Asia Pacific Network Information Centre

APNIC

APNIC Training

IPv6 Deployment Tutorial

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Introduction

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Overview

IPv6 Deployment Tutorial

- IPv6 Protocol Architecture Overview
- IPV6 Addressing and Sub-netting
- IPv6 Addressing plan case study
- IPv6 Host Configuration

Overview

IPv6 Deployment Tutorial

- **IPv6 Protocol Architecture Overview**
- IPV6 Addressing and Sub-netting
- IPv6 Addressing plan case study
- IPv6 Host Configuration

What Is IPv6?

- IP stands for **I**nternet **P**rotocol which is one of the main pillars that supports the Internet today
- Current version of IP protocol is IPv4
- The new version of IP protocol is IPv6
- There is a version of IPv5 but it was assigned for experimental use [RFC1190]
- IPv6 was also called IPng in the early days of IPv6 protocol development stage

Background Of IPv6 Protocol

- During the late 1980s (88-89) Internet has started to grow exponentially
- The ability to scale Internet for future demands requires a limitless supply of IP addresses and improved mobility
- In 1991 IETF decided that the current version of IP (IPv4) had outlived its design and need to develop a new protocol for Internet
- In 1994 IETF gave a clear direction of IPng or IPv6 after a long process of discussion

Background Of IPv6 Protocol

- August 1990
  - First wakeup call by Solensky in IETF on IPv4 address exhaustion
- December 1994
  - IPng area were formed within IETF to manage IPng effort [RFC1719]
- December 1994
  - List of technical criteria was defined to choose IPng [RFC1726]
- January 1995
  - IPng director recommendation to use 128 bit address [RFC1752]
- December 1995
  - First version of IPv6 address specification [RFC1883]
- December 1998
  - Updated version changing header format from 1st version [RFC2460]

Motivation Behind IPv6 Protocol

- New generation Internet need:
  - Plenty of address space (PDA, Mobile Phones, Tablet PC, Car, TV etc etc ☺)
  - Solution of very complex hierarchical addressing need, which IPv4 is unable provide
  - End to end communication without the need of NAT for some real time application i.e online transaction
  - Ensure security, reliability of data and faster processing of protocol overhead
  - Stable service for mobile network i.e Internet in airline

New Functional Improvement In IPv6

- Address Space
  - Increase from 32-bit to 128-bit address space
- Management
  - Stateless autoconfiguration means no more need to configure IP addresses for end systems, even via DHCP
- Performance
  - Fixed header sizes (40 byte) and 64-bit header alignment mean better performance from routers and bridges/switches
- No hop-by-hop segmentation
  - Path MTU discovery

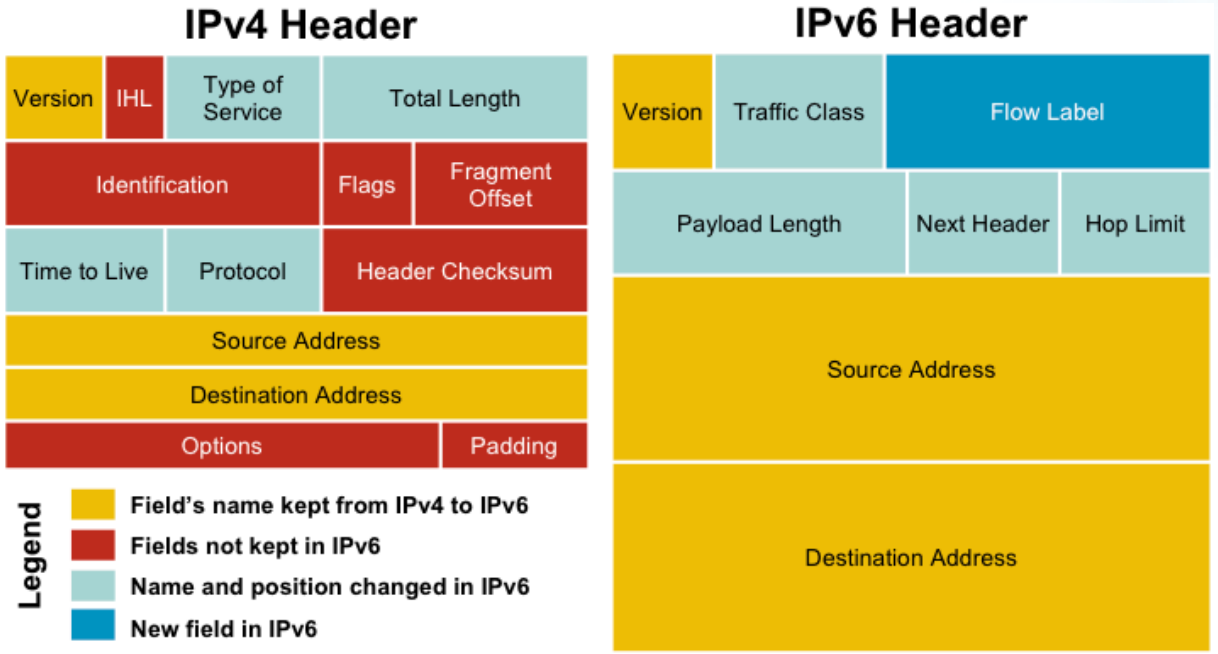
Source: http://www.opus1.com/ipv6/whatisipv6.html

New Functional Improvement In IPv6

- Multicast/Multimedia
  - Built-in features for multicast groups, management, and new "anycast" groups
- Mobile IP
  - Eliminate triangular routing and simplify deployment of mobile IP-based systems
- Virtual Private Networks
  - Built-in support for ESP/AH encrypted/ authenticated virtual private network protocols; built-in support for QoS tagging
- No more broadcast

Source: http://www.opus1.com/ipv6/whatisipv6.html

Protocol Header Comparison



- IPv4 contain 10 basic header field
- IPv6 contain 6 basic header field
- IPv6 header has 40 octets in contrast to the 20 octets in IPv4
- So a smaller number of header fields and the header is 64-bit aligned to enable fast processing by current processors

Diagram Source: www.cisco.com

IPv6 Protocol Header Format

The IPv6 header fields:

- Version:
  - A 4-bit field, same as in IPv4. It contains the number 6 instead of the number 4 for IPv4
- Traffic class:
  - A 8-bit field similar to the type of service (ToS) field in IPv4. It tags packet with a traffic class that it uses in differentiated services (DiffServ). These functionalities are the same for IPv6 and IPv4.
- Flow label:
  - A completely new 20-bit field. It tags a flow for the IP packets. It can be used for multilayer switching techniques and faster packet-switching performance

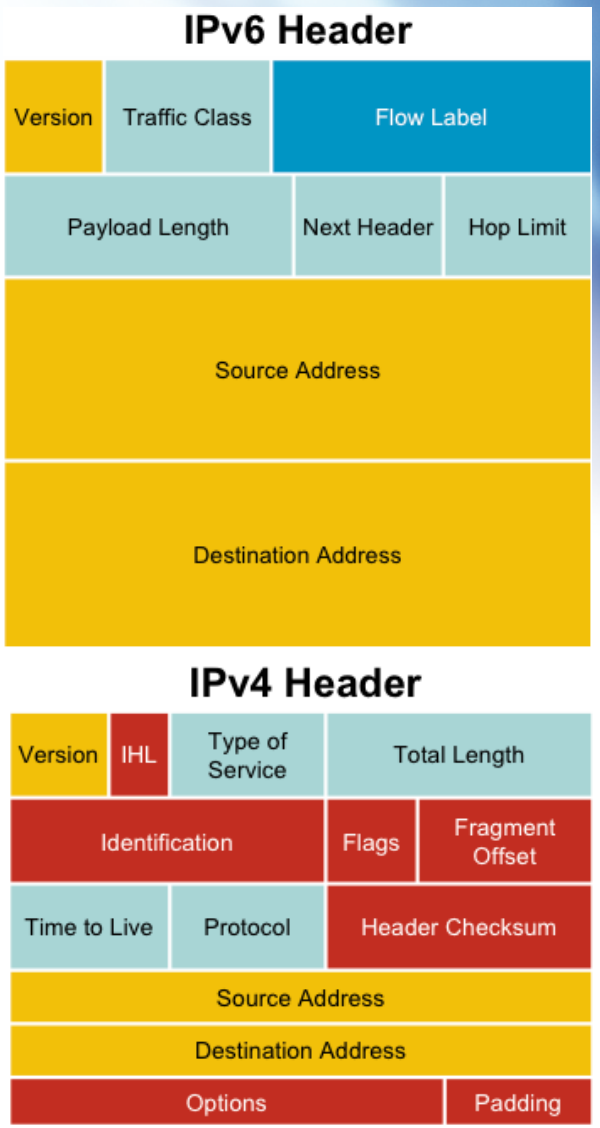


Diagram Source: www.cisco.com

IPv6 Protocol Header Format

- Payload length:
  - This 16-bit field is similar to the IPv4 Total Length Field, except that with IPv6 the Payload Length field is the length of the data carried after the header, whereas with IPv4 the Total Length Field included the header. 2^{16} = 65536 Octets.
- Next header:
  - The 8-bit value of this field determines the type of information that follows the basic IPv6 header. It can be a transport-layer packet, such as TCP or UDP, or it can be an extension header. The next header field is similar to the protocol field of IPv4.
- Hop limit:
  - This 8-bit field defines by a number which count the maximum hops that a packet can remain in the network before it is destroyed. With the IPv4 TLV field this was expressed in seconds and was typically a theoretical value and not very easy to estimate.

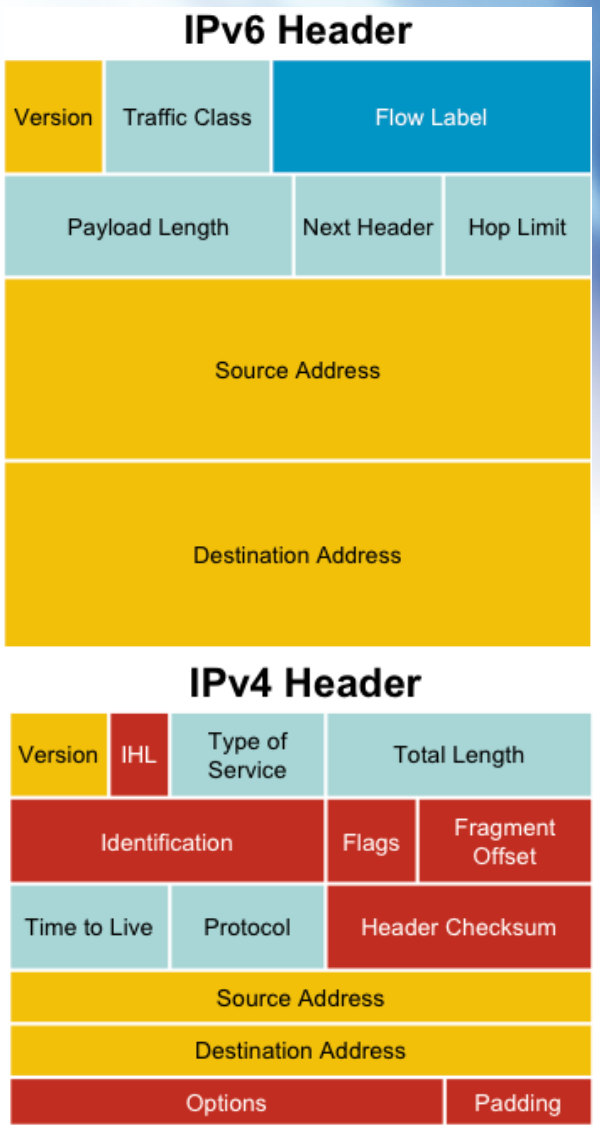


Diagram Source: www.cisco.com

IPv6 Extension Header

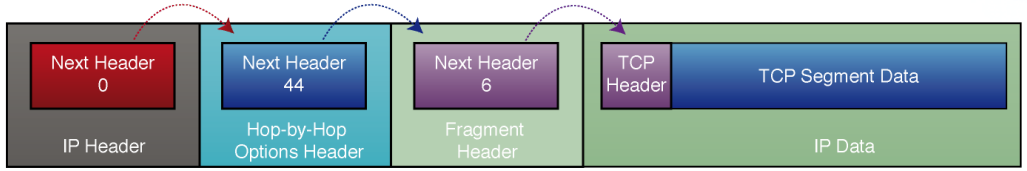
- Adding an optional Extension Header in IPv6 makes it simple to add new features in IP protocol in future without a major re-engineering of IP routers everywhere
- The number of extension headers are not fixed, so the total length of the extension header chain is variable
- The extension header will be placed in-between main header and payload in IPv6 packet

IPv6 Extension Header

- If the Next Header field value (code) is 6 it determine that there is no extension header and the next header field is pointing to TCP header which is the payload of this IPv6 packet
- Code values of Next Header field:
  - 0 Hop-by-hope option
  - 2 ICMP
  - 6 TCP
  - 17 UDP
  - 43 Source routing
  - 44 Fragmentation
  - 50 Encrypted security payload
  - 51 Authentication
  - 59 Null (No next header)
  - 60 Destination option

Link listed Extension Header

IPv6 Datagram With No Extension Headers Carrying TCP Segment



IPv6 Datagram With Two Extension Headers Carrying TCP Segment

- Link listed extension header can be used by simply using next header code value
- Above example use multiple extension header creating link list by using next header code value i.e 0 44 6
- The link list will end when the next header point to transport header i.e next header code 6

Order Of Extension Header

- Source node follow the order:
  - 1. Hop-by-hop
  - 2. Routing
  - 3. Fragment
  - 4. Authentication
  - 5. Encapsulating security payload
  - 6. Destination option
  - 7. Upper-layer
- Order is important because:
  - Only hop-by-hop has to be processed by every intermediate nodes
  - Routing header need to be processed by intermediate routers
  - At the destination fragmentation has to be processed before others
  - This is how it is easy to implement using hardware and make faster processing engine

Fragmentation Handling In IPv6

- Routers handle fragmentation in IPv4 which cause variety of processing performance issues
- IPv6 routers no longer perform fragmentation. IPv6 host use a discovery process [Path MTU Discovery] to determine most optimum MTU size before creating end to end session
- In this discovery process, the source IPv6 device attempts to send a packet at the size specified by the upper IP layers [i.e TCP/Application].
- If the device receives an "ICMP packet too big" message, it informs the upper layer to discard the packet and to use the new MTU.
- The "ICMP packet too big" message contains the proper MTU size for the pathway.
- Each source device needs to track the MTU size for each session.

Source: www.cisco.com

MTU Size Guideline

- MTU for IPv4 and IPv6
  - MTU is the largest size datagram that a given link layer technology can support [i.e HDLC]
  - Minimum MTU 68 Octet [IPv4] 1280 Octet [IPV6]
  - Most efficient MTU 576 [IPv4] 1500 [IPv6]
- Important things to remember:
  - Minimum MTU for IPv6 is 1280
  - Most efficient MTU is 1500
  - Maximum datagram size 64k

IPv6 Header Compression

- IPv6 header size is double then IPv4
- Some time it becomes an issue on limited bandwidth link i.e Radio
- Robust Header Compression [RoHC] standard can be used to minimize IPv6 overhead transmission in limited bandwidth link
- RoHC is IETF standard for IPv6 header compression

IPv6 Security Features

- IPsec is mandatory in IPv6
- Since IPsec become part of the IPv6 protocol all node can secure their IP traffic if they have required keying infrastructure
- In build IPsec does not replace standard network security requirement but introduce added layer of security with existing IP network

IPsec Transport and Tunnel Mode

- IPsec has two mode of encapsulation
  - Transport mode

    Provide end to end security between two end station
  - Tunnel mode

    Provide secure connection between two gateway (router). Unencrypted data from end system go through encrypted tunnel provided by the source and destination gateways

