunneling is used
  - Attacker can come in IPv6 interface and jump on the IPv4 interface (encrypted to enterprise)
  - In Windows Firewall—default policy is to DENY packets from one interface to another
- Remember that the IPv6 tunneled traffic is still encapsulated as a tunnel **when** it leaves the VPN device
- Allow IPv6 tunneled traffic across access lists (Protocol 41)

# Does It Work?




10.1.99.102—VPN Address

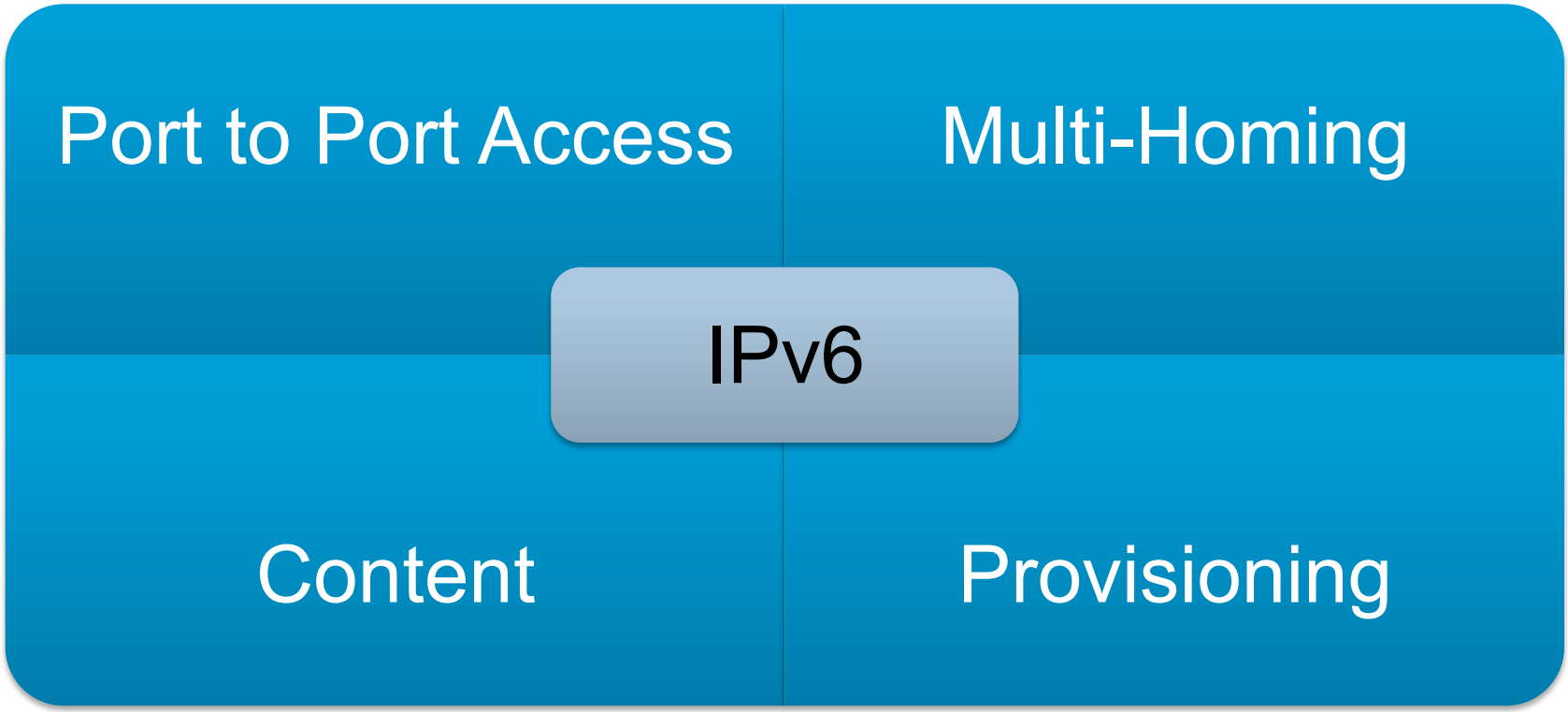
2001:DB8:c003:1101:0:5efe:10.1.99.102—IPv6 address

```
Interface 2: Automatic Tunneling Pseudo-Interface

Addr Type  DAD State  Valid Life    Pref. Life    Address
---------  ---------- ------------ ------------ ----------------------------
Public     Preferred   29d23h56m5s  6d23h56m5s 2001:db8:c003:1101:0:5efe:10.1.99.102
Link       Preferred   infinite     infinite   fe80::5efe:10.1.99.102
```

