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Deploying IPv6 for Service Providers

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Agenda

- Business case
- IPv6 basics
- Deployment scenarios

Business case

IPv6 - Key drivers for Next Generation Ubiquitous Networking

Business

Innovations

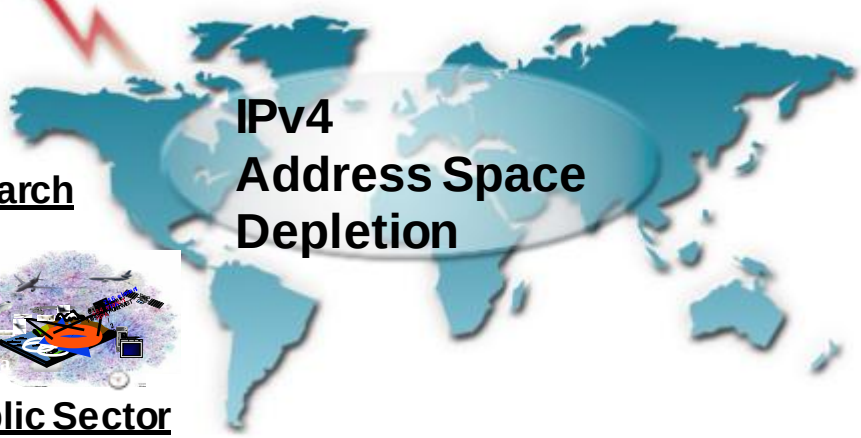
IP Mobility

The Ubiquitous Internet

Devices, Mobile Networks
Mobile Wireless

DOCSIS 3.0DSL, FTTH

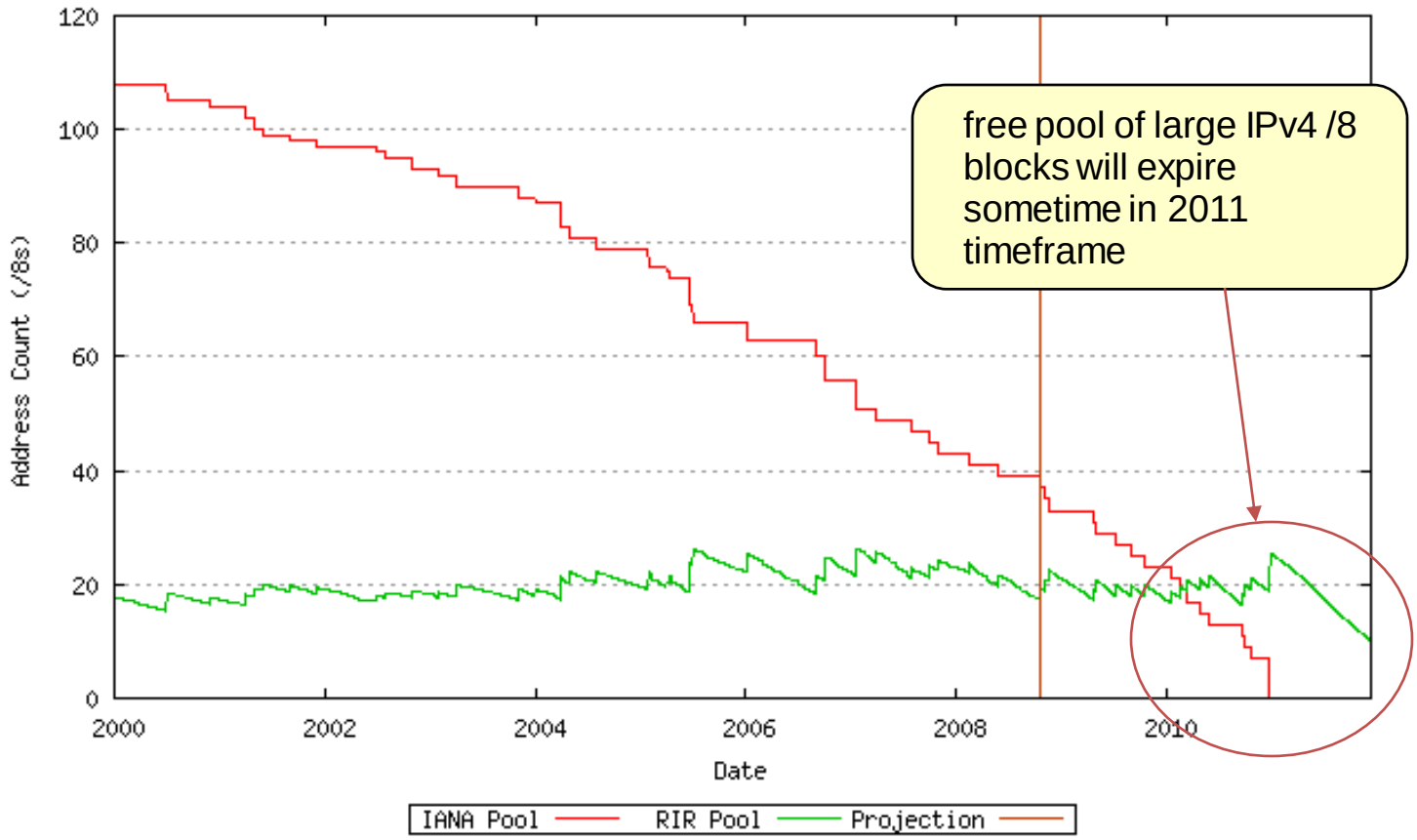
Higher Ed./Research



Edge's Appliances & Services

Government Public Sector

IPv4 Address Completion



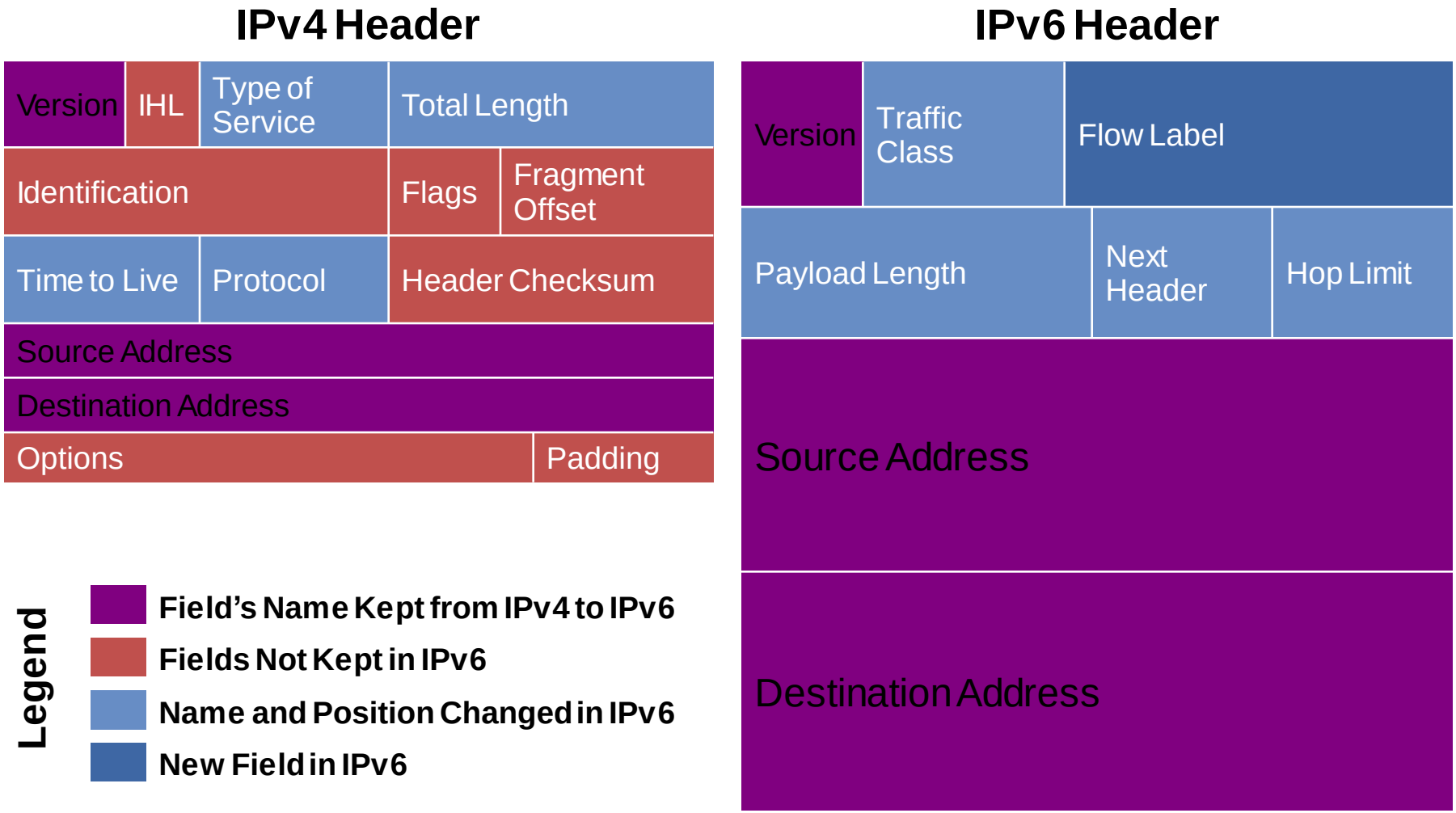
IP Basics

IPv6 Main Features

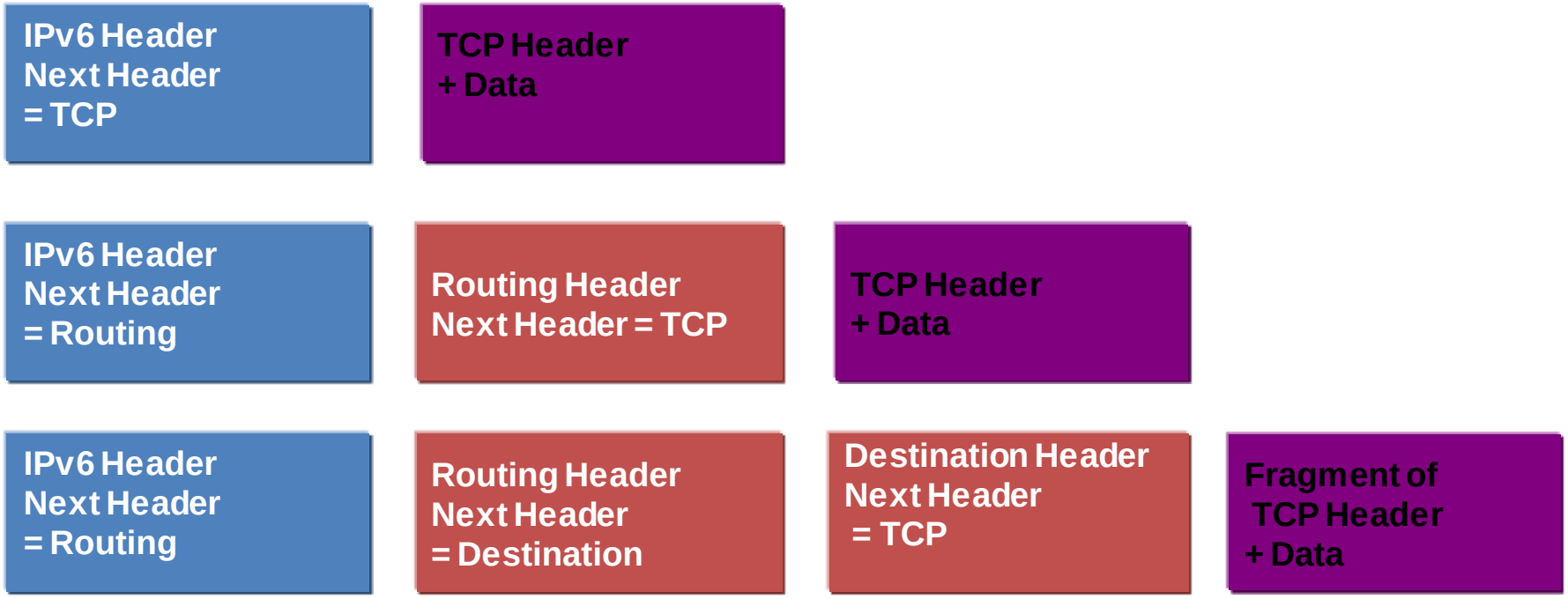
- Larger address space enables
  - –Global reachability
  - –Flexibility
  - –Aggregation
  - –Multi-homing
  - –Auto-configuration
  - –Plug and play" and renumbering
- Simpler header enables
  - –Fixed header length
  - –Routing efficiency
  - –Performance and forwarding rate scalability

- Security and Mobility
- Enhanced Multicast
- Transition richness
- No more broadcast

IPv4 and IPv6 Header Comparison



Extension Headers



Extension headers are daisy chained

IPv6 Addressing

IPv4 32-bits

IPv6 128-bits

2^{32} = 4,294,967,296

2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456

$2^{128} = 2^{32} * 2^{96}$