IPsec Transport and Tunnel Mode

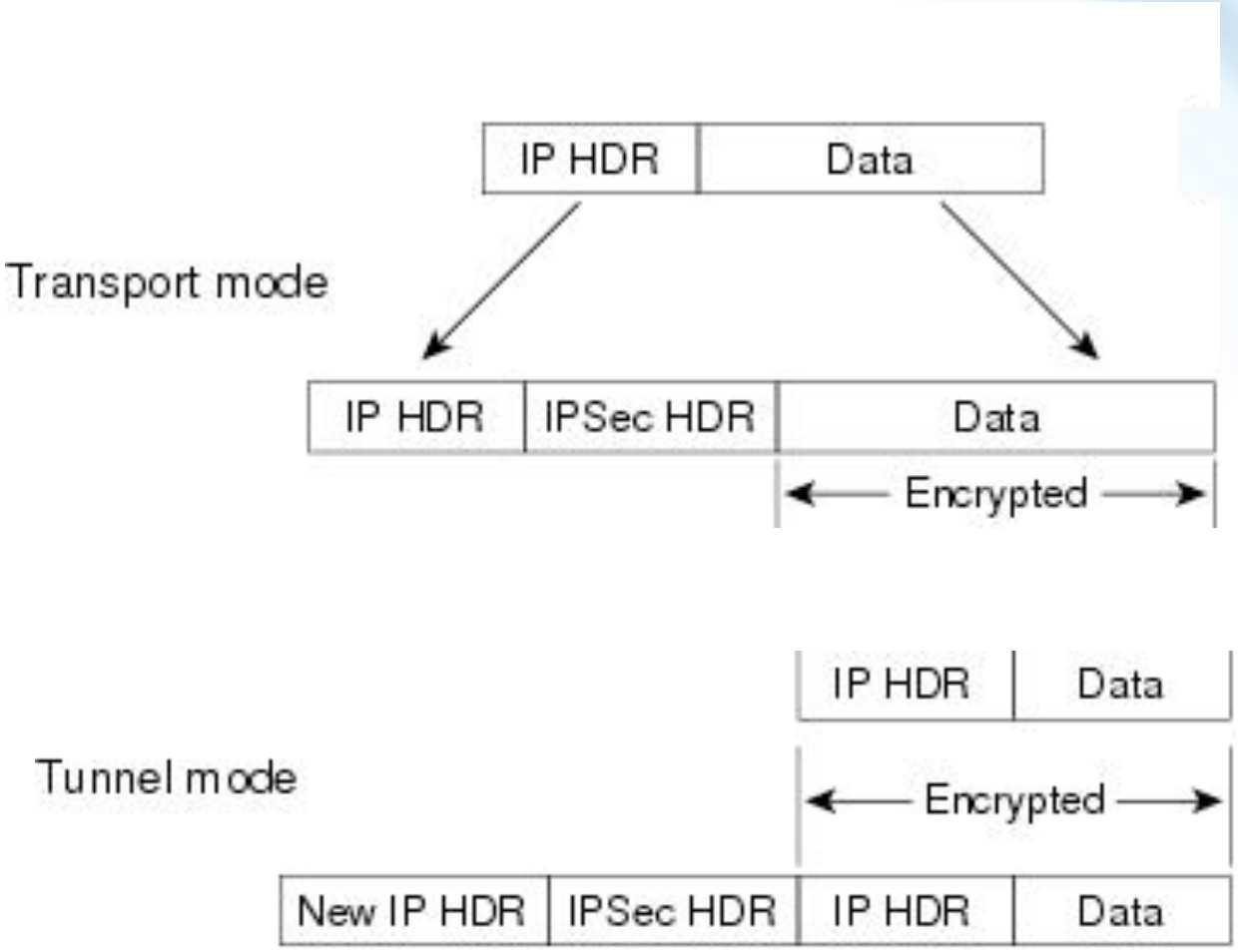


Diagram Source: www.cisco.com

IPsec Pre-establish Security Association

- IPsec peer need a pre-establish security association before they start sending packets
- This involves standard key exchange and cryptographic algorithm
- Standard IKE (Internet Key Exchange) protocol is used for IPsec of IPv6

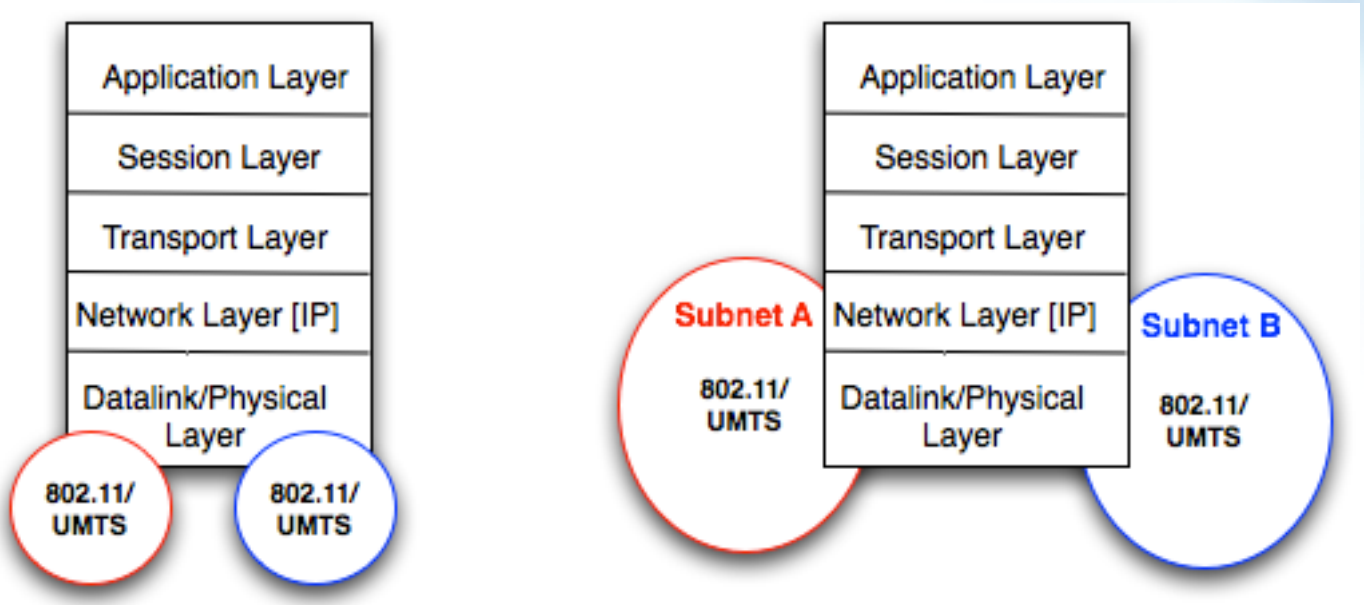
Symmetric and Asymmetric Keying

- There are two basic types of keying solutions:
  - Symmetric
    - Same key will be used to encrypt and decrypt data packet. Since same key is used for encryption and decryption its simple and faster. Key need to share out of band. Tunnel mode symmetric key
  - Asymmetric
    - Asymmetric keying use public key and private key for encryption and decryption. Key can be share in band. Transport mode use asymmetric key

IP Address Mobility

- IP address mobility is a mechanism that will sustain the IP connection even when the IP address change if the device move from one location to other location (subnet)
- IP address mobility is achieved by using Mobile IP
- Mobile IP is designed to work with both IPv4 [RFC3344] and IPv6 [RFC3775]
- Mobile IP operation is optimized for IPv6

Layer2 Vs Layer3 Mobility

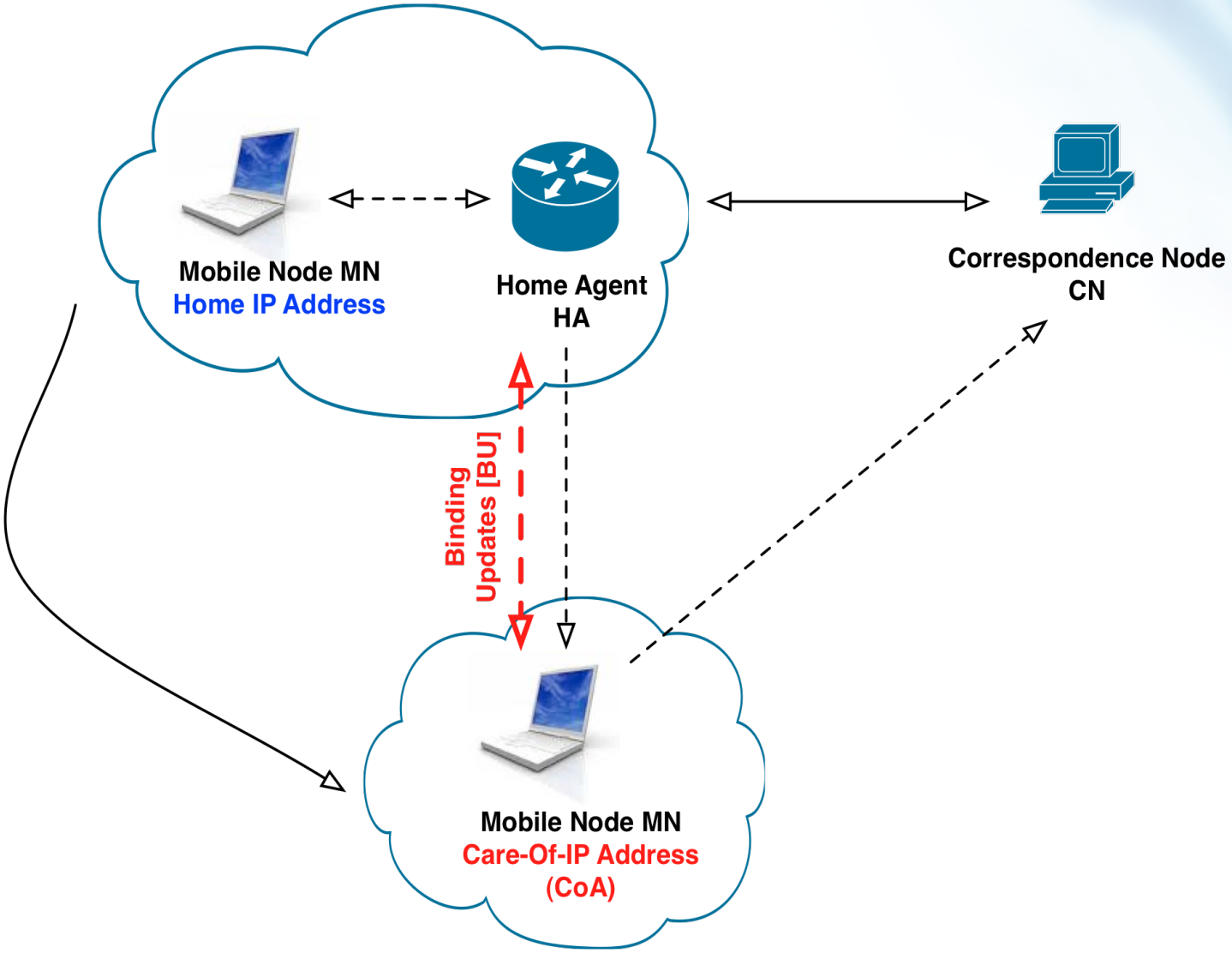


- If device move from one location to other location but belongs to the same IP subnet this will not consider as IP mobility and do not need mobile IP

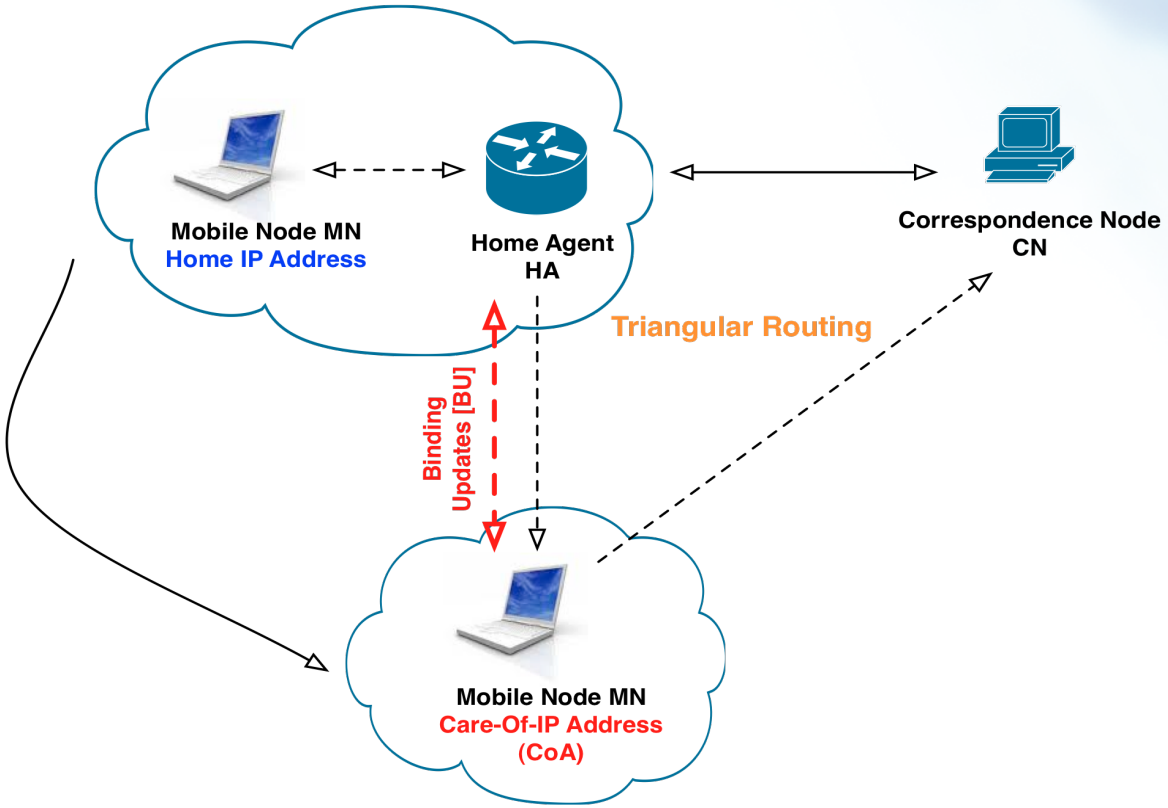
IP Address Mobility Terminology

- Mobile Node [MN]
  - Is the mobile user
- Correspondent Node [CN]
  - Fixed [or may be mobile] user
- Home Agent [HA]
  - Usually a router in home representing MN
- Home IP Address
  - Primary (fixed) IP address of MN
- Care-Of-Address [CoA]
  - Secondary (variable) IP address of MN
- Binding Update [BU]
  - Process to register new IP address to HA [some time CN]

Basic Mobile IP Operation

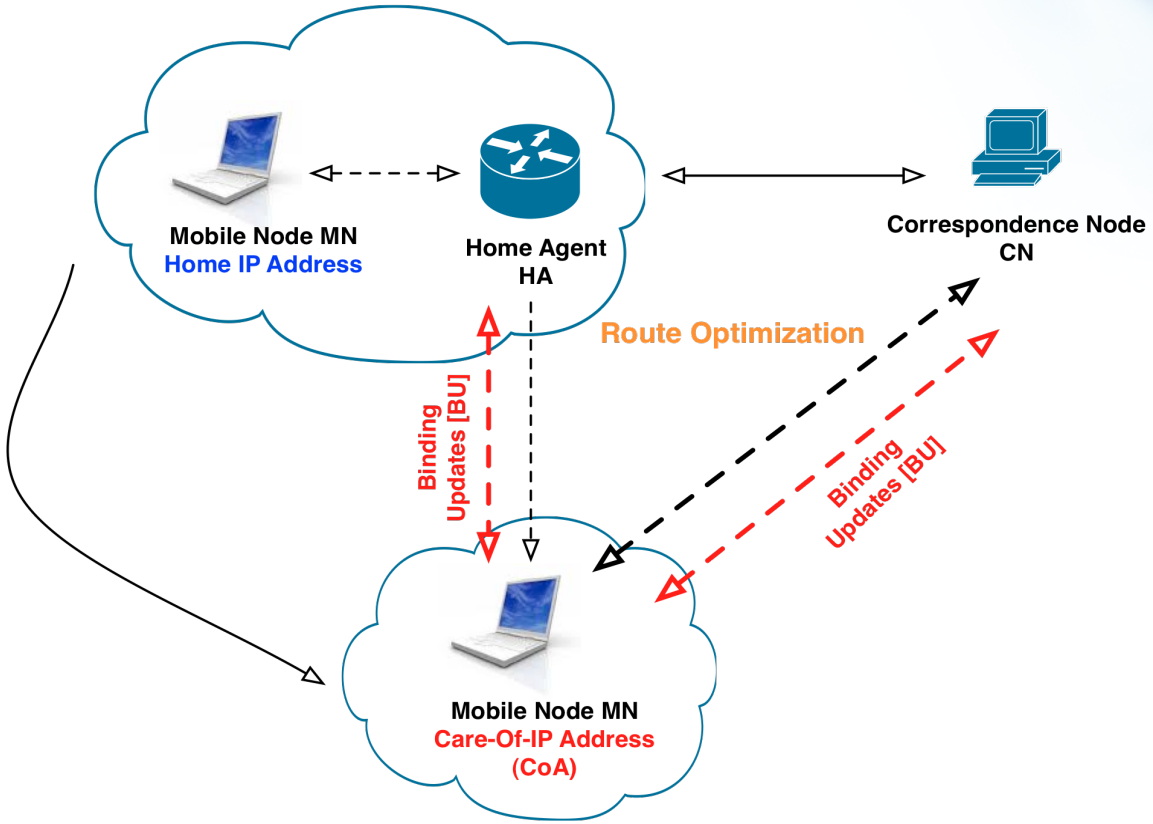


Triangular Routing Issue



- Triangular routing creates delay which affects real time application i.e VoIP, streaming etc

Route Optimization



- MN send BU to CN informing its CoA
- Direct data communication will start between MN and CN

Mobile IP Operation in IPv6

- Applications are transparent to IP mobility
  - Application software on both source and destination are not aware about mobile IP
- Mobile node [MN] is in home [HA]
  - HA are mobile IP enabled router sending Router Advertisement RA to MN advertising HA prefix
  - MN received RA compare with existing HA prefix. If match MN is at home
  - MN behaves as normal IP node