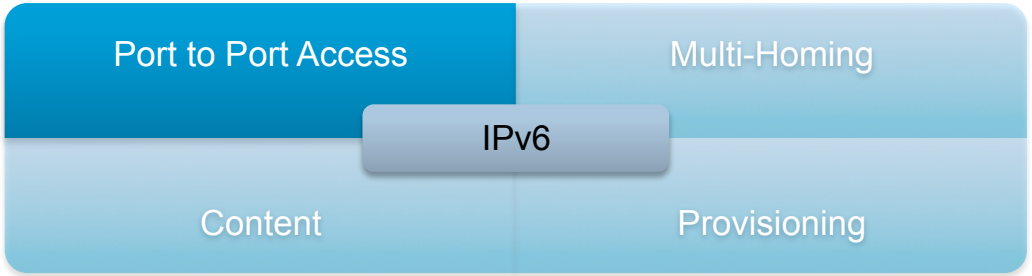
```
netsh interface ipv6>show route
Querying active state...

Publish  Type       Met  Prefix                    Idx  Gateway/Interface Name
-------  --------  ----  ------------------------  ---  --------------------
no       Autoconf     9  2001:db8:c003:1101::/64     2  Automatic Tunneling Pseudo-Interface
no       Manual       1  ::/0                        2  fe80::5efe:20.1.1.1
```

# Provider Considerations

# Top SP Concerns for Enterprise Accounts



# Port-to-Port Access




**Basic Internet** *

- Dual-stack or native IPv6 at each POP
- SLA driven just like IPv4 to support VPN, content access

**MPLS**

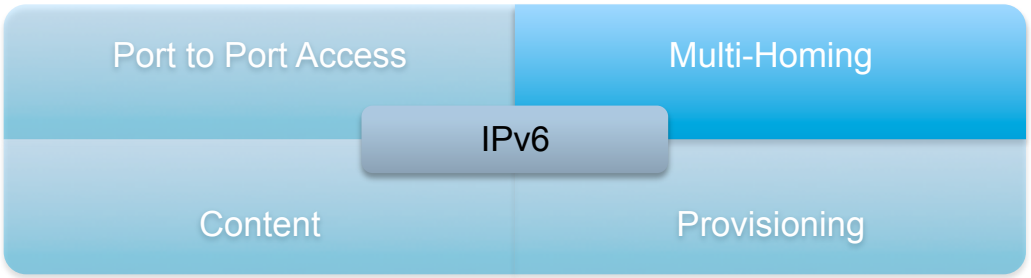
- 6VPE
- IPv6 Multicast
- End-to-End traceability

**Hosted (see content)**

- IPv6 access to hosted content
- Cloud migration (move data from Ent DC to Hosted DC)

* = most common issue

# Multi-Homing




**PI/PA Policy Concerns** *

- PA is no good for customers with multiple providers or change them at any pace
- PI is new, constantly changing expectations and no “guarantee” an SP won’t do something stupid like not route PI space
- Customers fear that RIR will review existing IPv4 space and want it back if they get IPv6 PI

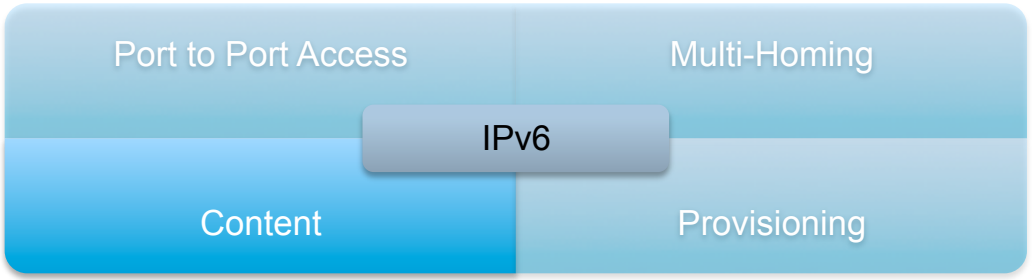
**NAT**

- Religious debate about the security exposure – not a multi-homing issue
- If customer uses NAT like they do today to prevent address/policy exposure, where do they get the technology from – no scalable IPv6 NAT exists today

**Routing**

- Is it really different from what we do today with IPv4? Is this policy stuff?
- Guidance on prefixes per peering point, per theater, per ISP, ingress/egress rules, etc.. – this is largely missing today

# Content




**Hosted/Cloud Apps today** *

- IPv6 provisioning and access to hosted or cloud-based services today (existing agreements)
- Salesforce.com, Microsoft BPOS (Business Productivity Online Services), Amazon, Google Apps

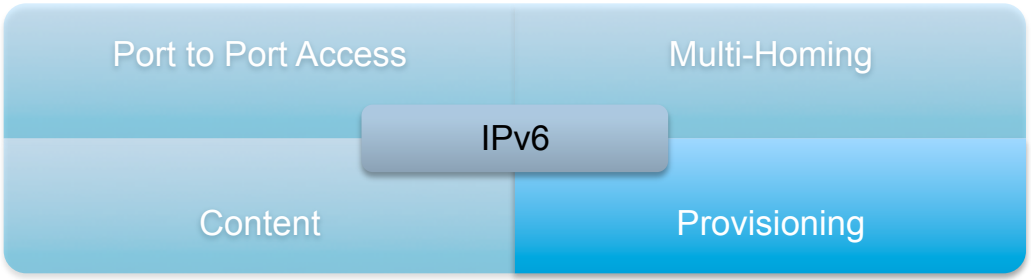
**Move to Hosted/ Cloud**

- Movement from internal-only DC services to hosted/ cloud-based DC
- Provisioning, data/network migration services, DR/HA