2^{96} = 79,228,162,514,264,337,593,543,950,336 times the number of possible IPv4 Addresses (79 trillion trillion)

IPv6 Addresses

World's population is approximately 6.5 billion

$$\frac{2^{128}}{6.5 \text{ Billion}} = 52 \text{ Trillion Trillion IPv6 addresses per person}$$

Typical brain has ~100 billion brain cells (your count may vary)

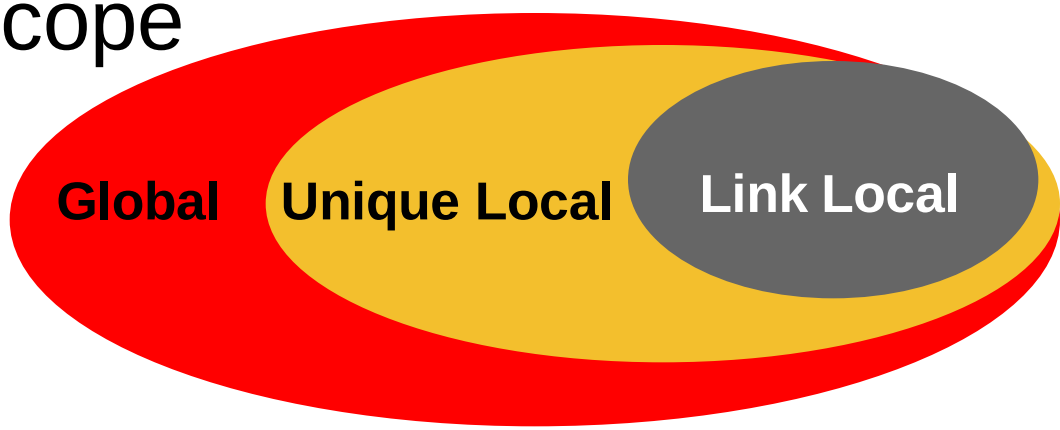
$$\frac{52 \text{ Trillion Trillion}}{100 \text{ Billion}} = 523 \text{ Quadrillion (523 thousand trillion) IPv6 addresses for every human brain cell on the planet!}$$

Addressing Format

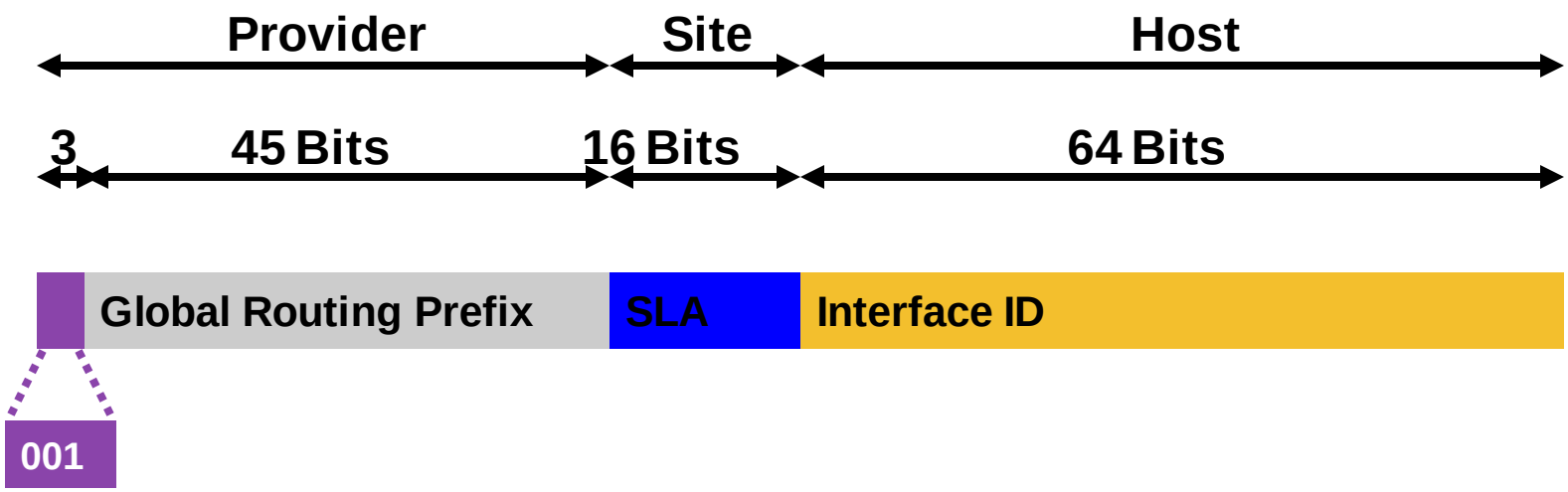
- 16-bit hexadecimal numbers
- Numbers are separated by (:)
- Hex numbers are not case sensitive
- Abbreviations are possible
  - Leading zeros in contiguous block could be represented by (::)
  - Example:
    - 2001:0db8:0000:130F:0000:0000:087C:140B
    - 2001:0db8:0:130F::87C:140B
  - Double colon only appears once in the address

IPv6—Addressing Model

- Addresses are assigned to interfaces
  - Change from IPv4 mode:
- Interface “expected” to have multiple addresses
- Addresses have scope
  - Link Local
  - Unique Local
  - Global
- Addresses have lifetime
  - Valid and preferred lifetime



Aggregatable Global Unicast Addresses

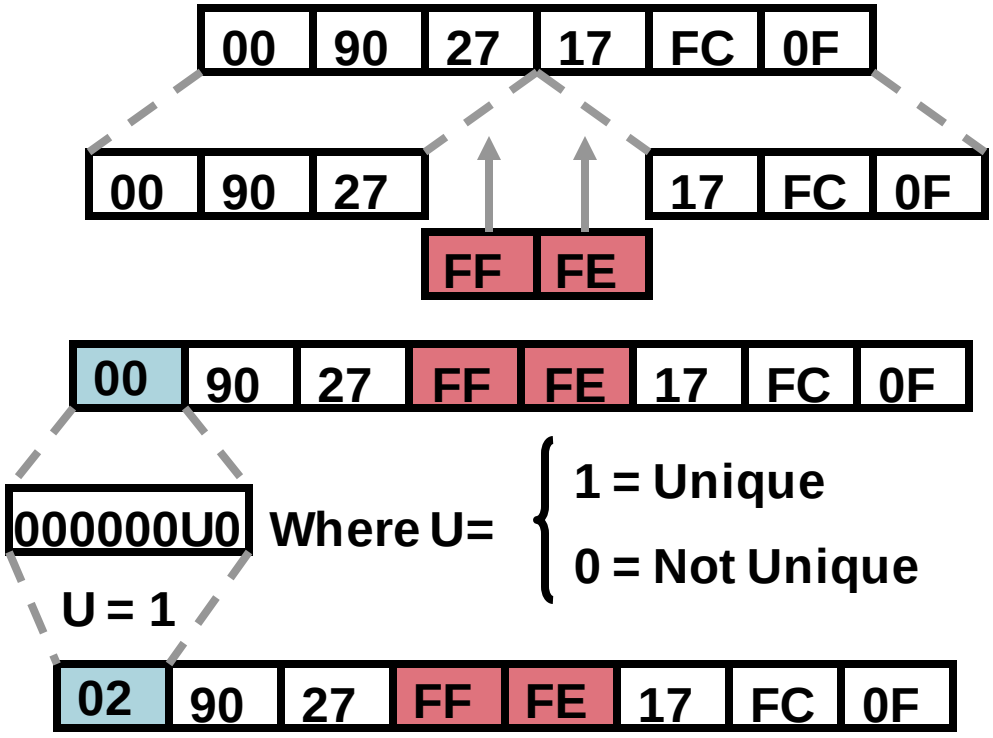


Aggregatable Global Unicast Addresses Are:

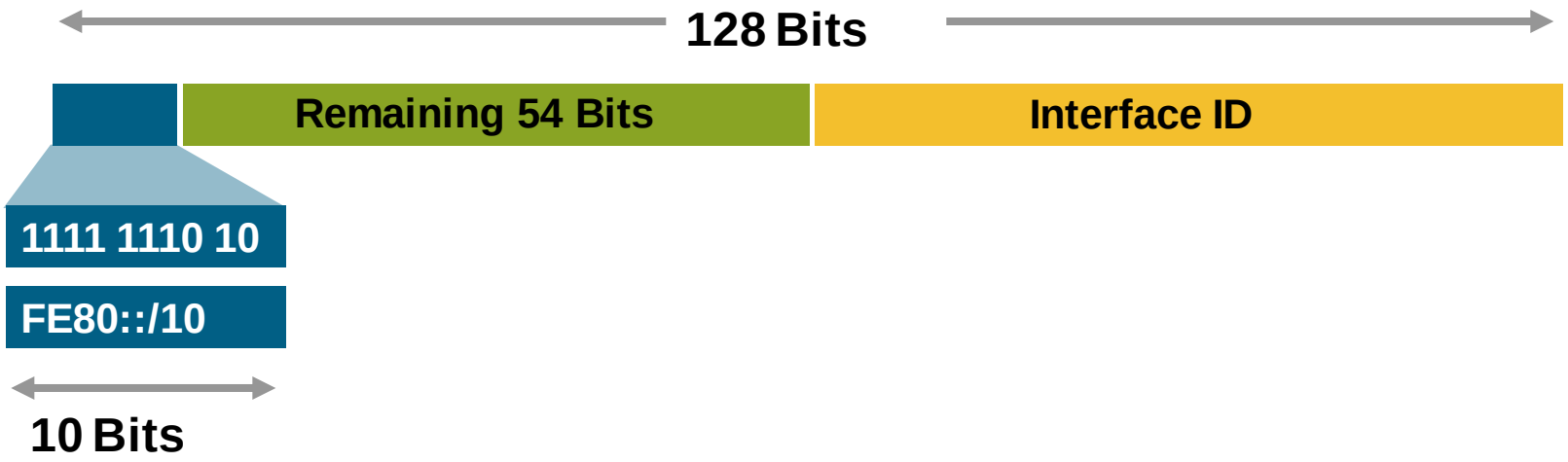
- Addresses for generic use of IPv6
- Structured as a hierarchy to keep the aggregation

IPv6 Interface Identifier

- Cisco uses the EUI-64 format to do stateless auto-configuration
- This format expands the 48 bit MAC address to 64 bits by inserting FFFE into the middle 16 bits
- To make sure that the chosen address is from a unique Ethernet MAC address, the universal/ local ("u" bit) is set to 1 for global scope and 0 for local scope



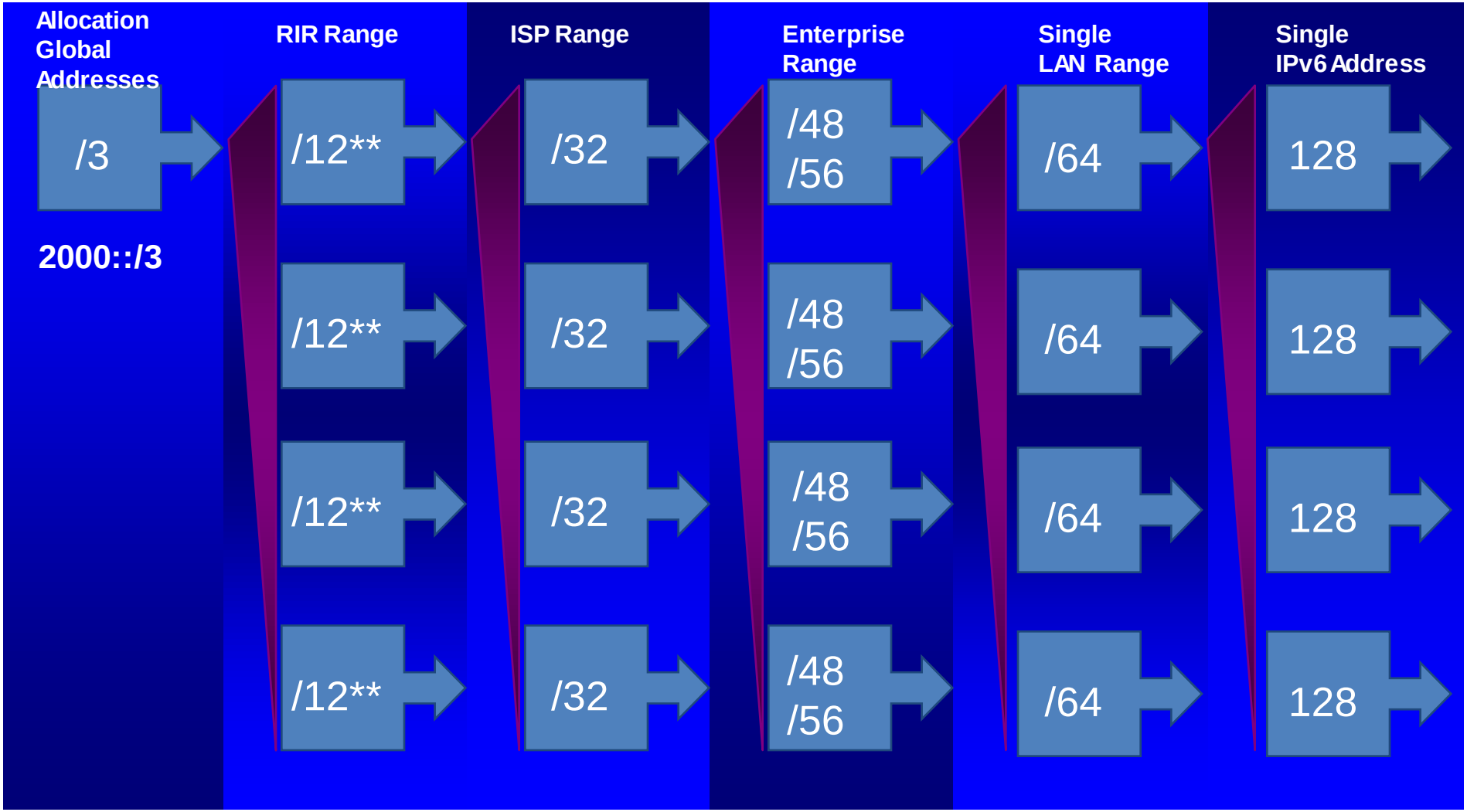
Link-Local



Link-Local Addresses Used for:

- Mandatory Address for Communication between two IPv6 device (like ARP but at Layer 3)
- Automatically assigned by Router as soon as IPv6 is enabled
- Also used for Next-Hop calculation in Routing Protocols
- Only Link Specific scope
- Remaining 54 bits could be Zero or any manual configured value

Address Allocation Model for Aggregation



Deployment scenarios

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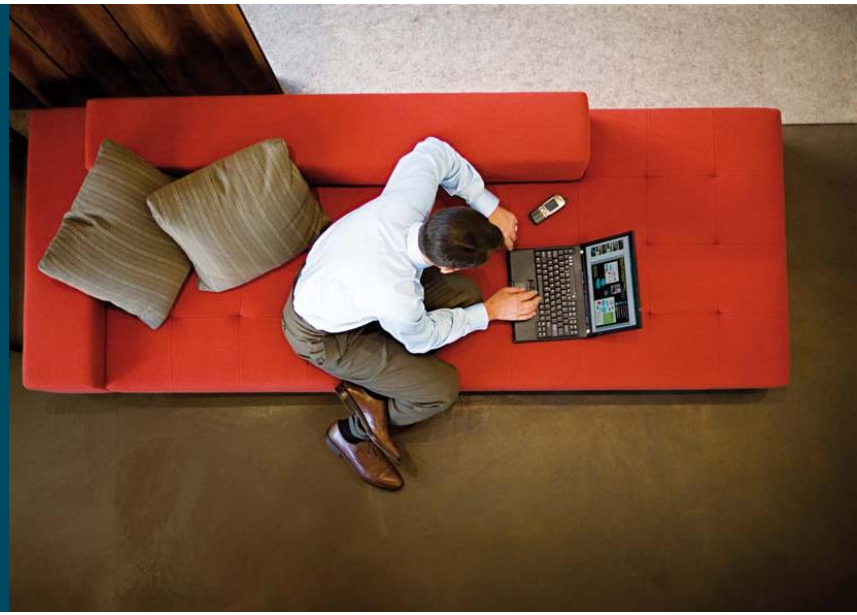
Today's Network Infrastructure

- Service Providers core infrastructure are basically following two paths
  - MPLS with its associated services
  - MPLS/VPN, L2 services over MPLS, QoS,
  - Native IPv4 core with associated services
  - L2TPv3, QoS, Multicast, …
- IP services portfolio—Access
  - Enterprise: Lease lines
  - Home Users/SOHO: ADSL, FTTH, Dial
  - Data Center: Web hosting, servers, …

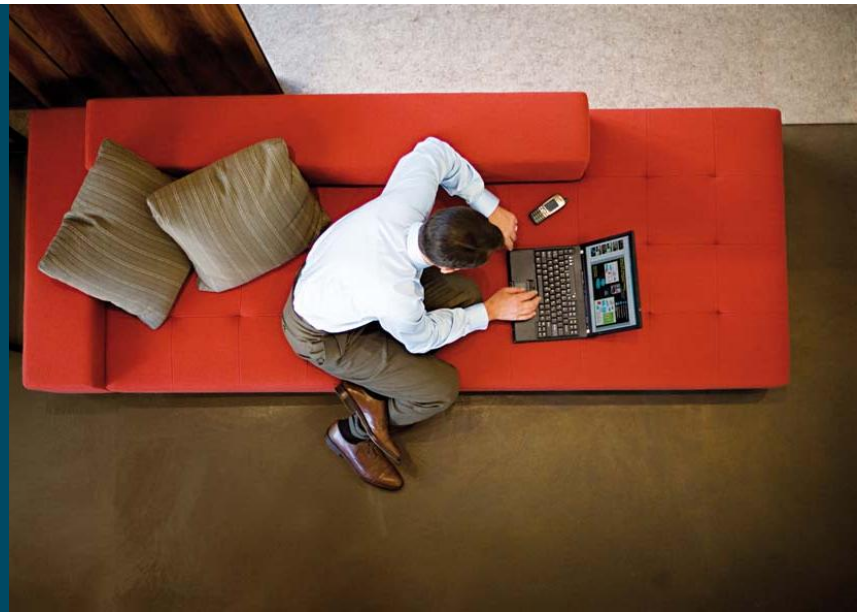
Service Provider Core



IPv6 Deployment Options—CORE

- IPv6 in Native IPv4 Environments
  - Tunneling IPv6-in-IPv4
  - Native IPv6 with Dedicated Resources
  - Dual-Stack IPv4-IPv6
- IPv6 in MPLS Environments
  - 6PE
  - 6VPE