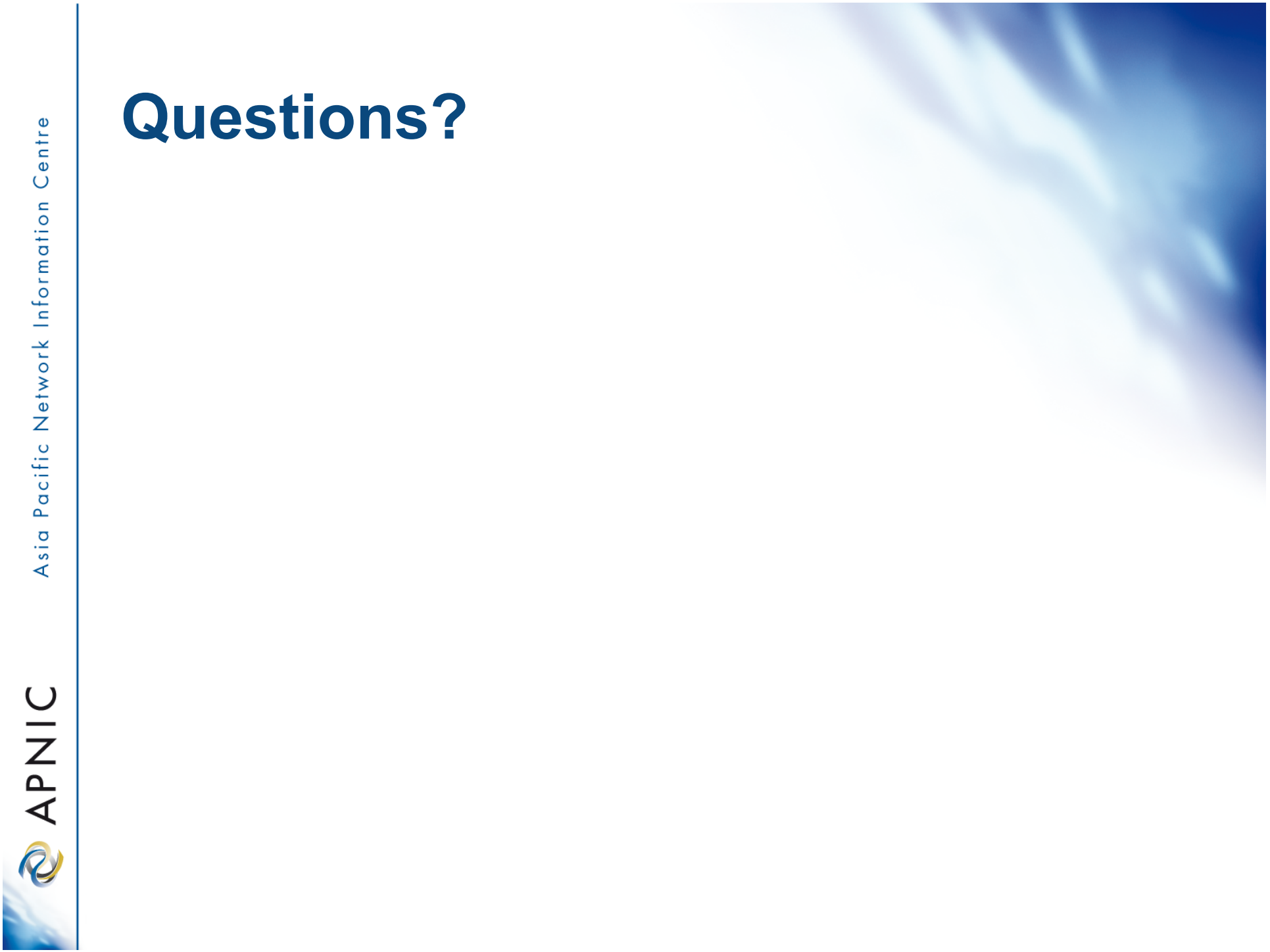
Mobile IP Operation in IPv6

- Mobile node [MN] is away from home [HA]
  - New network will receive new RA/DHCPv6 and will be different then existing prefix
  - Mobile node [MN] is away from home and will register it new CoA with HA by using BU
  - If there is an existing/new data session MN will also send BU to CN to eliminate/optimize triangular routing
  - To ensure authentic and secure BU IPsec ESP is used between MN and HA

Issue with Mobile IP Operation in IPv6

- In optimized routing environment source & destination address of IP packet between MN and CN will be CoA and CN IPv6 address
- This will create inconsistency in application software and firewall policy in both side [MN and CN]
- IPv6 use extension header [Destination option header] to carry home IP address within the same IPv6 packet which will be replaced at CN
- Router will still look at the header for faster processing

Questions?



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- **IPV6 Addressing and Sub-netting**
- IPv6 Addressing plan case study
- IPv6 Host Configuration

IPv6 Addressing

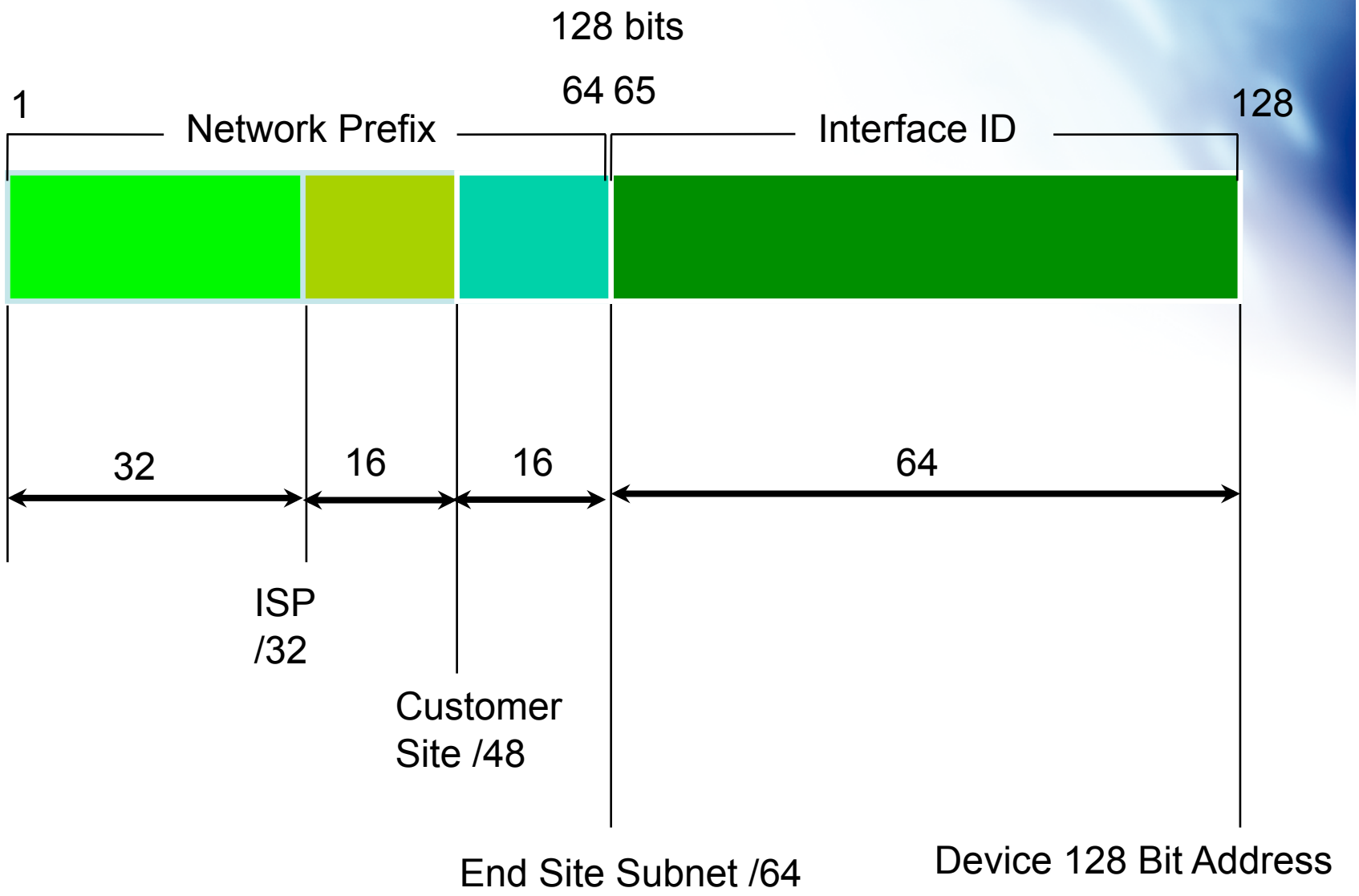
- An IPv6 address is 128 bits long
- So the number of addresses are 2^128
  =340282366920938463463374607431768211455
  (39 decimal digits)
  =0xffffffffffffffffffffffffffffffff (32 hexadecimal digits)
- In hex 4 bit (nibble) is represented by a hex digit
- So 128 bit is reduced down to 32 hex digit

IPv6 Address Representation

- Hexadecimal values of eight 16 bit fields
  - X:X:X:X:X:X:X:X (X=16 bit number, ex: A2FE)
  - 16 bit number is converted to a 4 digit hexadecimal number
- Example:
  - FE38:DCE3:124C:C1A2:BA03:6735:EF1C:683D

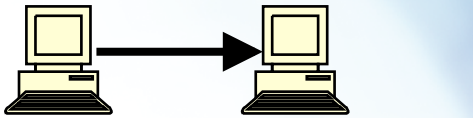
  – Abbreviated form of address
  - 4EED:0023:0000:0000:0000:036E:1250:2B00
  - →4EED:23:0:0:0:36E:1250:2B00
  - →4EED:23::36E:1250:2B00
  - (Null value can be used only once)

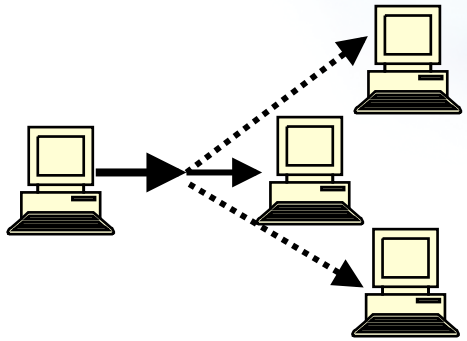
IPv6 addressing structure

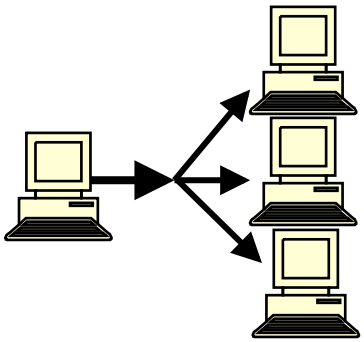


IPv6 addressing model

- **IPv6 Address type** RFC 4291
  - Unicast
    - An identifier for a single interface
  - Anycast
    - An identifier for a set of interfaces
  - Multicast
    - An identifier for a group of nodes







Addresses Without a Network Prefix

- Loopback ::1/128
- Unspecified Address ::/128
- IPv4-mapped IPv6 address ::ffff/96 [a.b.c.d]
- IPv4-compatible IPv6 address ::/96 [a.b.c.d]

Local Addresses With Network Prefix

- Link Local Address
  - A special address used to communicate within the local link of an interface
  - i.e. anyone on the link as host or router
  - This address in packet destination that packet would never pass through a router
  - fe80::/10

Local Addresses With Network Prefix

- Site Local Address
  - Addresses similar to the RFC 1918 / private address like in IPv4
  - fec0::/10
- This address type is now deprecated by RFC 3879 because of lack of uniqueness
- Still used in test lab

Local Addresses With Network Prefix

- Unique Local IPv6 Unicast Address
  - Addresses similar to the RFC 1918 / private address like in IPv4 but will ensure uniqueness
  - A part of the prefix (40 bits) are generated using a pseudo-random algorithm and it's improbable that two generated ones are equal
  - fc00::/7
  - Example webtools to generate ULA prefix

    http://www.sixxs.net/tools/grh/ula/

    http://www.goebel-consult.de/ipv6/createLULA

Global Addresses With Network Prefix

- IPV6 Global Unicast Address
  - Global Unicast Range: 0010 2000::/3
    0011 3000::/3
  - All five RIRs are given a /12 from the /3 to further distribute within the RIR region
    - APNIC 2400:0000::/12
    - ARIN 2600:0000::/12
    - AfriNIC 2C00:0000::/12
    - LACNIC 2800:0000::/12
    - Ripe NCC 2A00:0000::/12

Global Addresses With Network Prefix

- 6to4 Addresses
  - 2002::/16
  - Designed for a special tunneling mechanism [RFC 3056] to connect IPv6 Domains via IPv4 Clouds
  - Automatic tunnel transition Mechanisms for IPv6 Hosts and Routers
  - Need 6to4 relay routers in ISP network

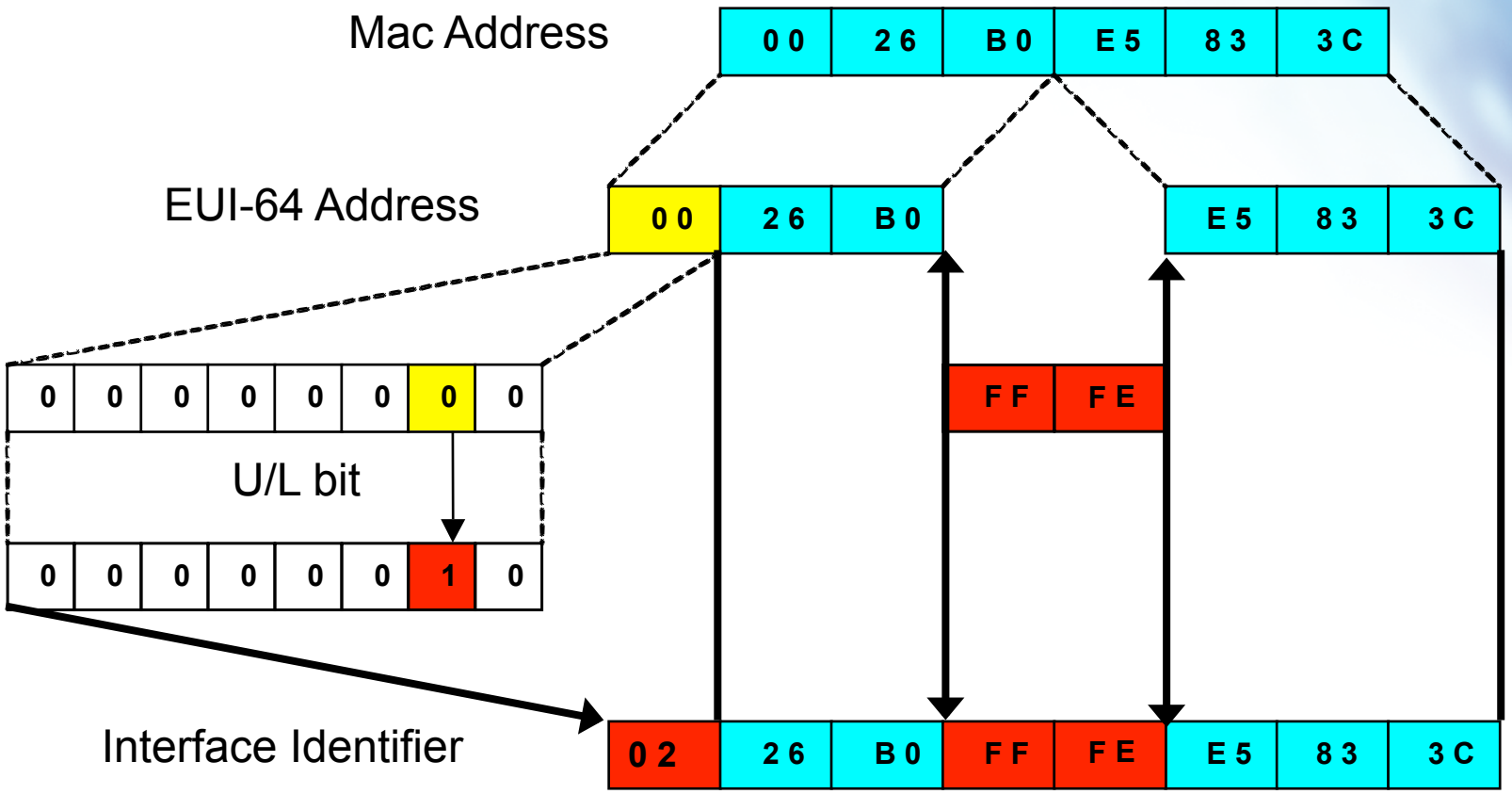
Examples and Documentation Prefix

- Two address ranges are reserved for examples and documentation purpose by RFC 3849
  - For example 3fff:ffff::/32
  - For documentation 2001:0DB8::/32

Interface ID

- The lowest-order 64-bit field addresses may be assigned in several different ways:
  - auto-configured from a 48-bit MAC address expanded into a 64-bit EUI-64
  - assigned via DHCP
  - manually configured
  - auto-generated pseudo-random number
  - possibly other methods in the future

EUI-64



Zone IDs for local-use addresses

- In Windows XP for example:
- Host A:
  - fe80::2abc:d0ff:fee9:4121%4
- Host B:
  - fe80::3123:e0ff:fe12:3001%3
- Ping from Host A to Host B
  - ping fe80::3123:e0ff:fe12:3001%4 (not %3)
    - identifies the interface zone ID on the host which is connected to that segment.

IPv6 autoconfiguration

- Stateless mechanism
  - For a site not concerned with the exact addresses
  - No manual configuration required
  - Minimal configuration of routers
  - No additional servers
- Stateful mechanism
  - For a site that requires tighter control over exact address assignments
  - Needs a DHCP server
    - DHCPv6

Plug and Play

- IPv6 link local address
  - Even if no servers/routers exist to assign an IP address to a device, the device can still auto-generate an IP address
    - Allows interfaces on the same link to communicate with each other
- Stateless
  - No control over information belongs to the interface with an assigned IP address
    - Possible security issues
- Stateful
  - Remember information about interfaces that are assigned IP addresses

IPv6 Neighbor Discovery (ND)

- IPv6 use multicast (L2) instead of broadcast to find out target host MAC address
- It increases network efficiency by eliminating broadcast from L2 network
- IPv6 ND use ICMP6 as transport
  - Compared to IPv4 ARP no need to write different ARP for different L2 protocol i.e. Ethernet etc.

IPv6 Neighbor Discovery (ND)

- Solicited Node Multicast Address
  - Start with FF02:0:0:0:0:1:ff::/104
  - Last 24 bit from the interface IPV6 address
- Example Solicited Node Multicast Address
  - IPV6 Address 2406:6400:0:0:0:0:00**00:0010**
  - Solicited Node Multicast Address is FF02:0:0:0:0:1:ff**00:0010**
- All host listen to its solicited node multicast address corresponding to its unicast and anycast address (If defined)

IPv6 Neighbor Discovery (ND)

- Host A would like to communicate with Host B
- Host A IPv6 global address 2406:6400::10
- Host A IPv6 link local address fe80::226:bbff:fe06:ff81
- Host A MAC address 00:26:bb:06:ff:81
- Host B IPv6 global address 2406:6400::20
- Host B Link local UNKNOWN [Gateway if outside the link]
- Host B MAC address UNKNOWN
- How Host A will create L2 frame for Host B?