**Contract/Managed Marketing/Portals**

- Third-party marketing, business development, outsourcing
- Existing contracts – connect over IPv6

# Provisioning



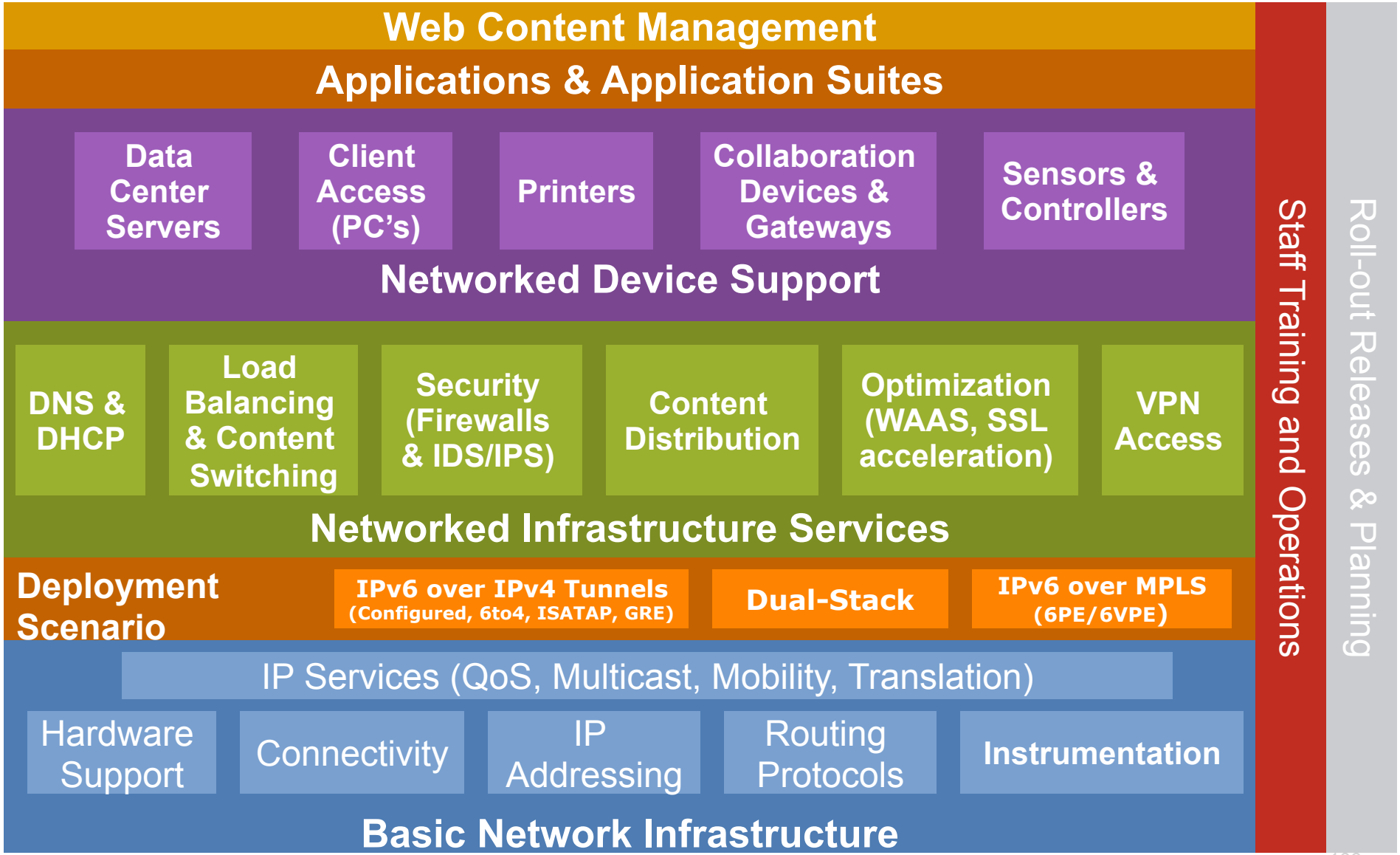

**SP Self-Service Portals**

- Not a lot of information from accounts on this but it does concern them
- How can they provision their own services (i.e. cloud) to include IPv6 services and do it over IPv6

**SLA** *

- More of a management topic but the point here is that customers want the ability to alter their services based on violations, expiration or restrictions on the SLA
- Again, how can they do this over IPv6 AND for IPv6 services

# The Scope of IPv6 Deployment



# Conclusion

- “Dual stack where you can – Tunnel where you must”
- Create a virtual team of IT representatives from every area of IT to ensure coverage for OS, Apps, Network and Operations/Management
- Microsoft Windows Vista, 7 and Server 2008 will have IPv6 enabled by default—understand what impact any OS has on the network
- Deploy it – at least in a lab – IPv6 won’t bite
- Things to consider:

  Focus on what you must have in the near-term (lower your expectations) but pound your vendors and others to support your long-term goals

  Don’t be too late to the party – anything done in a panic is likely going to go badly