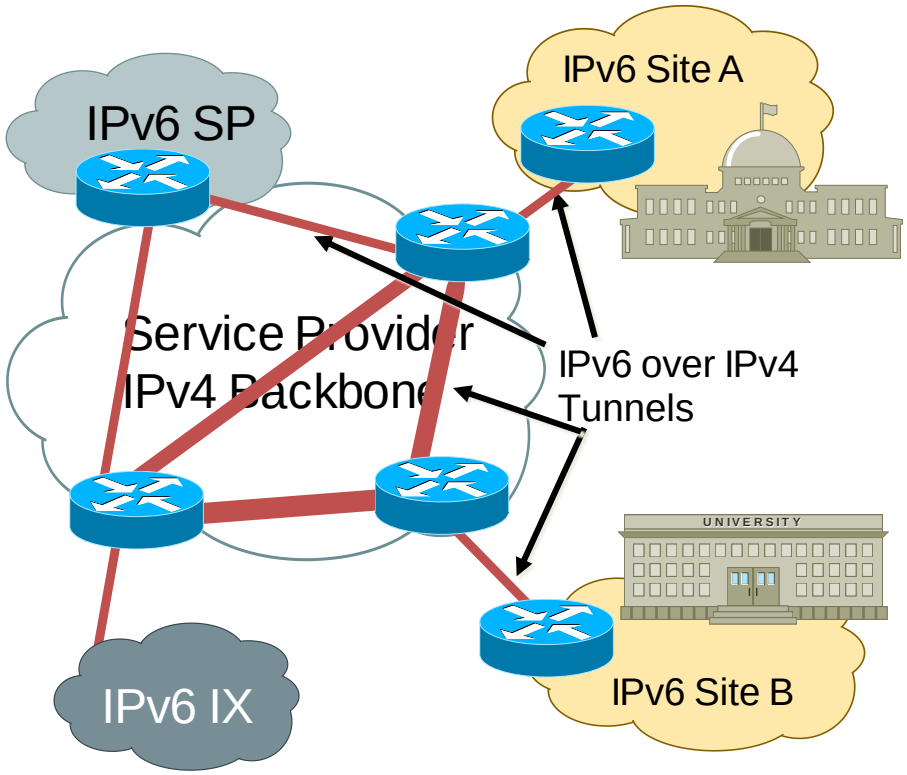
IPv6 in Native IPv4 Environments



Tunnelling IPv6 in IPv4

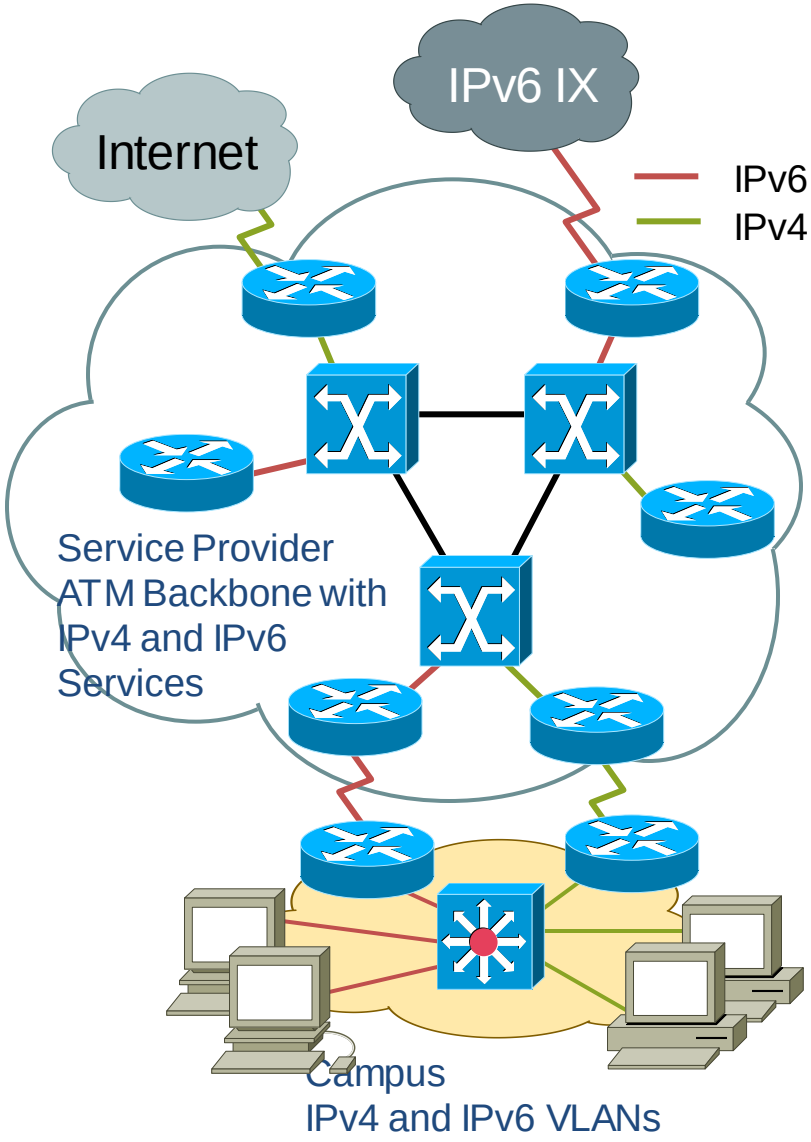
- Tunnelling Options
  - Manual Tunnels (RFC 2893)
  - GRE Tunnels (RFC 2473)
  - L2TPv3
- ISP scenario
  - Configured Tunnels in Core
  - Configured Tunnels or Native IPv6 to IPv6 Enterprise's Customers
  - MP-BGP4 Peering with other users
  - Connection to an IPv6 IX

Use the Most Appropriate

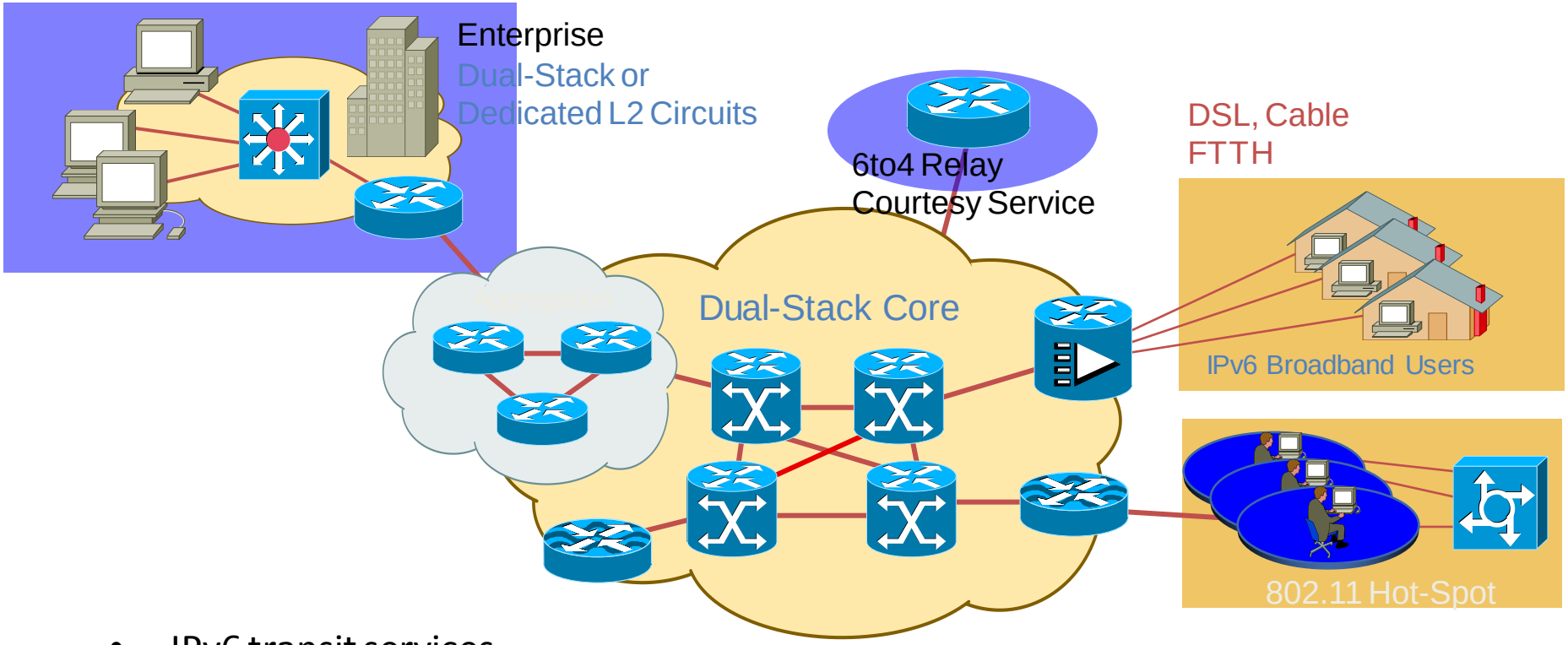


Native IPv6 over Dedicated Data Link

- ISP Scenario
  - Dedicated Data Links between Core routers
  - Dedicated Data Links to IPv6Customers
  - Connection to an IPv6 IX