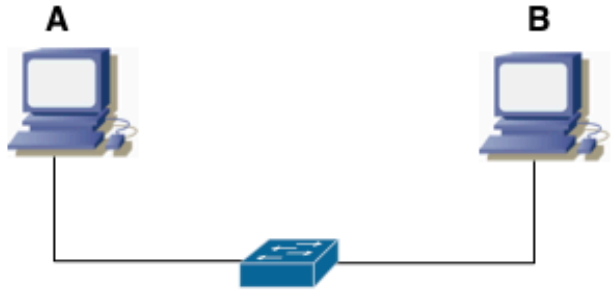
IPv6 Neighbor Discovery (ND)

Host A
IPV6 global address: 2406:6400::0010
IPv6 Link local: fe80::0226:bbff:fe06:ff81
MAC address: 00:26:bb:06:ff:81
Listen to other then above:
FF02::1 [All node multicast]
FF02:0:0:0:0:1:ff00:0010 [Solicited node m.cast unicast]
FF02:0:0:0:0:1:ff06:ff81 [Solicited node m.cast link local]

Packet S: 2406:6400::0010 D:2406:6400::0020

ICMP6 NS Type 135 S: fe80::0226:bbff:fe06:ff81 D:FF02:0:0:0:0:1:ff00:0020

Frame S: 00:26:bb:06:ff:81 D 33:33:ff:00:00:20
Ethernet reserved IPv6 m.cast: 33:33:xx:xx:xx:xx



Multicast enable switch: Unicast by IGMP snooping
Non multicast enable switch: broadcast, PC LAN card filter or discard

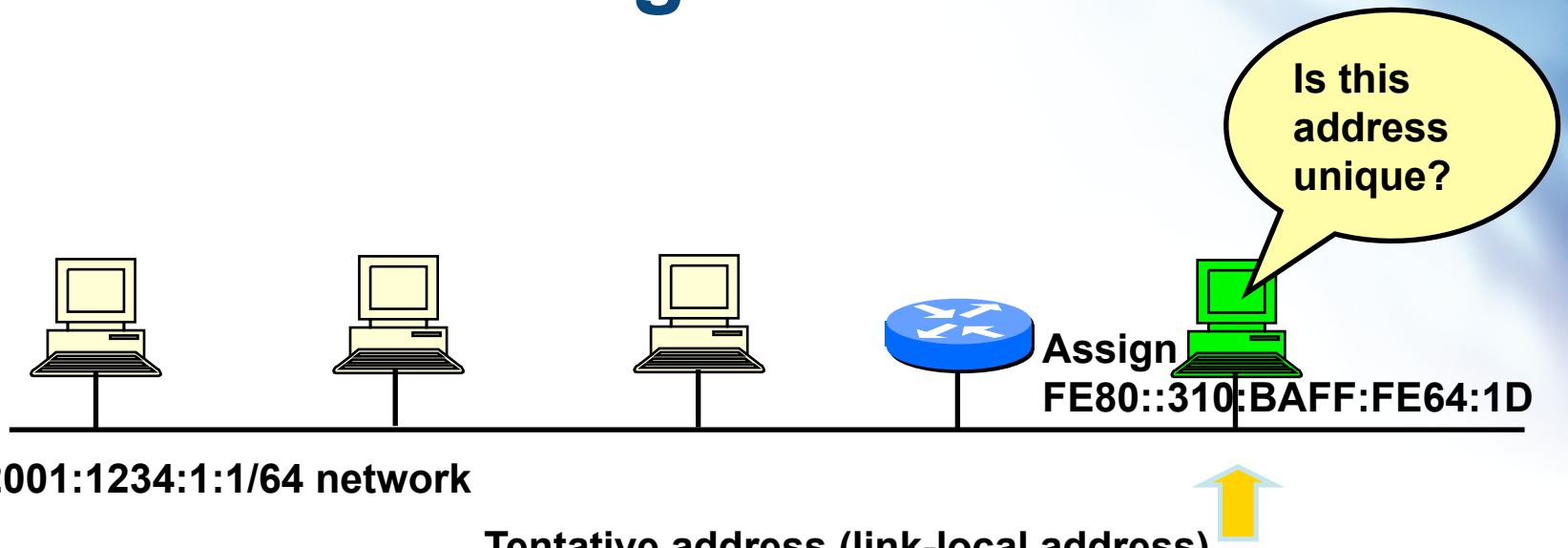
Host B
IPV6 global address: 2406:6400::0020
IPv6 Link local: fe80::0226:bbff:fe06:ff82 [Unknown to A]
MAC address: 00:26:bb:06:ff:82 [Unknown to A]
Listen to other then above:
FF02::1 [All node multicast]
FF02:0:0:0:0:1:ff00:0020 [Solicited node m.cast unicast]
FF02:0:0:0:0:1:ff06:ff82 [Solicited node m.cast link local]

Packet S: 2406:6400::0020 D:2406:6400::0010

ICMP6 NA Type 136 S: fe80::0226:bbff:fe06:ff82 D:fe80::0226:bbff:fe06:ff81

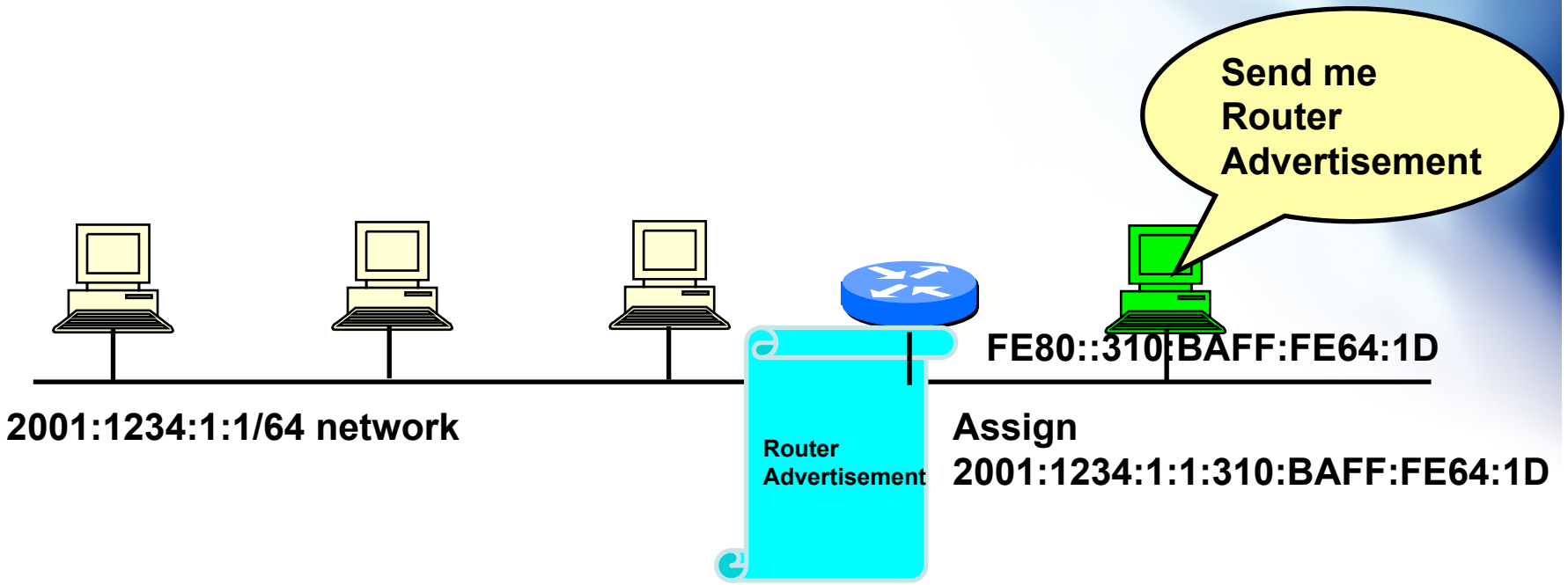
Frame S: 00:26:bb:06:ff:82 D 00:26:bb:06:ff:81

IPv6 autoconfiguration



1. A new host is turned on.
2. Tentative address will be assigned to the new host.
3. Duplicate Address Detection (DAD) is performed. First the host transmit a Neighbor Solicitation (NS) message to the solicited node multicast address (FF02::1:FFFE:641D) corresponding to its to be used address
5. If no Neighbor Advertisement (NA) message comes back then the address is unique.
6. FE80::310:BAFF:FE64:1D will be assigned to the new host.

IPv6 autoconfiguration



1. The new host will send Router Solicitation (RS) request to the all-routers multicast group (FF02::2).
2. The router will reply Routing Advertisement (RA).
3. The new host will learn the network prefix. E.g, 2001:1234:1:1/64
4. The new host will assigned a new address Network prefix+Interface ID E.g, 2001:1234:1:1:310:BAFF:FE64:1D

Exercise 1

IPv6 Sub-netting

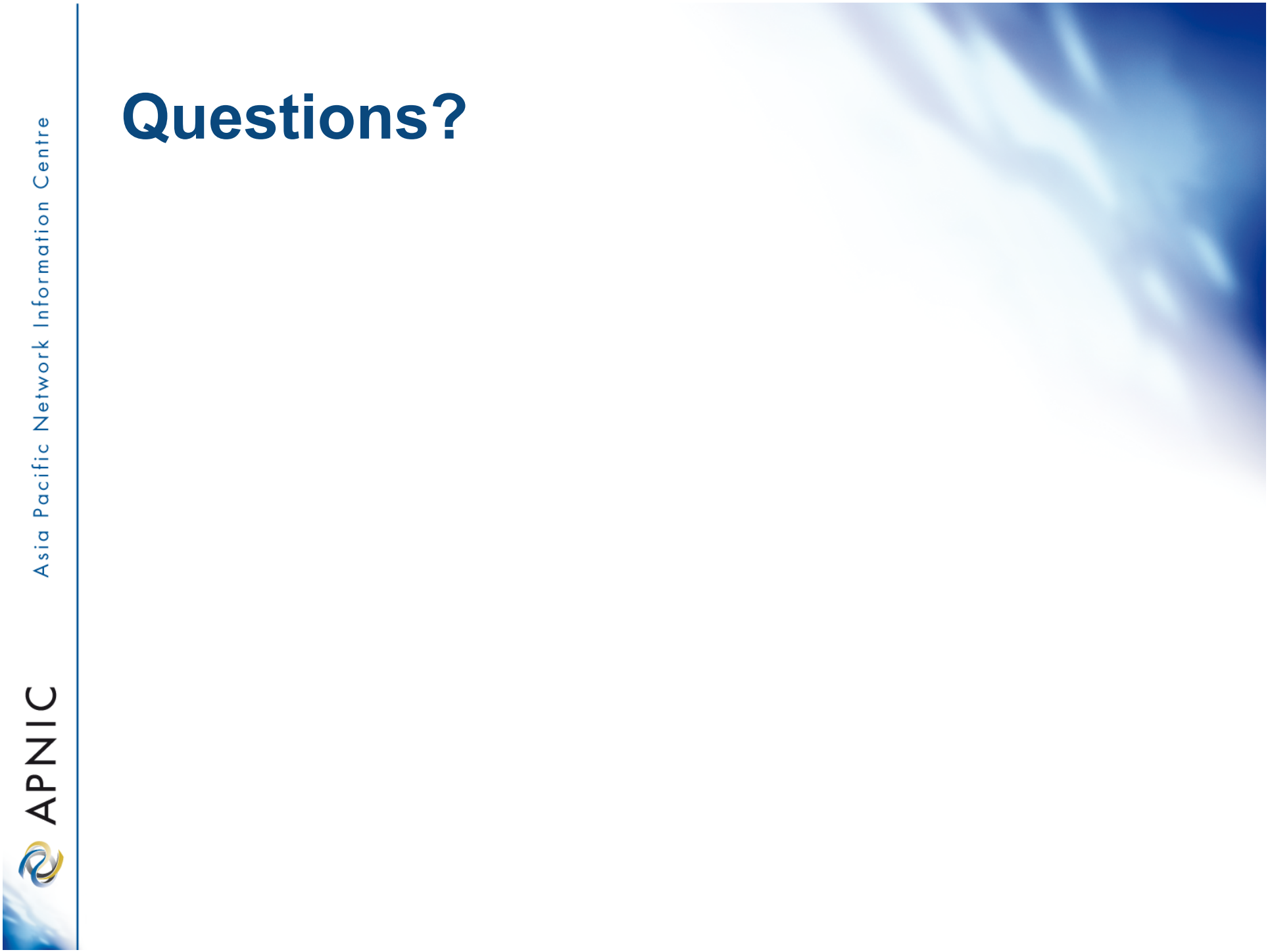
Exercise 1.1: IPv6 subnetting

1. Identify the first four /36 address blocks out of 2406:6400::/32
    1. _____
    2. _____
    3. _____
    4. _____

Exercise 1.2: IPv6 subnetting

1. Identify the fist four /35 address blocks out of 2406:6400::/32
    1. _____
    2. _____
    3. _____
    4. _____

Questions?



Overview

IPv6 Deployment Tutorial

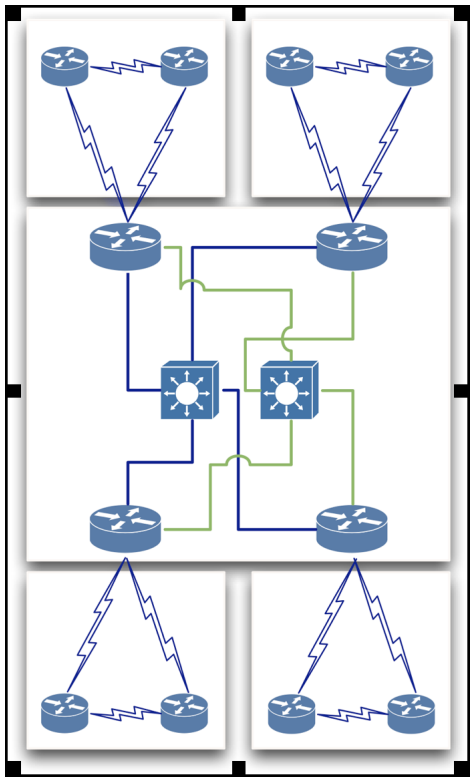
- IPv6 Protocol Architecture Overview
- IPV6 Addressing and Sub-netting
- **IPv6 Addressing plan case study**
- IPv6 Host Configuration

Training ISP Network Topology

Scenario:

- Training ISP has 4 main operating area or region
- Each region has 2 small POP
- Each region will have one datacenter to host content
- Regional network are inter -connected with multiple link

Training ISP Network Topology



Training ISP Topology Diagram

Training ISP Network Topology

Regional Network:

- Each regional network will have 3 routers
- 1 Core & 2 Edge Routers
- 2 Point of Presence (POP) for every region
- POP will use a router to terminate customer network i.e Edge Router
- Each POP is an aggregation point of ISP customer

Training ISP Network Topology

Access Network:

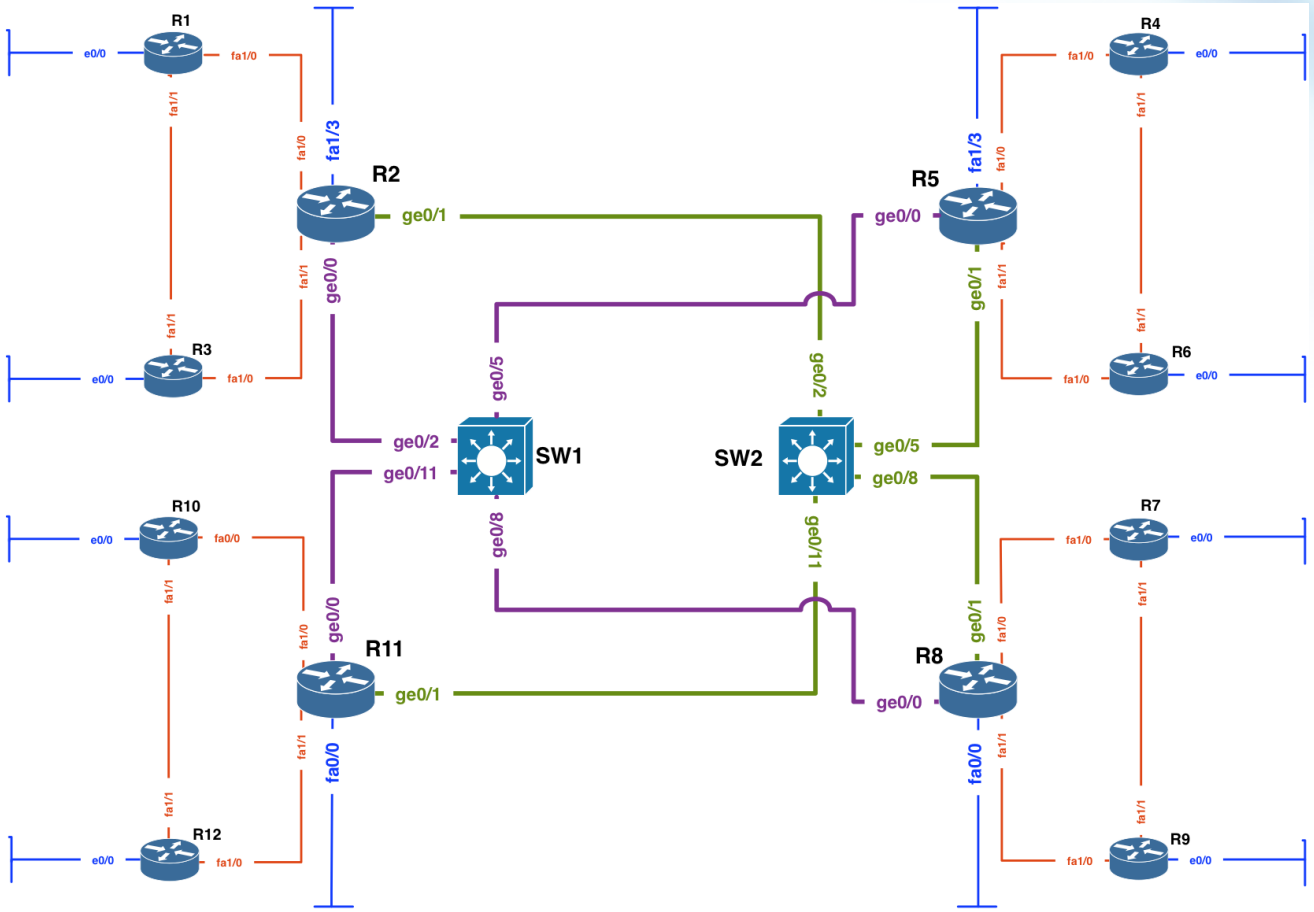
- Connection between customer network & Edge router
- Usually 10 to 100 MBPS link
- Separate routing policy from most of ISP
- Training ISP will connect them on edge router with separate customer IP prefix

Training ISP Network Topology

Transport Link:

- Inter-connection between regional core router
- Higher data transmission capacity then access link
- Training ISP has 2 transport link for link redundancy
- 2 Transport link i.e Purple link & Green link are connected to two career grade switch

Training ISP Network Topology



Training ISP Core IP Backbone

Training ISP Network Topology

Design Consideration:

- Each regional network should have address summarization capability for customer block and CS link WAN.
- Prefix planning should have scalability option for next couple of years for both customer block and infrastructure
- No Summarization require for infrastructure WAN and loopback address

Training ISP Network Topology

Design Consideration:

- All WAN link should be ICMP reachable for link monitoring purpose (At least from designated host)
- Conservation will get high preference for IPv4 address planning and aggregation will get high preference for IPv6 address planning.

Training ISP Network Topology

Design Consideration:

- OSPF is running in ISP network to carry infrastructure IP prefix
- Each region is a separate OSPF area
- Transport core is in OSPF area 0
- Customer will connect on either static or eBGP (Not OSPF)
- iBGP will carry external prefix within ISP core IP network

Training ISP IPV6 Addressing Plan

IPv6 address plan consideration:

- Big IPv6 address space can cause very very large routing table size
- Most transit service provider apply IPv6 aggregation prefix filter (i.e. anything other then /48 & <=/32 prefix size
- Prefix announcement need to send to Internet should be either /32 or /48 bit boundary

Training ISP IPV6 Addressing Plan

IPv6 address plan consideration (RFC3177):

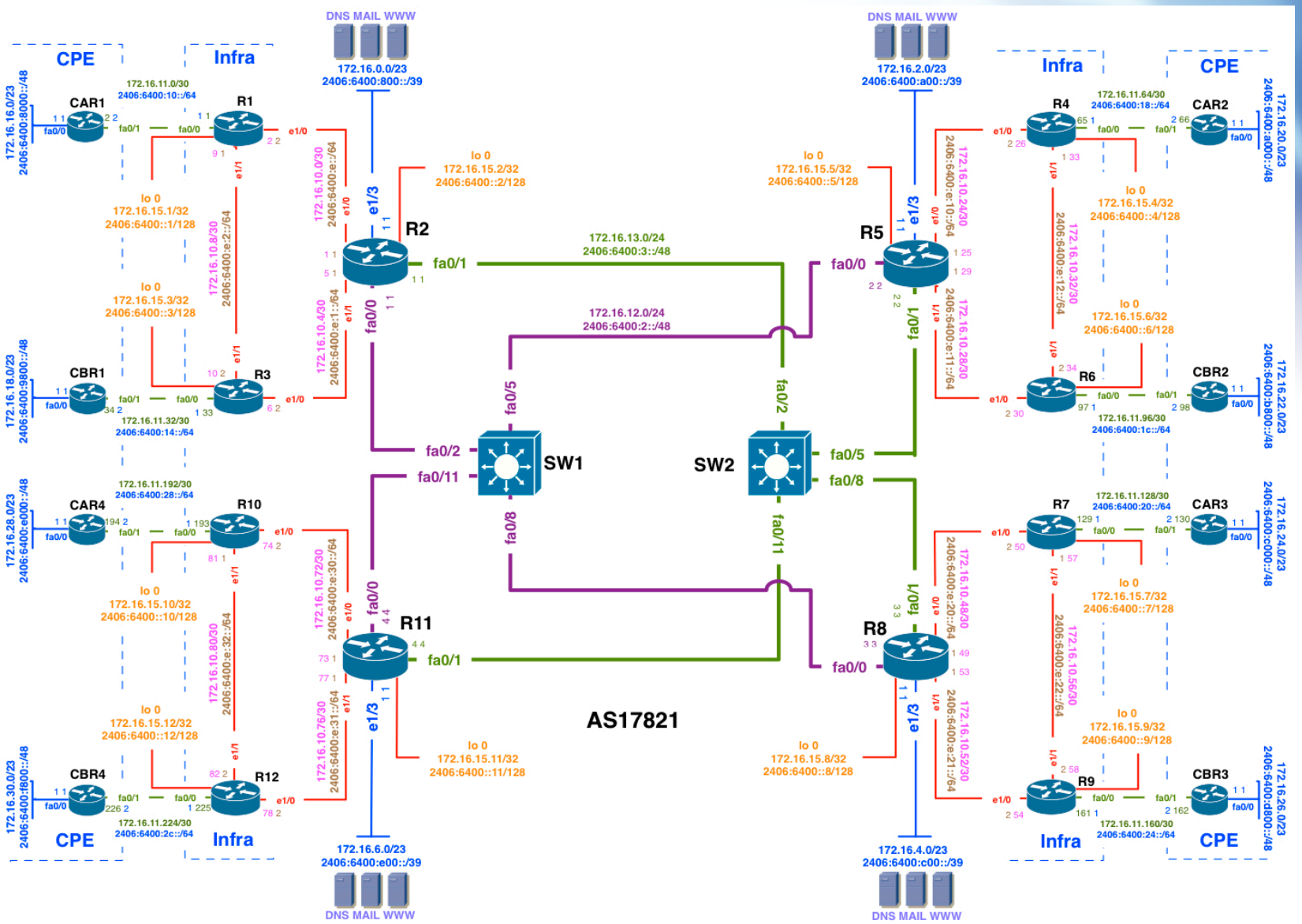
- WAN link can be used on /64 bit boundary
- End site/Customer sub allocation can be made between /48~/64 bit boundary
- APNIC Utilization/HD ratio will be calculated based on /56 end site assignment/sub-allocation

Assignments Guideline to End Sites

The following guidelines may be useful:

- /64
  - Where it is known that only one subnet/Link is required.
- /56
  - For small sites where it is expected only a few subnets/Links will be required within the next two years. I.e. SOHO connecting on demand
- /48
  - For larger sites, or if an end site is expected to grow into a large network.

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 1: Top level distribution infrastructure & customer

Block#	Prefix	Description	Reverse Domain	SOR	Registration
1	**2406:6400::/32**	***Parent Block***	0.0.4.6.6.0.4.2.ip6.arpa.	N/A	APNIC
2	2406:6400:0000:0000::/36	Infrastructure	0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Optional
	2406:6400:1000:0000::/36				
	2406:6400:2000:0000::/36				
	2406:6400:3000:0000::/36				
	2406:6400:4000:0000::/36				
	2406:6400:5000:0000::/36				
	2406:6400:6000:0000::/36				
	2406:6400:7000:0000::/36				
3	2406:6400:8000:0000::/36	Customer network Region 1	8.0.0.4.6.6.0.4.2.ip6.arpa.	Not yet	Optional
	2406:6400:9000:0000::/36				
4	2406:6400:a000:0000::/36	Customer network Region 2	a.0.0.4.6.6.0.4.2.ip6.arpa.	Not yet	Optional
	2406:6400:b000:0000::/36				
5	2406:6400:c000:0000::/36	Customer network Region 3	c.0.0.4.6.6.0.4.2.ip6.arpa.	Not yet	Optional
	2406:6400:d000:0000::/36				
6	2406:6400:e000:0000::/36	Customer network Region 4	e.0.0.4.6.6.0.4.2.ip6.arpa.	Not yet	Optional
	2406:6400:f000:0000::/36				

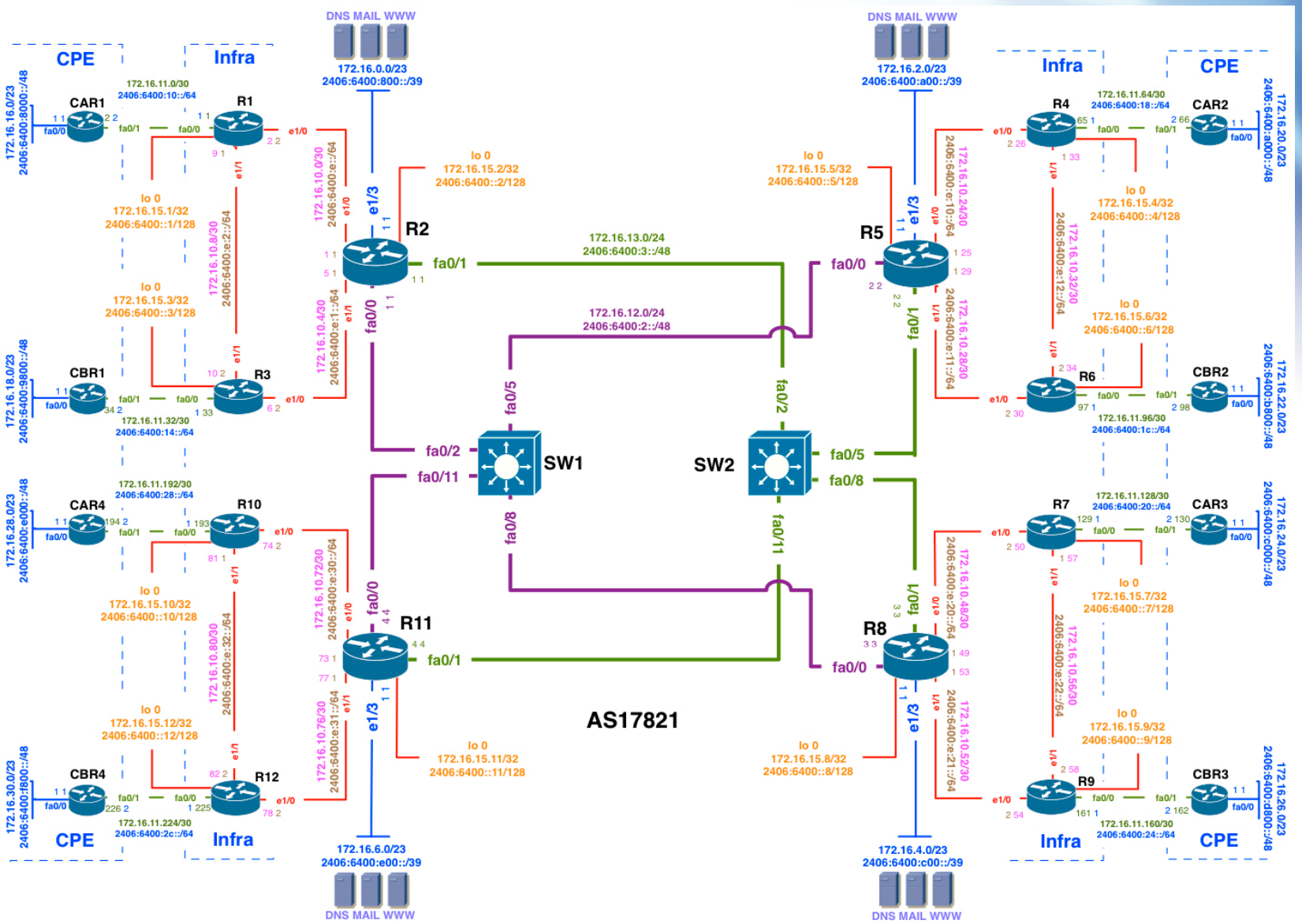
Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 2: Top level summarization option infrastructure & customer

Block#	Prefix	Description	Reverse Domain
7	2406:6400:8000:0000::/35	CS net summary region1 [R2]	2x/36 arpa domain
8	2406:6400:a000:0000::/35	CS net summary region2 [R5]	2x/36 arpa domain
9	2406:6400:c000:0000::/35	CS net summary region3 [R8]	2x/36 arpa domain
10	2406:6400:e000:0000::/35	CS net summary region4 [R11]	2x/36 arpa domain

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 3: Detail distribution infrastructure

Block#	Prefix	Description	Reverse Domain	SOR	Registration
2	***2406:6400:0000:0000::/36***	***Infrastructure***	0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Optional
11	2406:6400:0000:0000::/40	Loopback, Transport & WAN [Infra+CS]	0.0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Optional
	2406:6400:0100:0000::/40				
	2406:6400:0200:0000::/40				
	2406:6400:0300:0000::/40				
	2406:6400:0400:0000::/40				
	2406:6400:0500:0000::/40				
	2406:6400:0600:0000::/40				
	2406:6400:0700:0000::/40				
16	2406:6400:0800:0000::/40	R2 DC	8.0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Recommeded
	2406:6400:0900:0000::/40				
17	2406:6400:0a00:0000::/40	R5 DC	a.0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Recommeded
	2406:6400:0b00:0000::/40				
18	2406:6400:0c00:0000::/40	R8 DC	c.0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Recommeded
	2406:6400:0d00:0000::/40				
19	2406:6400:0e00:0000::/40	R11 DC	e.0.0.0.4.6.6.0.4.2.ip6.arpa.	No	Recommeded
	2406:6400:0f00:0000::/40				

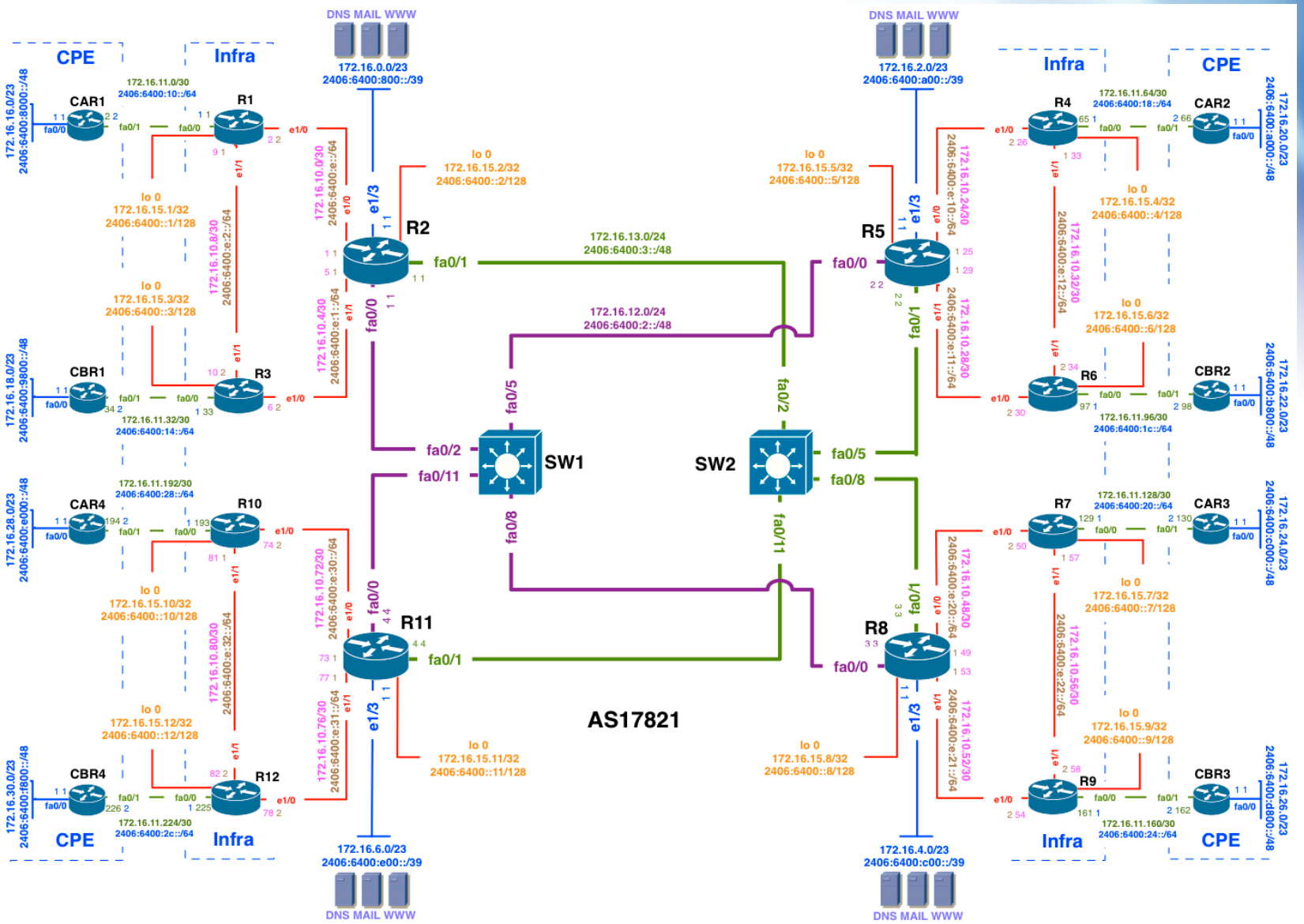
Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 4: Datacenter prefix summarization options