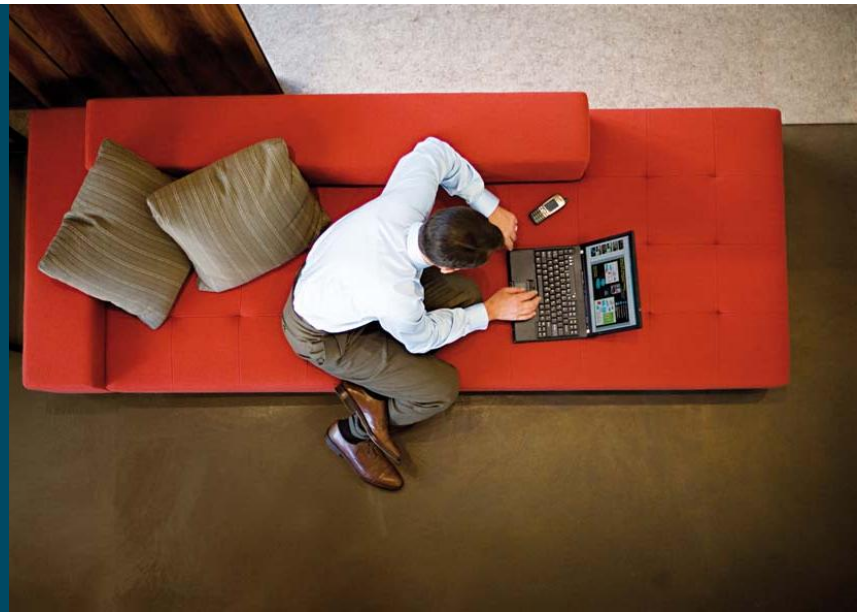


Dual-Stack IPv4-IPv6



- IPv6 transit services
- IPv6 enabled on Core routers
- Enterprise and consumer IPv6 access
- Additional services
  - IPv6 multicast for streaming

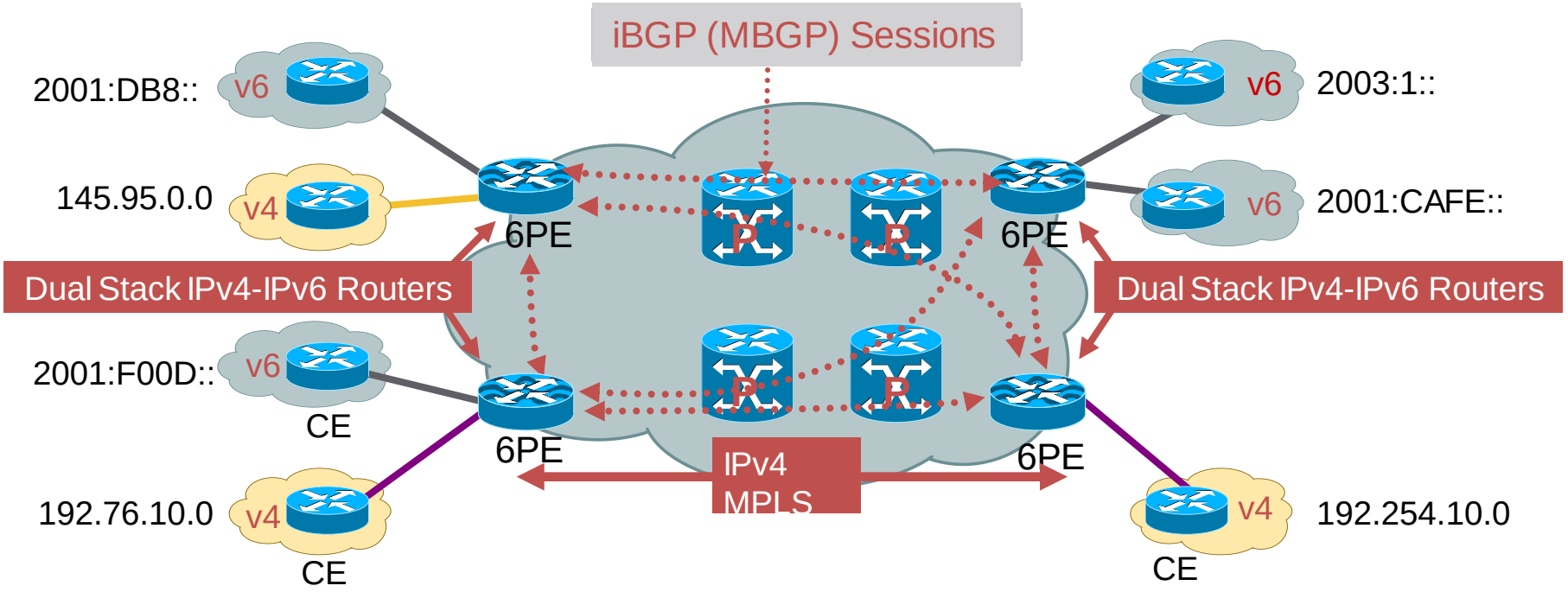
IPv6 in MPLS Environments



IPv6 over MPLS

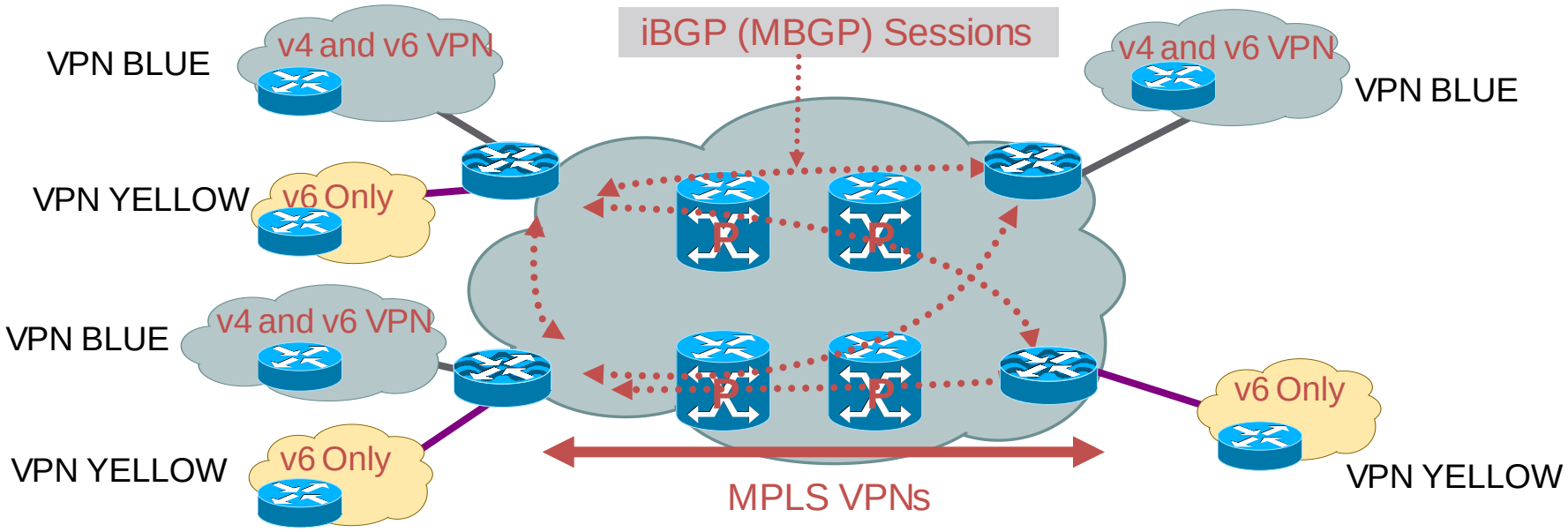
- Many ways to deliver IPv6 services to end users
  - Most important is end-to-end IPv6 traffic forwarding
- Many service providers have already deployed MPLS in their IPv4 backbone for various reasons
- MPLS can be used to facilitate IPv6 integration
- Multiple approaches for IPv6 over MPLS:
  - IPv6 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 MPLS

IPv6 Provider Edge Router (6PE) over MPLS



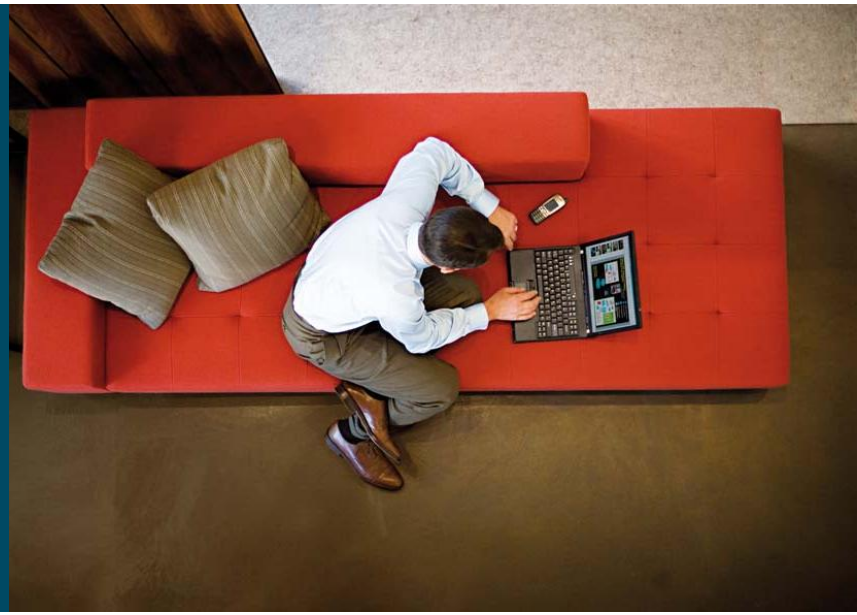
- IPv6 global connectivity over and IPv4-MPLS core
- Transitioning mechanism for providing unicast IP
- PEs are updated to support dual stack/6PE
- IPv6 reachability exchanged among 6PEs via iBGP (MBGP)
- IPv6 packets transported from 6PE to 6PE inside MPLS
  - http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/iosip_an.htm

6VPE Deployment



- 6VPE ~ IPv6 + BGP-MPLS IPv4 VPN + 6PE
- Cisco 6VPE is an implementation of RFC4659
- VPNv6 address:
  - Address including the 64 bits route distinguisher and the 128 bits IPv6 address
- MP-BGP VPNv6 address-family:
  - AFI “IPv6” (2), SAFI “VPN” (128)
- VPN IPv6 MP_REACH_NLRI
  - With VPNv6 next-hop (192bits) and NLRI in the form of <length, IPv6-prefix, label>
- Encoding of the BGP next-hop

Service Provider Access



Drivers for IPv6 in Broadband

- Network Management: The most striking aspect of Broadband Access Services is the large number of users that imply a larger number of devices to be managed by providers. Even the private IPv4 address space will be unable to withstand the expected needs. IPv6 is seen as
  the answer to this problem
- New Services: The current business models for Network Access Provider (wholesale model) avoid handling users
  at Layer 3 at the access layer. These models do not scale for services such as Multicast. IPv6 offers the address resources needed to deploy such services optimally
- Prepare for the Future: Build an infrastructure that would
  be ready for the new services and IP enabled appliances

Broadband Home and IPv6 – a Must!