Block#	Prefix	Description	Reverse Domain
12	2406:6400:0800:0000::/39	Region 1 DC Summary [R2]	
13	2406:6400:0a00:0000::/39	Region 2 DC Summary [R5]	
14	2406:6400:0c00:0000::/39	Region 3 DC Summary [R8]	
15	2406:6400:0e00:0000::/39	Region 4 DC Summary [R11]	

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 5: Further detail loopback, transport & infrastructure WAN

Block#	Prefix	Description	Reverse Domain	SOR	Registration
11	***2406:6400:0000:0000::/40***	***Loopback, Transport & Infra WAN***	*0.0.0.0.4.6.6.0.4.2.ip6.arpa.*		
20	2406:6400:0000:0000::/48	Loopback		No	Recommeded
	2406:6400:0001:0000::/48				
21	2406:6400:0002:0000::/48	Purple Transport		No	Recommeded
22	2406:6400:0003:0000::/48	Green Transport		No	Recommeded
	2406:6400:0004:0000::/48				
	2406:6400:0005:0000::/48				
	2406:6400:0006:0000::/48				
	2406:6400:0007:0000::/48				
	2406:6400:0008:0000::/48				
	2406:6400:0009:0000::/48				
	2406:6400:000A:0000::/48				
	2406:6400:000B:0000::/48				
	2406:6400:000C:0000::/48				
	2406:6400:000D:0000::/48				
23	2406:6400:000E:0000::/48	WAN Prefix Infra Link		No	Recommeded
	2406:6400:000F:0000::/48				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 6: Further detail CS link WAN					
Block#	**Prefix**	**Description**	**Reverse Domain**	**SOR**	**Registration**
27	2406:6400:0010:0000::/48	WAN Prefix CS Link R1 Region1		No	Recommeded
	2406:6400:0011:0000::/48				
	2406:6400:0012:0000::/48				
	2406:6400:0013:0000::/48				
28	2406:6400:0014:0000::/48	WAN Prefix CS Link R3 Region1		No	Recommeded
	2406:6400:0015:0000::/48				
	2406:6400:0016:0000::/48				
	2406:6400:0017:0000::/48				
32	2406:6400:0018:0000::/48	WAN Prefix CS Link R4 Region2		No	Recommeded
	2406:6400:0019:0000::/48				
	2406:6400:001A:0000::/48				
	2406:6400:001B:0000::/48				
33	2406:6400:001C:0000::/48	WAN Prefix CS Link R6 Region2		No	Recommeded
	2406:6400:001D:0000::/48				
	2406:6400:001E:0000::/48				
	2406:6400:001F:0000::/48				
37	2406:6400:0020:0000::/48	WAN Prefix CS Link R7 Region3		No	Recommeded
	2406:6400:0021:0000::/48				
	2406:6400:0022:0000::/48				
	2406:6400:0023:0000::/48				
38	2406:6400:0024:0000::/48	WAN Prefix CS Link R9 Region3		No	Recommeded
	2406:6400:0025:0000::/48				
	2406:6400:0026:0000::/48				
	2406:6400:0027:0000::/48				
42	2406:6400:0028:0000::/48	WAN Prefix CS Link R10 Region4		No	Recommeded
	2406:6400:0029:0000::/48				
	2406:6400:002A:0000::/48				
	2406:6400:002B:0000::/48				
43	2406:6400:002C:0000::/48	WAN Prefix CS Link R12 Region4		No	Recommeded
	2406:6400:002D:0000::/48				
	2406:6400:002E:0000::/48				
	2406:6400:002F:0000::/48				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 7: CS link WAN summarization options

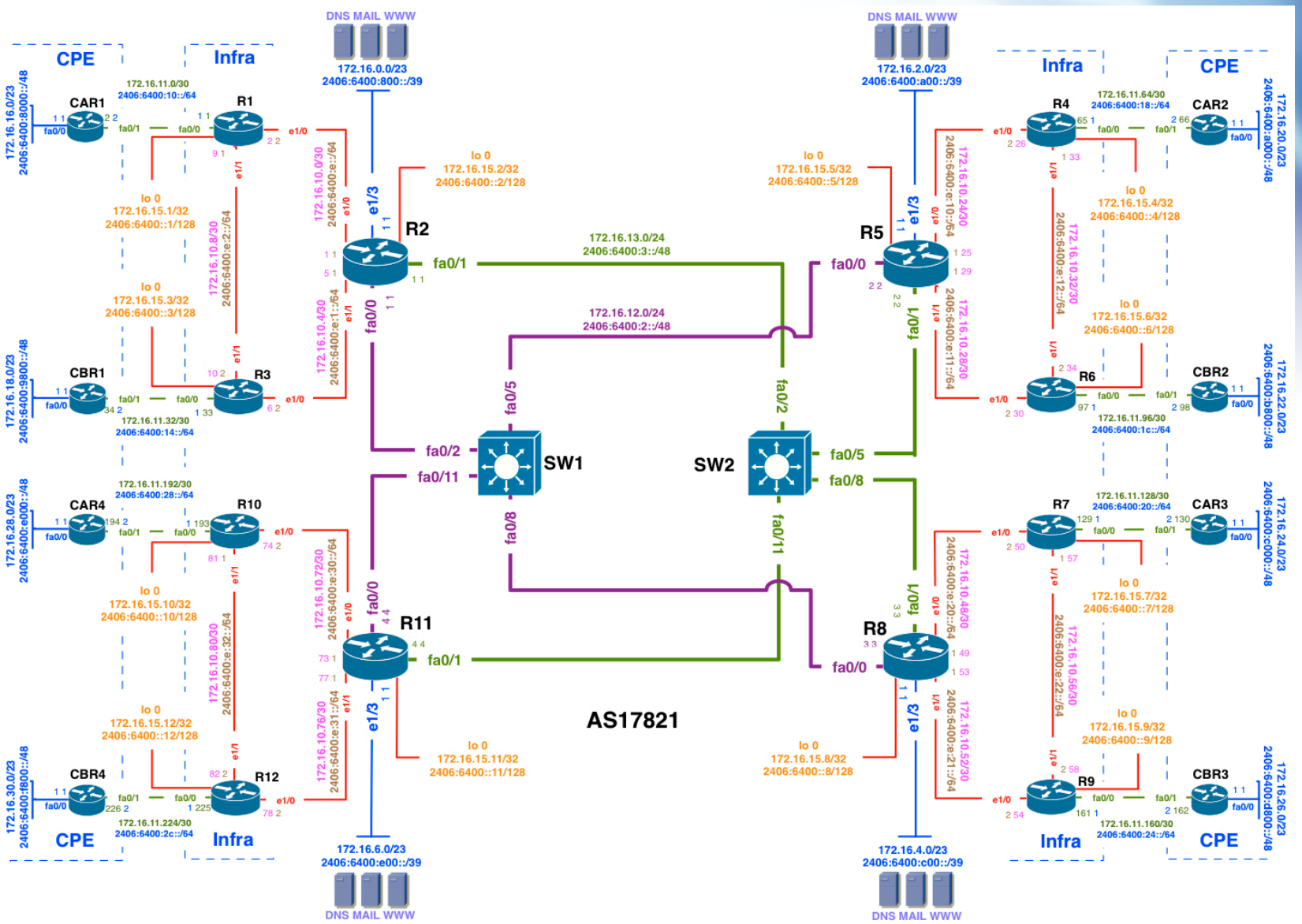
Block#	Prefix	Description	Reverse Domain
24	2406:6400:0010:0000::/45	WAN CS Link Region1 Summary [R2]	
25	2406:6400:0010:0000::/46	WAN CS Link Region1 POP1 Summary [R1]	
26	2406:6400:0014:0000::/46	WAN CS Link Region1 POP2 Summary [R3]	

Block#	Prefix	Description	Reverse Domain
29	2406:6400:0018:0000::/45	WAN Prefix CS Link Region2 Summary [R5]	
30	2406:6400:0018:0000::/46	WAN CS Link Region2 POP1 Summary [R4]	
31	2406:6400:001C:0000::/46	WAN CS Link Region2 POP2 Summary [R6]	

Block#	Prefix	Description	Reverse Domain
34	2406:6400:0020:0000::/45	WAN Prefix CS Link Region3 Summary [R8]	
35	2406:6400:0020:0000::/46	WAN CS Link Region3 POP1 Summary [R7]	
36	2406:6400:0024:0000::/46	WAN CS Link Region3 POP2 Summary [R9]	

Block#	Prefix	Description	Reverse Domain
39	2406:6400:0028:0000::/45	WAN Prefix CS Link Region4 Summary [R11]	
40	2406:6400:0028:0000::/46	WAN CS Link Region4 POP1 Summary [R10]	
41	2406:6400:002C:0000::/46	WAN CS Link Region4 POP2 Summary [R12]	

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 8: Further detail loopback

Block#	Prefix	Description	PTR Record	SOR	Registration
20	2406:6400:0000:0000::/48	Loopback		No	Recommeded
			YES		
43	2406:6400:0000:0000::1/128	Router1 loopback 0	YES	No	No
44	2406:6400:0000:0000::2/128	Router2 loopback 0	YES	No	No
45	2406:6400:0000:0000::3/128	Router3 loopback 0	YES	No	No
46	2406:6400:0000:0000::4/128	Router4 loopback 0	YES	No	No
47	2406:6400:0000:0000::5/128	Router5 loopback 0	YES	No	No
48	2406:6400:0000:0000::6/128	Router6 loopback 0	YES	No	No
49	2406:6400:0000:0000::7/128	Router7 loopback 0	YES	No	No
50	2406:6400:0000:0000::8/128	Router8 loopback 0	YES	No	No
51	2406:6400:0000:0000::9/128	Router9 loopback 0	YES	No	No
52	2406:6400:0000:0000::10/128	Router10 loopback 0	YES	No	No
53	2406:6400:0000:0000::11/128	Router11 loopback 0	YES	No	No
54	2406:6400:0000:0000::12/128	Router12 loopback 0	YES	No	No

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 9: Further detail transport

Block#	Prefix	Description	PTR Record	SOR	Registration
21	2406:6400:0002:0000::/48	Purple Transport		No	Recommeded
	2406:6400:0002:0000::1/48	Router2 fa0/0	YES	No	No
	2406:6400:0002:0000::2/48	Router5 fa0/0	YES	No	No
	2406:6400:0002:0000::3/48	Router8 fa0/0	YES	No	No
	2406:6400:0002:0000::4/48	Router11 fa0/0	YES	No	No
Block#	**Prefix**	**Description**	**PTR Record**	**SOR**	**Registration**
22	2406:6400:0003:0000::/48	Green Transport		No	Recommended
	2406:6400:0003:0000::1/48	Router2 fa0/1	YES	No	No
	2406:6400:0003:0000::2/48	Router5 fa0/1	YES	No	No
	2406:6400:0003:0000::3/48	Router8 fa0/1	YES	No	No
	2406:6400:0003:0000::4/48	Router11 fa0/1	YES	No	No

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 10: Further detail Infra WAN

Block#	Prefix	Description	PTR Record	SOR	Registration
23	2406:6400:000E:0000::/48	WAN Prefix Infra Link		No	Recommeded
55	2406:6400:000E:0000::/64	R2[::1]-R1[::2]	YES	No	No
56	2406:6400:000E:0001::/64	R2[::1]-R3[::2]	YES	No	No
57	2406:6400:000E:0002::/64	R1[::1]-R3[::2]	YES	No	No
	2406:6400:000E:0003::/64				
	2406:6400:000E:0004::/64				
	2406:6400:000E:0005::/64				
	2406:6400:000E:0006::/64				
	2406:6400:000E:0007::/64				
	2406:6400:000E:0008::/64				
	2406:6400:000E:0009::/64				
	2406:6400:000E:000A::/64				
	2406:6400:000E:000B::/64				
	2406:6400:000E:000C::/64				
	2406:6400:000E:000D::/64				
	2406:6400:000E:000E::/64				
	2406:6400:000E:000F::/64				
58	2406:6400:000E:0010::/64	R5[::1]-R4[::2]	YES	No	No
59	2406:6400:000E:0011::/64	R5[::1]-R6[::2]	YES	No	No
60	2406:6400:000E:0012::/64	R4[::1]-R6[::2]	YES	No	No
	2406:6400:000E:0013::/64				
	2406:6400:000E:0014::/64				
	2406:6400:000E:0015::/64				
	2406:6400:000E:0016::/64				
	2406:6400:000E:0017::/64				
	2406:6400:000E:0018::/64				
	2406:6400:000E:0019::/64				
	2406:6400:000E:001A::/64				
	2406:6400:000E:001B::/64				
	2406:6400:000E:001C::/64				
	2406:6400:000E:001D::/64				
	2406:6400:000E:001E::/64				
	2406:6400:000E:001F::/64				
61	2406:6400:000E:0020::/64	R8[::1]-R7[::2]	YES	No	No
62	2406:6400:000E:0021::/64	R8[::1]-R9[::2]	YES	No	No
63	2406:6400:000E:0022::/64	R7[::1]-R9[::2]	YES	No	No
	2406:6400:000E:0023::/64				
	2406:6400:000E:0024::/64				
	2406:6400:000E:0025::/64				
	2406:6400:000E:0026::/64				
	2406:6400:000E:0027::/64				
	2406:6400:000E:0028::/64				
	2406:6400:000E:0029::/64				
	2406:6400:000E:002A::/64				
	2406:6400:000E:002B::/64				
	2406:6400:000E:002C::/64				
	2406:6400:000E:002D::/64				
	2406:6400:000E:002E::/64				
	2406:6400:000E:002F::/64				
64	2406:6400:000E:0030::/64	R11[::1]-R10[::2]	YES	No	No
65	2406:6400:000E:0031::/64	R11[::1]-R12[::2]	YES	No	No
66	2406:6400:000E:0032::/64	R10[::1]-R12[::2]	YES	No	No
	2406:6400:000E:0033::/64				
	2406:6400:000E:0034::/64				
	2406:6400:000E:0035::/64				
	2406:6400:000E:0036::/64				
	2406:6400:000E:0037::/64				
	2406:6400:000E:0038::/64				
	2406:6400:000E:0039::/64				
	2406:6400:000E:003A::/64				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 11: Detail CS link WAN Region 1

Block#	Prefix	Description	PTR Record	SOR	Registration
27	2406:6400:0010:0000::/48	WAN Prefix CS Link R1 Region1		No	Recommeded
	2406:6400:0010:0000::/64	R1[::1]-CAR1[::2]	Yes	No	No
	2406:6400:0010:0001::/64		Yes	No	No
	2406:6400:0010:0002::/64		Yes	No	No
	2406:6400:0010:0003::/64		Yes	No	No
	2406:6400:0010:0004::/64		Yes	No	No
	2406:6400:0010:0005::/64		Yes	No	No
	2406:6400:0010:0006::/64		Yes	No	No
	2406:6400:0010:0007::/64		Yes	No	No
	2406:6400:0010:0008::/64		Yes	No	No
	2406:6400:0010:0009::/64		Yes	No	No
	2406:6400:0010:000A::/64		Yes	No	No
	2406:6400:0010:000B::/64		Yes	No	No
	2406:6400:0010:000C::/64		Yes	No	No
	2406:6400:0010:000D::/64		Yes	No	No
	2406:6400:0010:000E::/64		Yes	No	No
	2406:6400:0010:000F::/64		Yes	No	No
Block#	**Prefix**	**Description**	**PTR Record**	**SOR**	**Registration**
28	2406:6400:0014:0000::/48	WAN Prefix CS Link R3 Region1		No	Recommeded
	2406:6400:0014:0000::/64	R3[::1]-CBR1[::2]	Yes	No	No
	2406:6400:0014:0001::/64		Yes	No	No
	2406:6400:0014:0002::/64		Yes	No	No
	2406:6400:0014:0003::/64		Yes	No	No
	2406:6400:0014:0004::/64		Yes	No	No
	2406:6400:0014:0005::/64		Yes	No	No
	2406:6400:0014:0006::/64		Yes	No	No
	2406:6400:0014:0007::/64		Yes	No	No
	2406:6400:0014:0008::/64		Yes	No	No
	2406:6400:0014:0009::/64		Yes	No	No
	2406:6400:0014:000A::/64		Yes	No	No
	2406:6400:0014:000B::/64		Yes	No	No
	2406:6400:0014:000C::/64		Yes	No	No
	2406:6400:0014:000D::/64		Yes	No	No
	2406:6400:0014:000E::/64		Yes	No	No
	2406:6400:0014:000F::/64		Yes	No	No

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 12: Detail CS link WAN Region 2