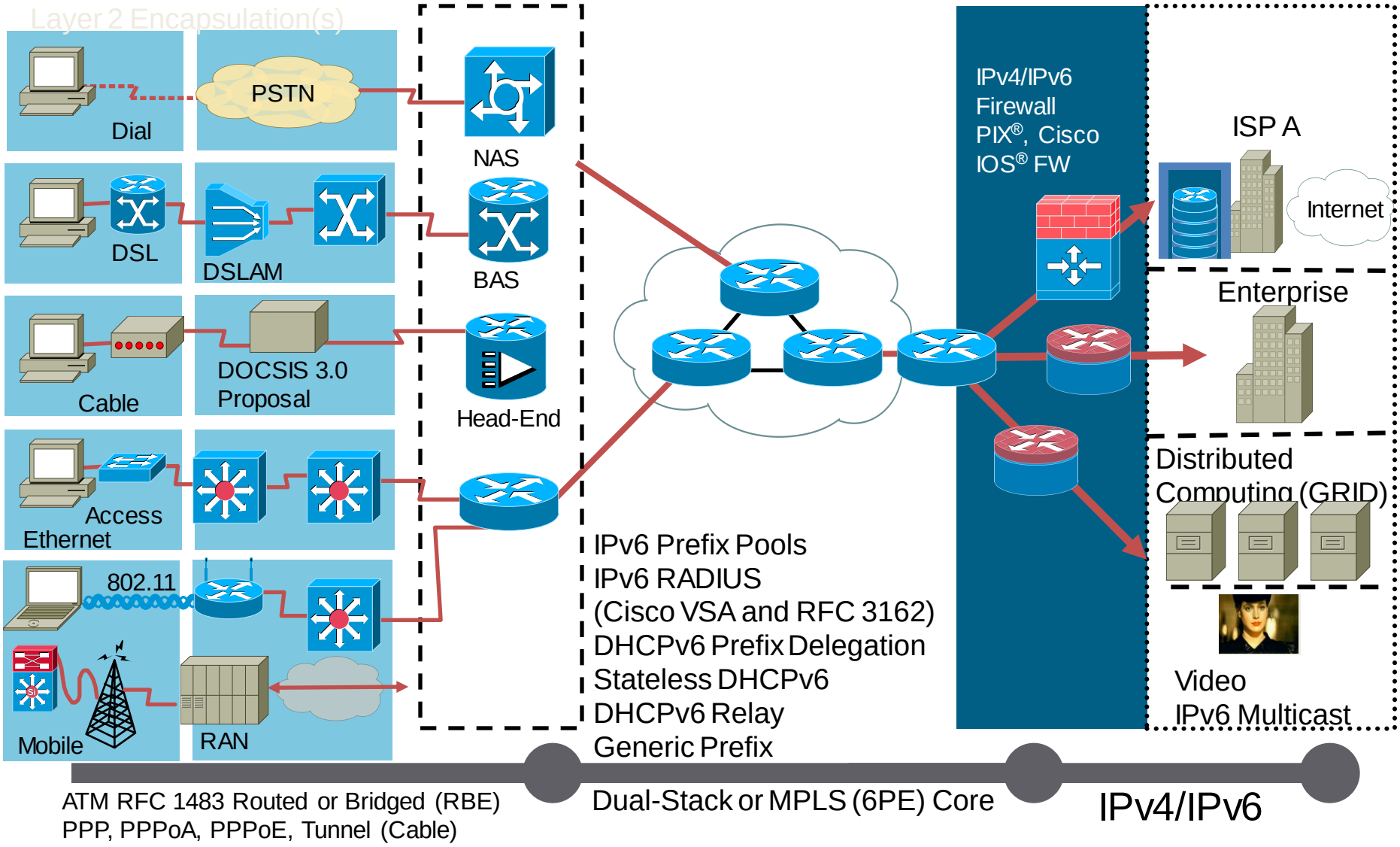
Convergence of n IP networks in Quad Play calls for huge scale (nxIP) address space. Plug & play home networking

IPv6 Multicast Based Multimedia Services (NTT-East Example)

- NTT-East rolled out native IPv6 multicast services instead of IPv4 offering IPTV, music and games:
  - http://www.ipv6style.jp/en/action/20040902/index.shtml

- The IPv6 solution is scaleable since it allows for the replication to be performed at the access layer

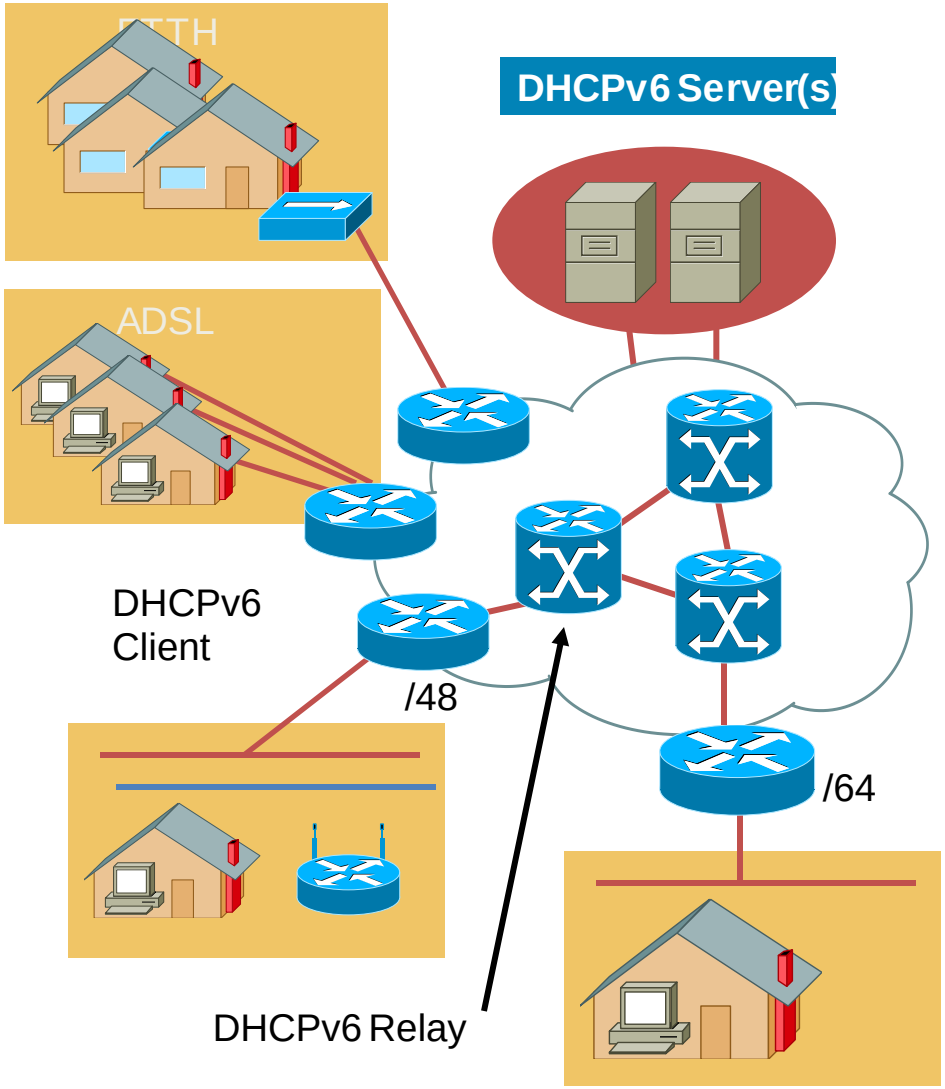
Cisco IOS IPv6 Broadband Access Solutions



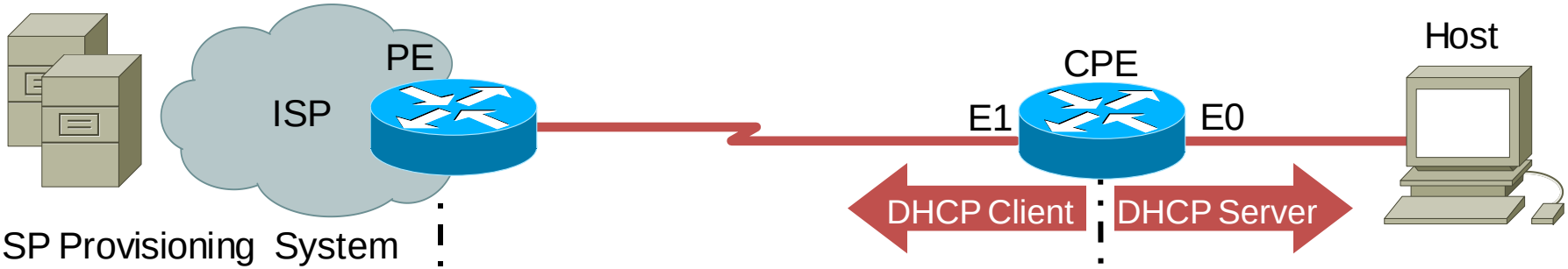
Provisioning in IPv6 Access Environments

DHCPv6 PD: RFC 3633

- Media independence
  - e.g., ADSL, FTTH
  - Only knows identity of requesting router
- Leases for prefixes
- Flexible deployments
  - Client/relay/server model
- Requesting router includes request for prefixes in DHCP configuration request
- Delegating router assigns prefixes in response along with other DHCP configuration information



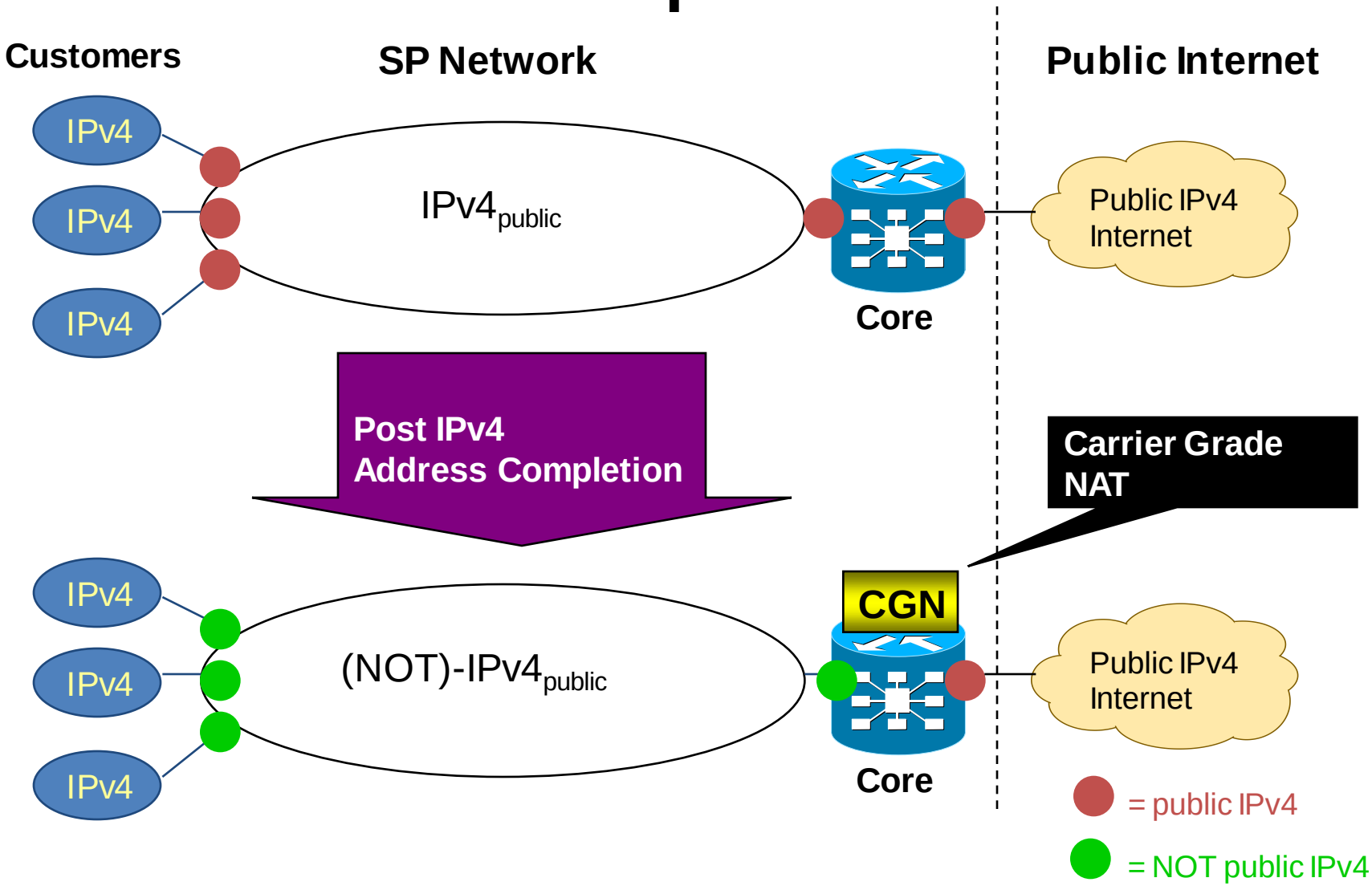
Prefix/Options Assignment



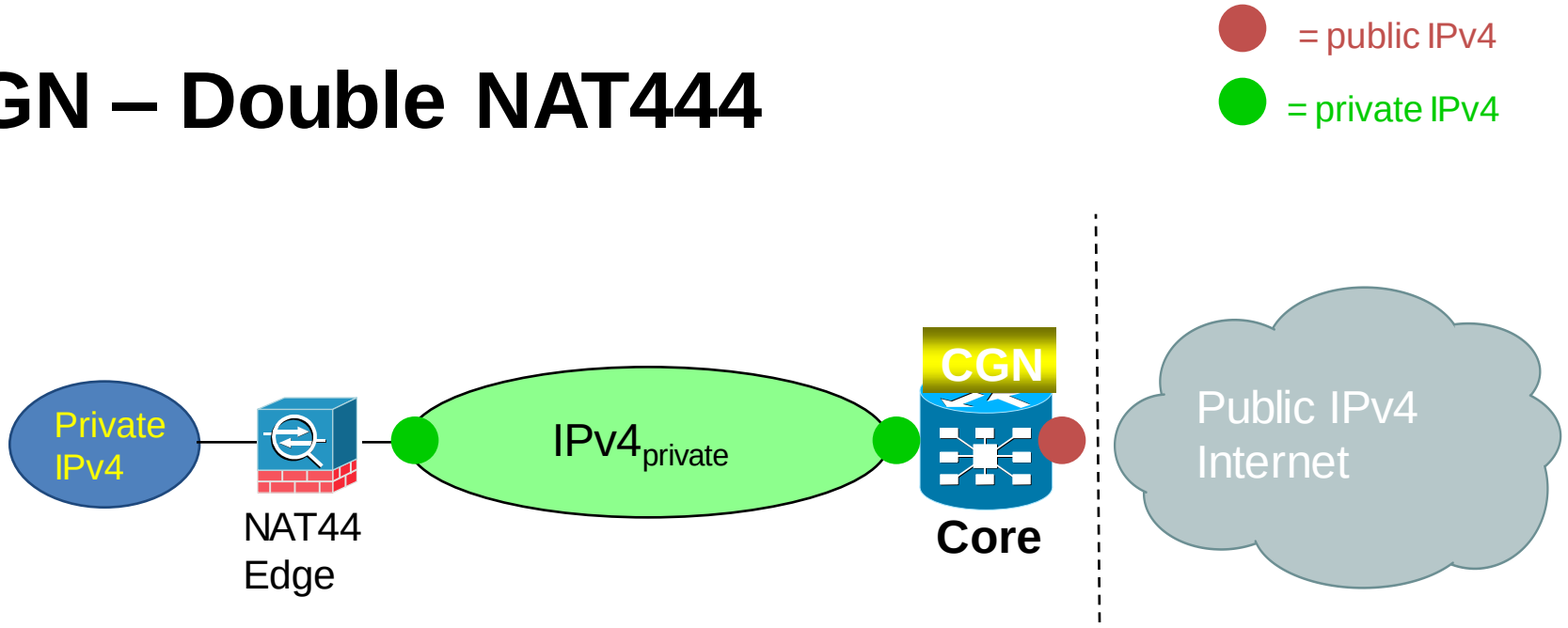
1. CPE Sends DHCP Solicit with ORO = PD
2. PE Sends RADIUS Request for the User
3. RADIUS Responds with User's Prefix(es)
4. PE Sends DHCP REPLY with Prefix Delegation Options
5. CPE Configures Addresses from The Prefix on Its Downstream Interfaces, and Sends an RA. O-bit Is Set to On
6. Host Configures Addresses Based on the Prefixes Received in the RA. As the O-bit Is on, It Sends a DHCP Information-request Message, with an ORO = DNS
7. CPE Sends a DHCP REPLY Containing Request Options