Block#	Prefix	Description	PTR Record	SOR	Registration
32	2406:6400:0018:0000::/48	WAN Prefix CS Link R4 Region2		No	Recommeded
	2406:6400:0018:0000::/64	R4[::1]-CAR2[::2]	Yes	No	No
	2406:6400:0018:0001::/64		Yes	No	No
	2406:6400:0018:0002::/64		Yes	No	No
	2406:6400:0018:0003::/64		Yes	No	No
	2406:6400:0018:0004::/64		Yes	No	No
	2406:6400:0018:0005::/64		Yes	No	No
	2406:6400:0018:0006::/64		Yes	No	No
	2406:6400:0018:0007::/64		Yes	No	No
	2406:6400:0018:0008::/64		Yes	No	No
	2406:6400:0018:0009::/64		Yes	No	No
	2406:6400:0018:000A::/64		Yes	No	No
	2406:6400:0018:000B::/64		Yes	No	No
	2406:6400:0018:000C::/64		Yes	No	No
	2406:6400:0018:000D::/64		Yes	No	No
	2406:6400:0018:000E::/64		Yes	No	No
	2406:6400:0018:000F::/64		Yes	No	No
Block#	**Prefix**	**Description**	**PTR Record**	**SOR**	**Registration**
33	2406:6400:001C:0000::/48	WAN Prefix CS Link R6 Region2		No	Recommeded
	2406:6400:001C:0000::/64	R6[::1]-CBR2[::2]	Yes	No	No
	2406:6400:001C:0001::/64		Yes	No	No
	2406:6400:001C:0002::/64		Yes	No	No
	2406:6400:001C:0003::/64		Yes	No	No
	2406:6400:001C:0004::/64		Yes	No	No
	2406:6400:001C:0005::/64		Yes	No	No
	2406:6400:001C:0006::/64		Yes	No	No
	2406:6400:001C:0007::/64		Yes	No	No
	2406:6400:001C:0008::/64		Yes	No	No
	2406:6400:001C:0009::/64		Yes	No	No
	2406:6400:001C:000A::/64		Yes	No	No
	2406:6400:001C:000B::/64		Yes	No	No
	2406:6400:001C:000C::/64		Yes	No	No
	2406:6400:001C:000D::/64		Yes	No	No
	2406:6400:001C:000E::/64		Yes	No	No
	2406:6400:001C:000F::/64		Yes	No	No

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 13: Detail CS link WAN Region3					
Block#	**Prefix**	**Description**	**PTR Record**	**SOR**	**Registration**
37	2406:6400:0020:0000::/48	WAN Prefix CS Link R7 Region3		No	Recommeded
	2406:6400:0020:0000::/64	R7[::1]-CAR3[::2]	Yes	No	No
	2406:6400:0020:0001::/64		Yes	No	No
	2406:6400:0020:0002::/64		Yes	No	No
	2406:6400:0020:0003::/64		Yes	No	No
	2406:6400:0020:0004::/64		Yes	No	No
	2406:6400:0020:0005::/64		Yes	No	No
	2406:6400:0020:0006::/64		Yes	No	No
	2406:6400:0020:0007::/64		Yes	No	No
	2406:6400:0020:0008::/64		Yes	No	No
	2406:6400:0020:0009::/64		Yes	No	No
	2406:6400:0020:000A::/64		Yes	No	No
	2406:6400:0020:000B::/64		Yes	No	No
	2406:6400:0020:000C::/64		Yes	No	No
	2406:6400:0020:000D::/64		Yes	No	No
	2406:6400:0020:000E::/64		Yes	No	No
	2406:6400:0020:000F::/64		Yes	No	No
Block#	**Prefix**	**Description**	**PTR Record**	**SOR**	**Registration**
38	2406:6400:0024:0000::/48	WAN Prefix CS Link R9 Region3		No	Recommeded
	2406:6400:0024:0000::/64	R9[::1]-CBR3[::2]	Yes	No	No
	2406:6400:0024:0001::/64		Yes	No	No
	2406:6400:0024:0002::/64		Yes	No	No
	2406:6400:0024:0003::/64		Yes	No	No
	2406:6400:0024:0004::/64		Yes	No	No
	2406:6400:0024:0005::/64		Yes	No	No
	2406:6400:0024:0006::/64		Yes	No	No
	2406:6400:0024:0007::/64		Yes	No	No
	2406:6400:0024:0008::/64		Yes	No	No
	2406:6400:0024:0009::/64		Yes	No	No
	2406:6400:0024:000A::/64		Yes	No	No
	2406:6400:0024:000B::/64		Yes	No	No
	2406:6400:0024:000C::/64		Yes	No	No
	2406:6400:0024:000D::/64		Yes	No	No
	2406:6400:0024:000E::/64		Yes	No	No
	2406:6400:0024:000F::/64		Yes	No	No

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 15: Customer block Region 1

Block#	Prefix	Description	Reverse DNS	SOR	Registration
7	2406:6400:8000:0000::/35	Customer block Region 1			
	2406:6400:8000:0000::/40	Customer block POP1 [R1]		>= /48 Yes	Yes
	2406:6400:8100:0000::/40				
	2406:6400:8200:0000::/40				
	2406:6400:8300:0000::/40				
	2406:6400:8400:0000::/40				
	2406:6400:8500:0000::/40				
	2406:6400:8600:0000::/40				
	2406:6400:8700:0000::/40				
	2406:6400:8800:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:8900:0000::/40				
	2406:6400:8A00:0000::/40				
	2406:6400:8B00:0000::/40				
	2406:6400:8C00:0000::/40				
	2406:6400:8D00:0000::/40				
	2406:6400:8E00:0000::/40				
	2406:6400:8F00:0000::/40				
	2406:6400:9000:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:9100:0000::/40				
	2406:6400:9200:0000::/40				
	2406:6400:9300:0000::/40				
	2406:6400:9400:0000::/40				
	2406:6400:9500:0000::/40				
	2406:6400:9600:0000::/40				
	2406:6400:9700:0000::/40				
	2406:6400:9800:0000::/40	Customer block POP2 [R3]		>= /48 Yes	Yes
	2406:6400:9900:0000::/40				
	2406:6400:9A00:0000::/40				
	2406:6400:9B00:0000::/40				
	2406:6400:9C00:0000::/40				
	2406:6400:9D00:0000::/40				
	2406:6400:9E00:0000::/40				
	2406:6400:9F00:0000::/40				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 16: Summarization oprions customer block Region 1			
Block#	**Prefix**	**Description**	**Reverse Domain**
	2406:6400:8000:0000::/35	Customer block Region 1 [R2]	
	2406:6400:8000:0000::/37	Customer block POP1 [R1]	
	2406:6400:8800:0000::/37	Customer block future use/POP	
	2406:6400:9000:0000::/37	Customer block future use/POP	
	2406:6400:9800:0000::/37	Customer block POP2 [R3]	

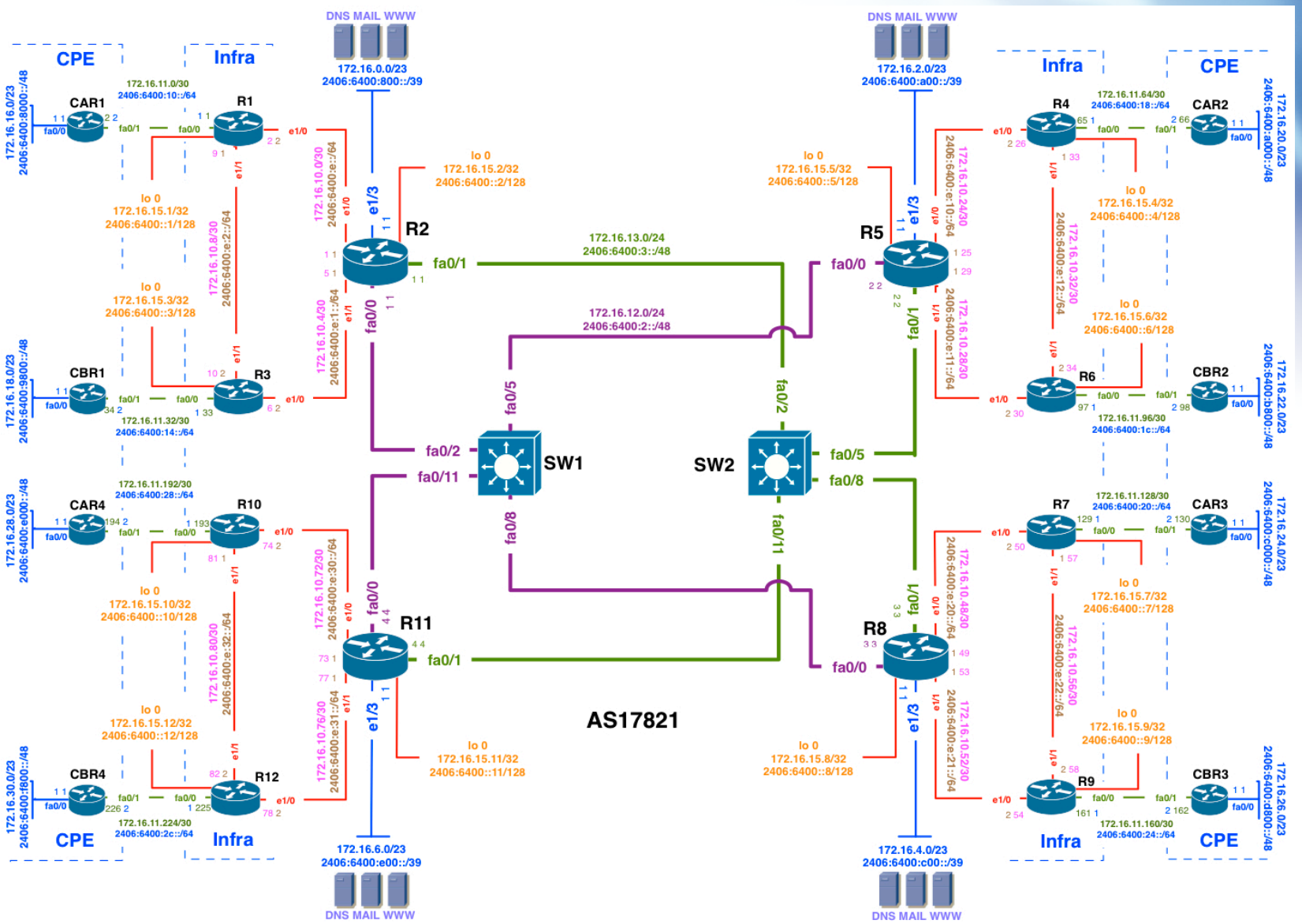
Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 17: Detail customer block Region 1

Block#	Prefix	Description	Reverse DNS	SOR	Registration
	2406:6400:8000:0000::/40	1st Customer block POP1 [R1]			
	2406:6400:8000:0000::/48	1st Customer prefix POP1 [R1]		Yes	Yes
	2406:6400:8001:0000::/48				
	2406:6400:8002:0000::/48				
	2406:6400:8003:0000::/48				
	2406:6400:8004:0000::/48				
	2406:6400:8005:0000::/48				
	2406:6400:8006:0000::/48				
	2406:6400:8007:0000::/48				
	2406:6400:9800:0000::/40	1st Customer block POP2 [R3]			
	2406:6400:9800:0000::/48	1st Customer prefix POP2 [R3]		Yes	Yes
	2406:6400:9801:0000::/48				
	2406:6400:9802:0000::/48				
	2406:6400:9803:0000::/48				
	2406:6400:9804:0000::/48				
	2406:6400:9805:0000::/48				
	2406:6400:9806:0000::/48				
	2406:6400:9807:0000::/48				

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 18: Customer block Region 2					
Block#	**Prefix**	**Description**	**Reverse DNS**	**SOR**	**Registration**
8	2406:6400:a000:0000::/35	Customer block Region 2			
	2406:6400:A000:0000::/40	Customer block POP1 [R4]		>= /48 Yes	Yes
	2406:6400:A100:0000::/40				
	2406:6400:A200:0000::/40				
	2406:6400:A300:0000::/40				
	2406:6400:A400:0000::/40				
	2406:6400:A500:0000::/40				
	2406:6400:A600:0000::/40				
	2406:6400:A700:0000::/40				
	2406:6400:A800:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:A900:0000::/40				
	2406:6400:AA00:0000::/40				
	2406:6400:AB00:0000::/40				
	2406:6400:AC00:0000::/40				
	2406:6400:AD00:0000::/40				
	2406:6400:AE00:0000::/40				
	2406:6400:AF00:0000::/40				
	2406:6400:B000:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:B100:0000::/40				
	2406:6400:B200:0000::/40				
	2406:6400:B300:0000::/40				
	2406:6400:B400:0000::/40				
	2406:6400:B500:0000::/40				
	2406:6400:B600:0000::/40				
	2406:6400:B700:0000::/40				
	2406:6400:B800:0000::/40	Customer block POP2 [R6]		>= /48 Yes	Yes
	2406:6400:B900:0000::/40				
	2406:6400:BA00:0000::/40				
	2406:6400:BB00:0000::/40				
	2406:6400:BC00:0000::/40				
	2406:6400:BD00:0000::/40				
	2406:6400:BE00:0000::/40				
	2406:6400:BF00:0000::/40				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 19: Summarization oprions customer block Region 2			
Block#	**Prefix**	**Description**	**Reverse Domain**
	2406:6400:A000:0000::/35	Customer block Region 2 [R5]	
	2406:6400:A000:0000::/37	Customer block POP1 [R4]	
	2406:6400:A800:0000::/37	Customer block future use/POP	
	2406:6400:B000:0000::/37	Customer block future use/POP	
	2406:6400:B800:0000::/37	Customer block POP2 [R6]	

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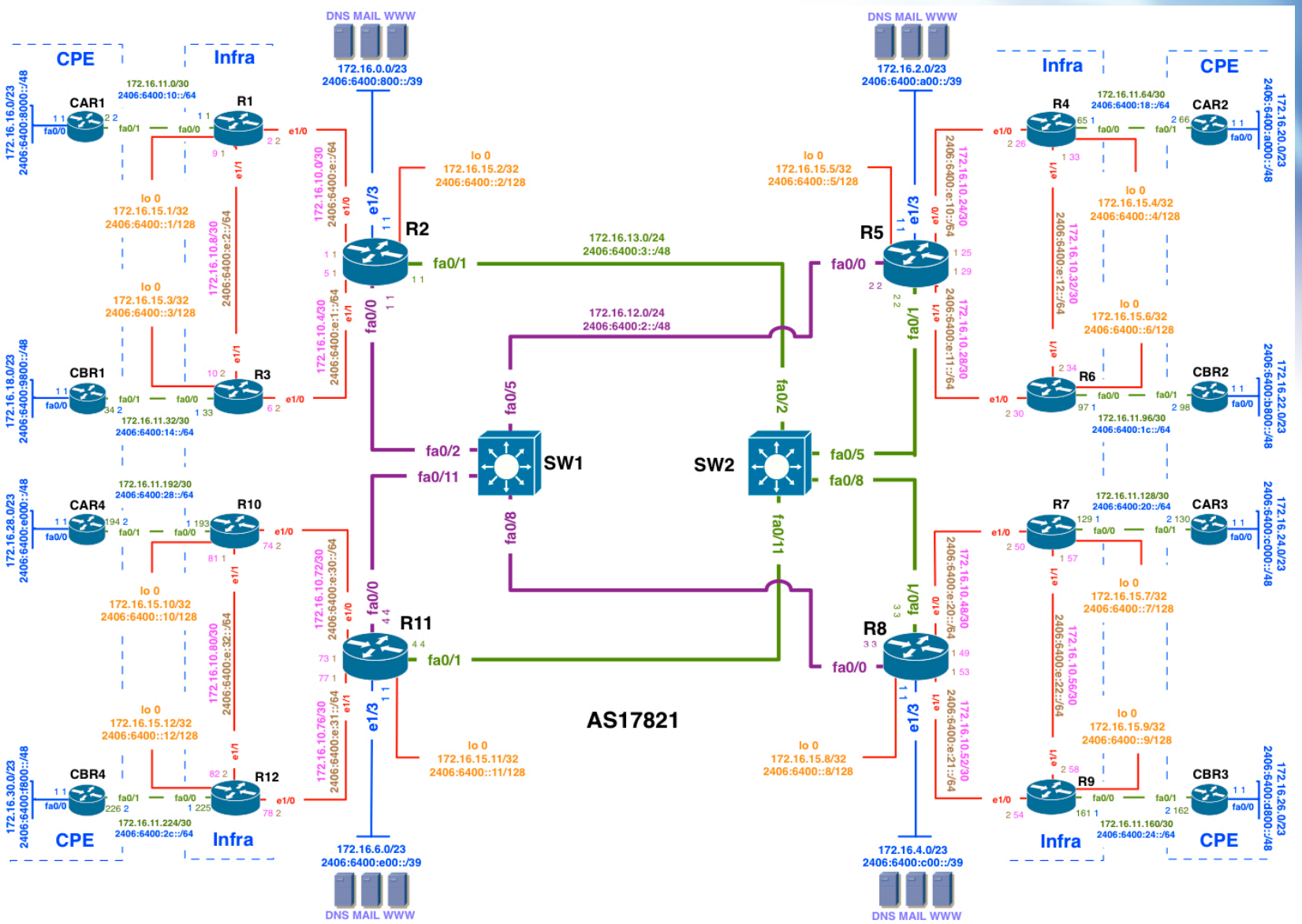


Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 20: Detail customer block Region 2

Block#	Prefix	Description	Reverse DNS	SOR	Registration
	2406:6400:A000:0000::/40	1st Customer block POP1 [R4]			
	2406:6400:A000:0000::/48	1st Customer prefix POP1 [R4]		Yes	Yes
	2406:6400:A001:0000::/48				
	2406:6400:A002:0000::/48				
	2406:6400:A003:0000::/48				
	2406:6400:A004:0000::/48				
	2406:6400:A005:0000::/48				
	2406:6400:A006:0000::/48				
	2406:6400:A007:0000::/48				
	2406:6400:B800:0000::/40	1st Customer block POP2 [R6]			
	2406:6400:B800:0000::/48	1st Customer prefix POP2 [R6]		Yes	Yes
	2406:6400:B801:0000::/48				
	2406:6400:B802:0000::/48				
	2406:6400:B803:0000::/48				
	2406:6400:B804:0000::/48				
	2406:6400:B805:0000::/48				
	2406:6400:B806:0000::/48				
	2406:6400:B807:0000::/48				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 21: Customer block Region 3