AAA | DHCP | ND/DHCP

A Strategy for Dealing with the IPv4 Address Completion Problem

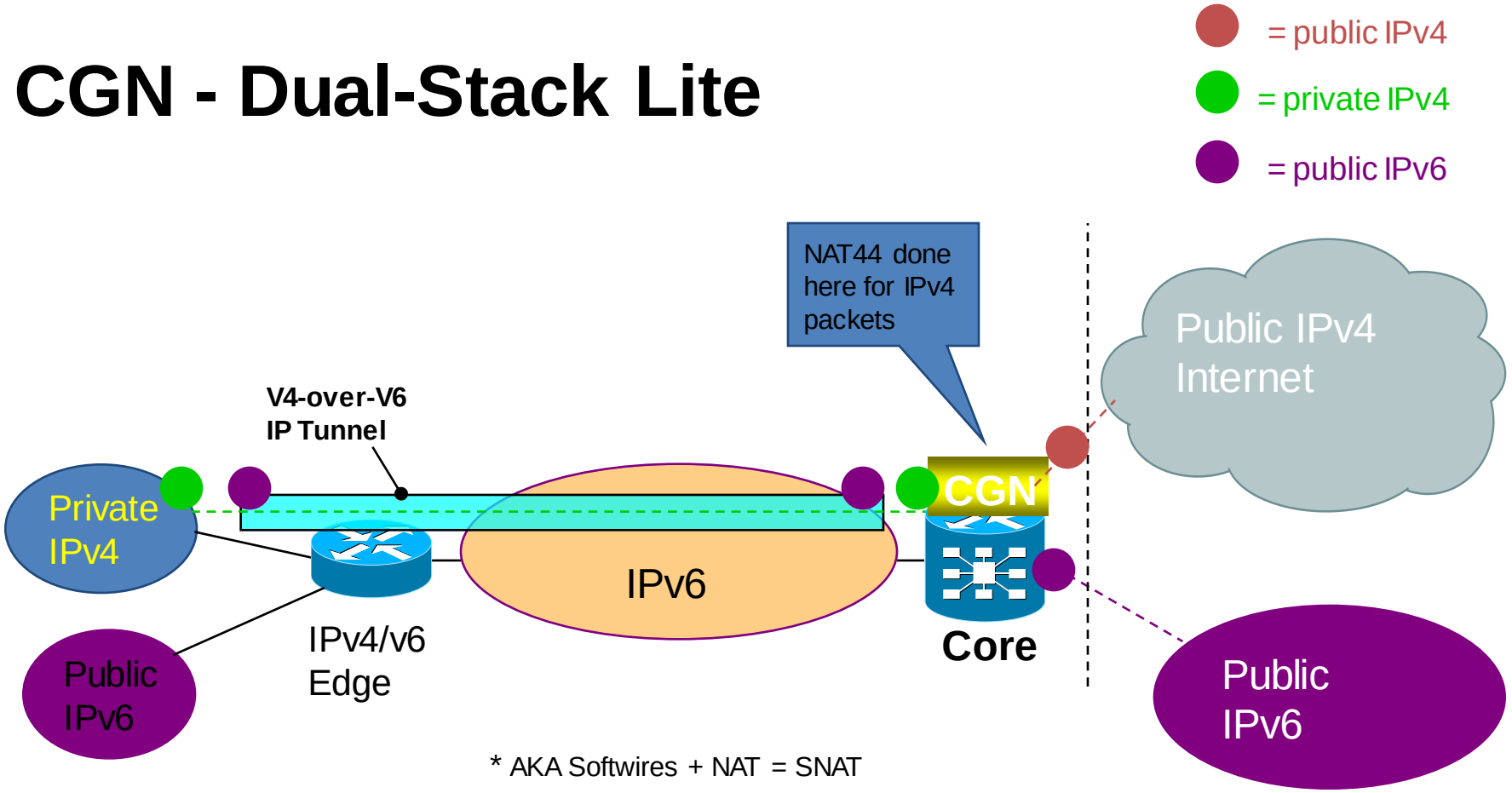


CGN – Double NAT444



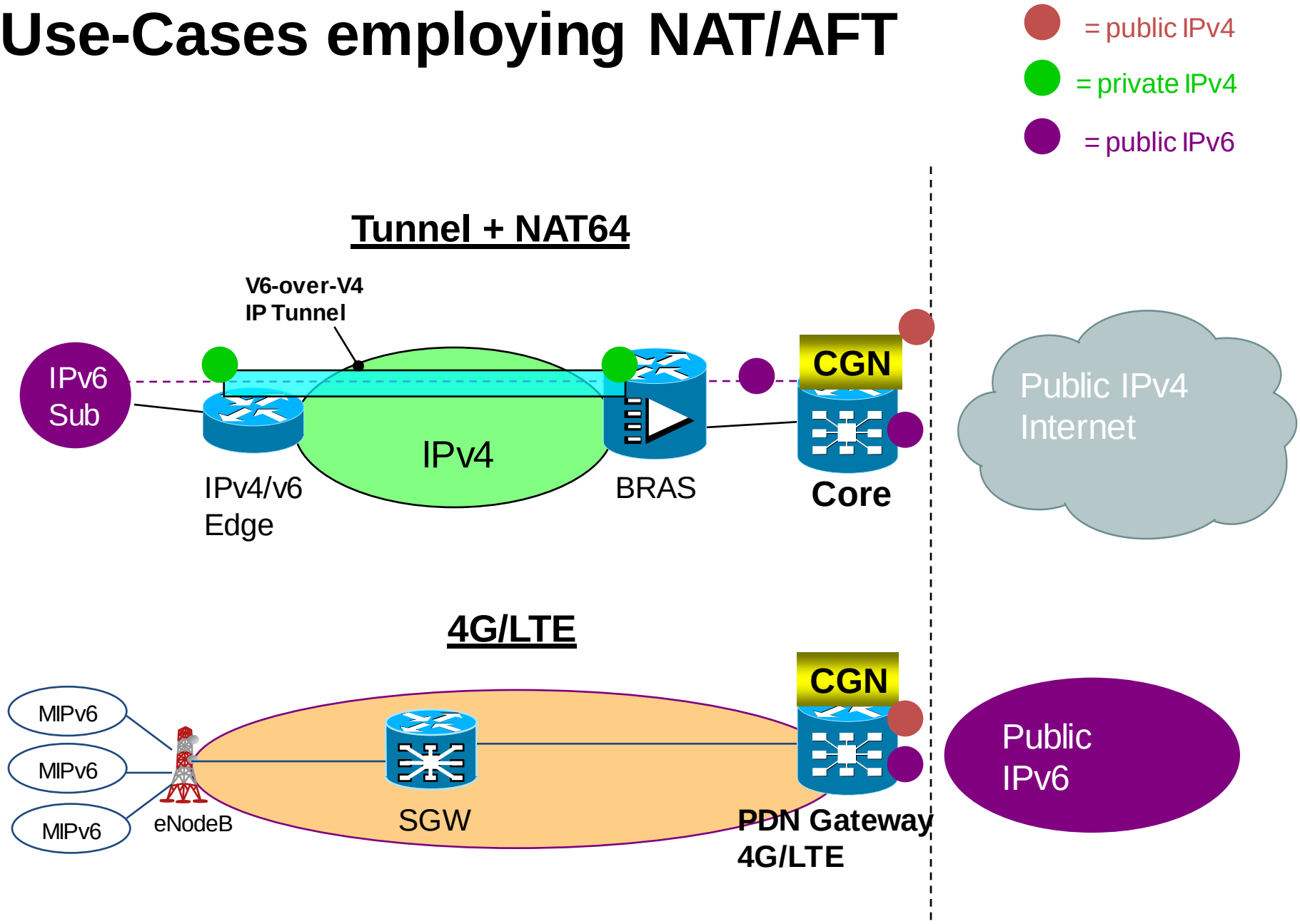
- CGN does NAT44 or O(large number) of private IPv4 subscribers
- No need for IPv6 anywhere
- Opportunity to control & manage per-subscriber NAT state
- Many challenges related to scale, performance, logging, subscriber interaction, etc.

CGN - Dual-Stack Lite



- Employs softwire 4over6 tunnels plus CGN-NAT44 to support private IPv4 connectivity with public IPv4 Internet
- IPv6 hosts use native IPv6 routing to public IPv6 Internet

Use-Cases employing NAT/AFT



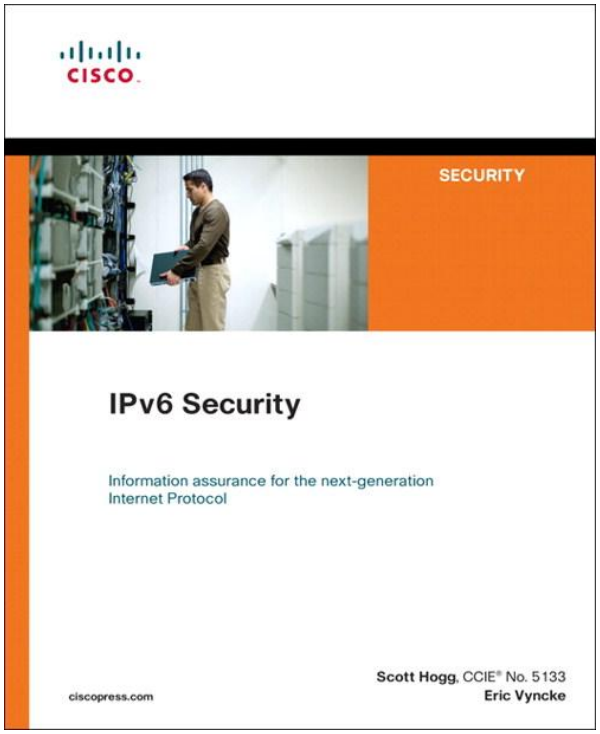
Conclusion

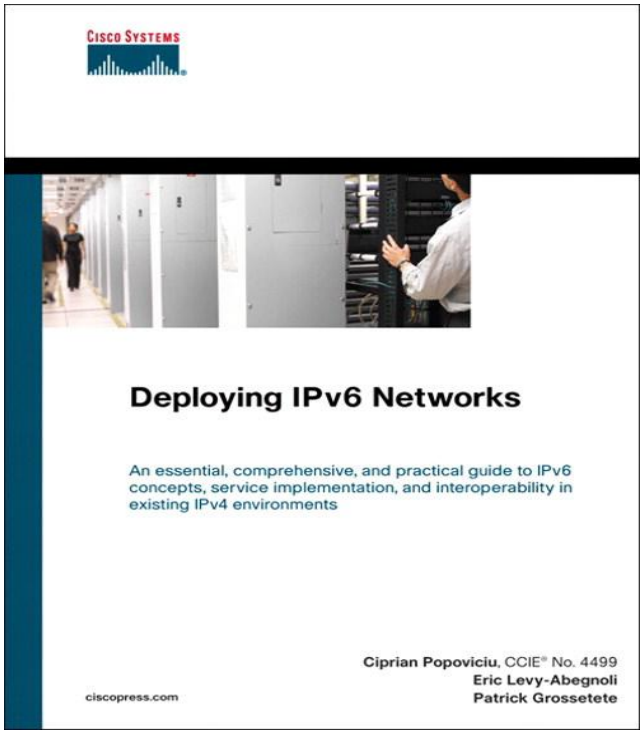
- Start now rather than later
  - Purchase for the future and test, test and then test some more
  - Start moving legacy application towards IPv6 support
- Things to consider:
  - Don’t assume your favorite vendor/app/gear has an IPv6 plan
  - Full parity between IPv4 and IPv6 is still a ways off
- SP deployments Scenarios
  - ISP IPv6 Deployment Scenarios in Broadband Access Networks (RFC 4779)
  - Scenarios and Analysis for Introducing IPv6 into ISP Networks (RFC 4029)
  - Procedures for Renumbering an IPv6 Network without a Flag Day (RFC 4192)

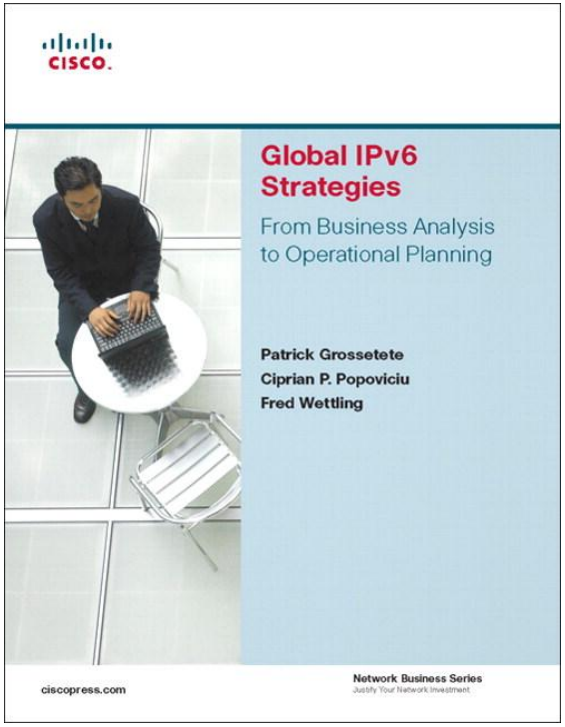
Reference Materials

- www.cisco.com/go/ipv6—CCO IPv6 main page
- www.cisco.com/go/srnd—CISCO NETWORK DESIGN CENTRAL
- www.cisco.com/go/fn—Select “Feature” and search for “IPv6”, then select “IPv6
  for Cisco IOS Software”
- www.ietf.org
- www.ipv6forum.com
- www.ipv6.org
- www.nav6tf.org/
- www.usipv6.com

Recommended Reading







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