Block#	Prefix	Description	Reverse DNS	SOR	Registration
9	2406:6400:c000:0000::/35	Customer block Region 3			
	2406:6400:C000:0000::/40	Customer block POP1 [R7]		>= /48 Yes	Yes
	2406:6400:C100:0000::/40				
	2406:6400:C200:0000::/40				
	2406:6400:C300:0000::/40				
	2406:6400:C400:0000::/40				
	2406:6400:C500:0000::/40				
	2406:6400:C600:0000::/40				
	2406:6400:C700:0000::/40				
	2406:6400:C800:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:C900:0000::/40				
	2406:6400:CA00:0000::/40				
	2406:6400:CB00:0000::/40				
	2406:6400:CC00:0000::/40				
	2406:6400:CD00:0000::/40				
	2406:6400:CE00:0000::/40				
	2406:6400:CF00:0000::/40				
	2406:6400:D000:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:D100:0000::/40				
	2406:6400:D200:0000::/40				
	2406:6400:D300:0000::/40				
	2406:6400:D400:0000::/40				
	2406:6400:D500:0000::/40				
	2406:6400:D600:0000::/40				
	2406:6400:D700:0000::/40				
	2406:6400:D800:0000::/40	Customer block POP2 [R9]		>= /48 Yes	Yes
	2406:6400:D900:0000::/40				
	2406:6400:DA00:0000::/40				
	2406:6400:DB00:0000::/40				
	2406:6400:DC00:0000::/40				
	2406:6400:DD00:0000::/40				
	2406:6400:DE00:0000::/40				
	2406:6400:DF00:0000::/40				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 22: Summarization oprions customer block Region 3			
Block#	**Prefix**	**Description**	**Reverse Domain**
	2406:6400:c000:0000::/35	Customer block Region 3 [R8]	
	2406:6400:C000:0000::/37	Customer block POP1 [R7]	
	2406:6400:C800:0000::/37	Customer block future use/POP	
	2406:6400:D000:0000::/37	Customer block future use/POP	
	2406:6400:D800:0000::/37	Customer block POP2 [R9]	

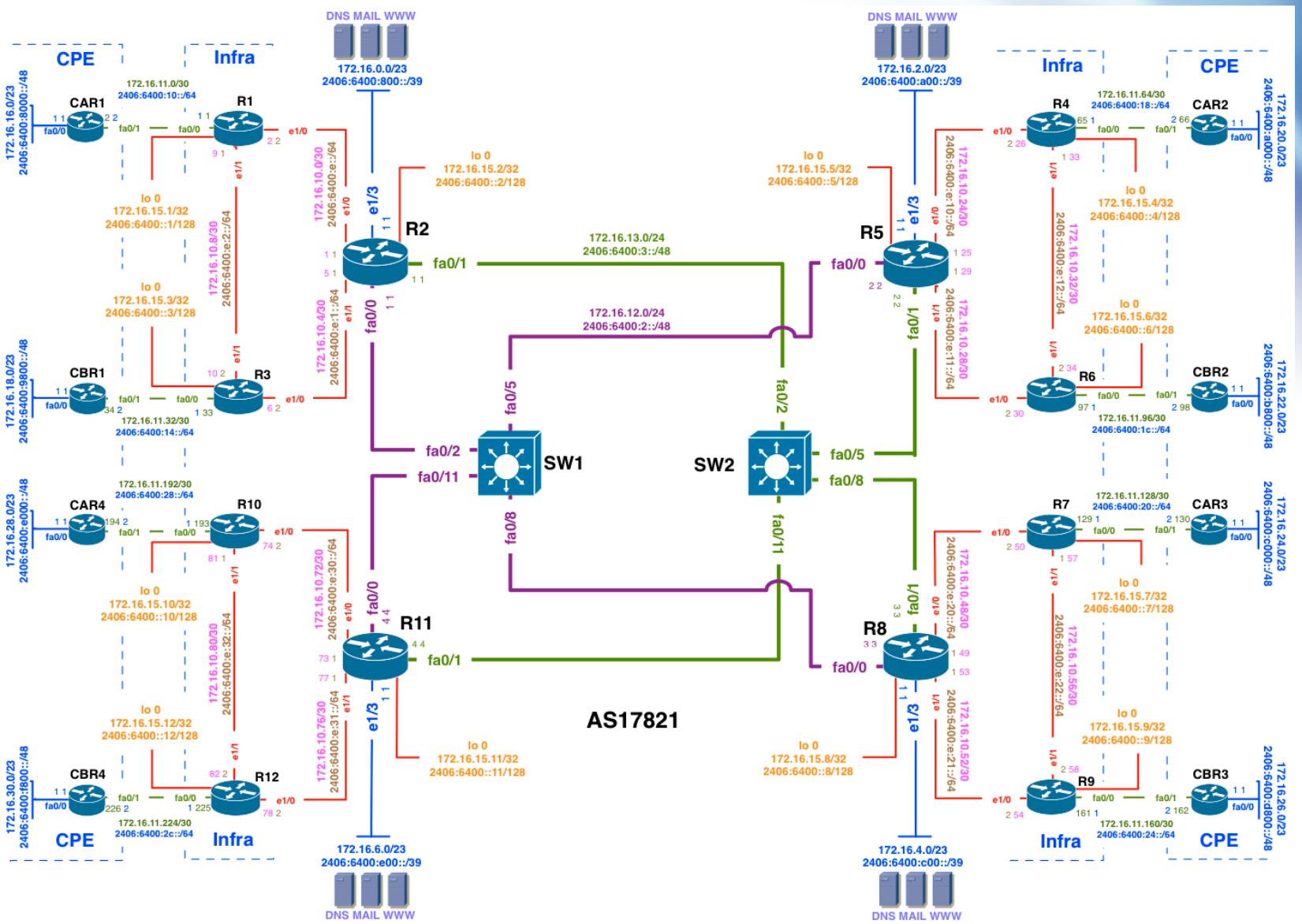
Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 23: Detail customer block Region 3

Block#	Prefix	Description	Reverse DNS	SOR	Registration
	2406:6400:C000:0000::/40	1st Customer block POP1 [R7]			
	2406:6400:C000:0000::/48	1st Customer prefix POP1 [R7]		Yes	Yes
	2406:6400:C001:0000::/48				
	2406:6400:C002:0000::/48				
	2406:6400:C003:0000::/48				
	2406:6400:C004:0000::/48				
	2406:6400:C005:0000::/48				
	2406:6400:C006:0000::/48				
	2406:6400:C007:0000::/48				
	2406:6400:D800:0000::/40	1st Customer block POP2 [R9]			
	2406:6400:D800:0000::/48	1st Customer prefix POP2 [R9]		Yes	Yes
	2406:6400:D801:0000::/48				
	2406:6400:D802:0000::/48				
	2406:6400:D803:0000::/48				
	2406:6400:D804:0000::/48				
	2406:6400:D805:0000::/48				
	2406:6400:D806:0000::/48				
	2406:6400:D807:0000::/48				

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

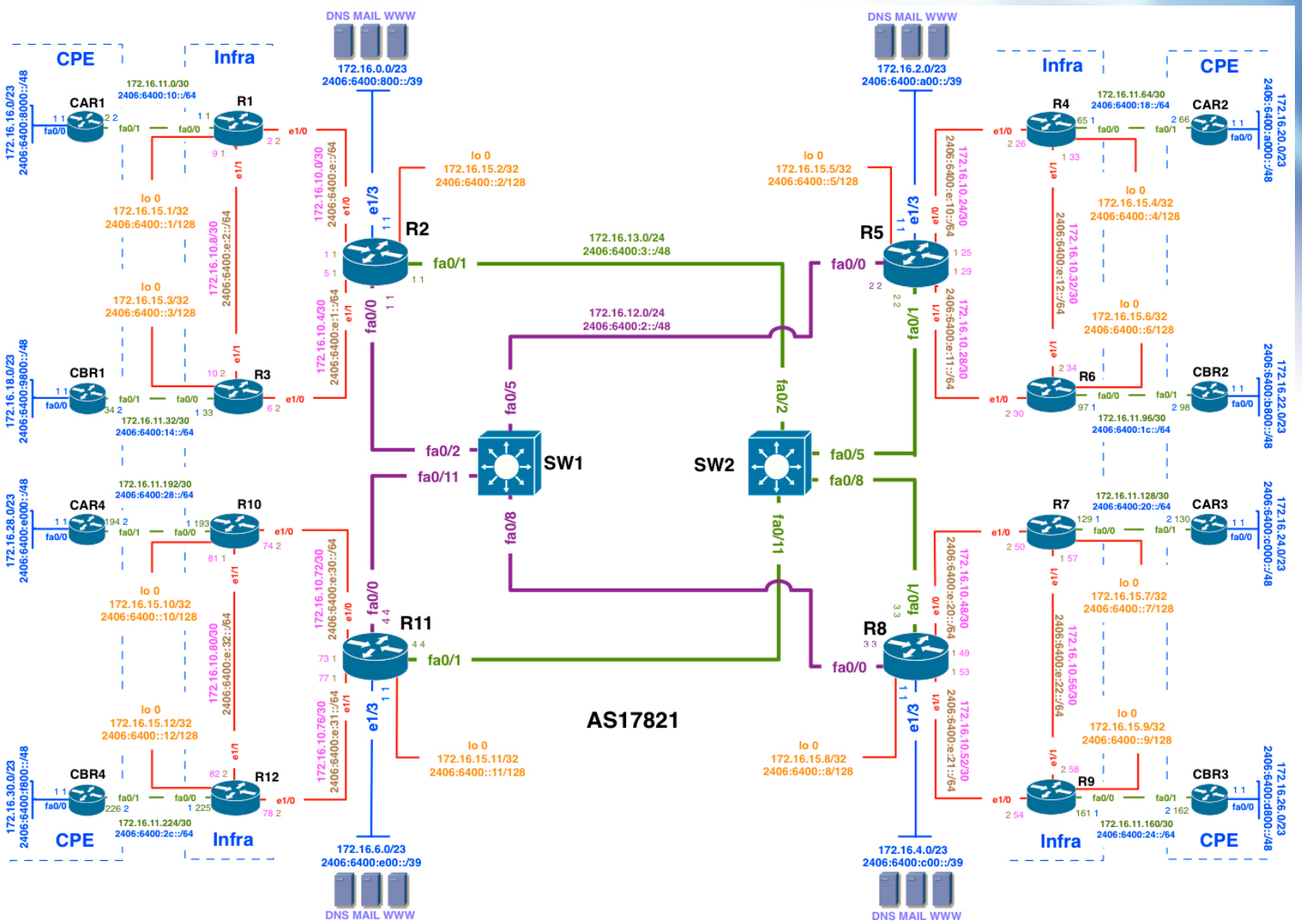
Table 24: Customer block Region 4					
Block#	**Prefix**	**Description**	**Reverse DNS**	**SOR**	**Registration**
10	2406:6400:e000:0000::/35	Customer block Region 4			
	2406:6400:E000:0000::/40	Customer block POP1 [R10]		>= /48 Yes	Yes
	2406:6400:E100:0000::/40				
	2406:6400:E200:0000::/40				
	2406:6400:E300:0000::/40				
	2406:6400:E400:0000::/40				
	2406:6400:E500:0000::/40				
	2406:6400:E600:0000::/40				
	2406:6400:E700:0000::/40				
	2406:6400:E800:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:E900:0000::/40				
	2406:6400:EA00:0000::/40				
	2406:6400:EB00:0000::/40				
	2406:6400:EC00:0000::/40				
	2406:6400:ED00:0000::/40				
	2406:6400:EE00:0000::/40				
	2406:6400:EF00:0000::/40				
	2406:6400:F000:0000::/40	Customer block future use/POP		>= /48 Yes	Yes
	2406:6400:F100:0000::/40				
	2406:6400:F200:0000::/40				
	2406:6400:F300:0000::/40				
	2406:6400:F400:0000::/40				
	2406:6400:F500:0000::/40				
	2406:6400:F600:0000::/40				
	2406:6400:F700:0000::/40				
	2406:6400:F800:0000::/40	Customer block POP2 [R12]		>= /48 Yes	Yes
	2406:6400:F900:0000::/40				
	2406:6400:FA00:0000::/40				
	2406:6400:FB00:0000::/40				
	2406:6400:FC00:0000::/40				
	2406:6400:FD00:0000::/40				
	2406:6400:FE00:0000::/40				
	2406:6400:FF00:0000::/40				

Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 25: Summarization oprions customer block Region 4			
Block#	**Prefix**	**Description**	**Reverse Domain**
	2406:6400:e000:0000::/35	Customer block Region 4 [R11]	
	2406:6400:E000:0000::/37	Customer block POP1 [R10]	
	2406:6400:E800:0000::/37	Customer block future use/POP	
	2406:6400:F000:0000::/37	Customer block future use/POP	
	2406:6400:F800:0000::/37	Customer block POP2 [R12]	

Training ISP IPV6 Addressing Plan



Training ISP IPV6 Addressing Plan

IPv6 Address Plan:

Table 26: Detail customer block Region 4

Block#	Prefix	Description	Reverse DNS	SOR	Registration
	2406:6400:E000:0000::/40	1st Customer block POP1 [R10]			
	2406:6400:E000:0000::/48	1st Customer prefix POP1 [R10]		Yes	Yes
	2406:6400:E001:0000::/48				
	2406:6400:E002:0000::/48				
	2406:6400:E003:0000::/48				
	2406:6400:E004:0000::/48				
	2406:6400:E005:0000::/48				
	2406:6400:E006:0000::/48				
	2406:6400:E007:0000::/48				
	2406:6400:F800:0000::/40	1st Customer block POP2 [R10]			
	2406:6400:F800:0000::/48	1st Customer prefix POP2 [R10]		Yes	Yes
	2406:6400:F801:0000::/48				
	2406:6400:F802:0000::/48				
	2406:6400:F803:0000::/48				
	2406:6400:F804:0000::/48				
	2406:6400:F805:0000::/48				
	2406:6400:F806:0000::/48				
	2406:6400:F807:0000::/48				

Training ISP IPV4 Addressing Plan

Current IPv4 Addressing Plan:

Summary parent block IPV4

Block#	Prefix	Size	Description
1	172.16.0.0	/19	Parent block
2	172.16.0.0	/20	Infrastructure
3	172.16.16.0	/20	Customer network

Training ISP IPV4 Addressing Plan

Current IPv4 Addressing Plan:

Detail DC infrastructure block IPV4

Block#	Prefix	Size	Description	SOR	Register
2	172.16.0.0	/20	Infrastructure		
4	172.16.0.0	/23	Router2 DC summary net		
5	172.16.0.0	/24	Router2 DC	No	Recommended
6	172.16.2.0	/23	Router5 DC summary net		
7	172.16.2.0	/24	Router5 DC	No	Recommended
8	172.16.4.0	/23	Router8 DC summary net		
9	172.16.4.0	/24	Router8 DC	No	Recommended
10	172.16.6.0	/23	Router11 DC summary net		
11	172.16.6.0	/24	Router11 DC	No	Recommended

Training ISP IPV4 Addressing Plan

Current IPv4 Addressing Plan:

Detail infrastructure WAN block IPV4

12	172.16.10.0	/24	WAN prefix		Optional
13	172.16.10.0	/30	Router2-1 WAN	No	
14	172.16.10.4	/30	Router2-3 WAN	No	
15	172.16.10.8	/30	Router1-3 WAN	No	
16	172.16.10.24	/30	Router5-4 WAN	No	
17	172.16.10.28	/30	Router5-6 WAN	No	
18	172.16.10.32	/30	Router4-6 WAN	No	
19	172.16.10.48	/30	Router8-7 WAN	No	
20	172.16.10.52	/30	Router8-9 WAN	No	
21	172.16.10.56	/30	Router7-9 WAN	No	
22	172.16.10.72	/30	Router11-10 WAN	No	
23	172.16.10.76	/30	Router11-12 WAN	No	
24	172.16.10.80	/30	Router10-12 WAN	No	

Training ISP IPV4 Addressing Plan

Current IPv4 Addressing Plan:

Detail customer link WAN block

Block#	Prefix	Size	Description	SOR	Register
	172.16.11.0	/26	WAN CS Link Region1		
	172.16.11.0	/27	WAN CS Link POP1 [R1]		
	172.16.11.0	/30	R1[::1]-CAR1[::2]	No	No
	172.16.11.4	/30			
	172.16.11.32	/27	WAN CS Link POP2 [R3]		
	172.16.11.32	/30	R3[::33]-CBR1[::34]	No	No
	172.16.11.36	/30			
	172.16.11.64	/26	WAN CS Link Region2		
	172.16.11.64	/27	WAN CS Link POP1 [R4]		
	172.16.11.64	/30	R4[::65]-CAR2[::66]	No	No
	172.16.11.68	/30			
	172.16.11.96	/27	WAN CS Link POP2 [R6]		
	172.16.11.96	/30	R6[::97]-CBR2[::98]	No	No
	172.16.11.100	/30			
	172.16.11.128	/26	WAN CS Link Region3		
	172.16.11.128	/27	WAN CS Link POP1 [R7]		
	172.16.11.128	/30	R7[::129]-CAR3[::130]	No	No
	172.16.11.132	/30			
	172.16.11.160	/27	WAN CS Link POP2 [R9]		
	172.16.11.160	/30	R9[::161]-CBR3[::162]	No	No
	172.16.11.164	/30			
	172.16.11.192	/26	WAN CS Link Region4		
	172.16.11.192	/27	WAN CS Link POP1 [R10]		
	172.16.11.192	/30	R10[::193]-CAR4[::194]	No	No
	172.16.11.196	/30			
	172.16.11.224	/27	WAN CS Link POP2 [R12]		
	172.16.11.224	/30	R12[::225]-CBR4[::226]	No	No
	172.16.11.228	/30			

Training ISP IPV4 Addressing Plan

Current IPv4 Addressing Plan:

Detail infrastructure block Transport & Loopback IPV4

25	172.16.12.0	/24	Transport link PURPLE	No	
26	172.16.13.0	/24	Transport link GREEN	No	
27	172.16.15.0	/24	Loopback	No	

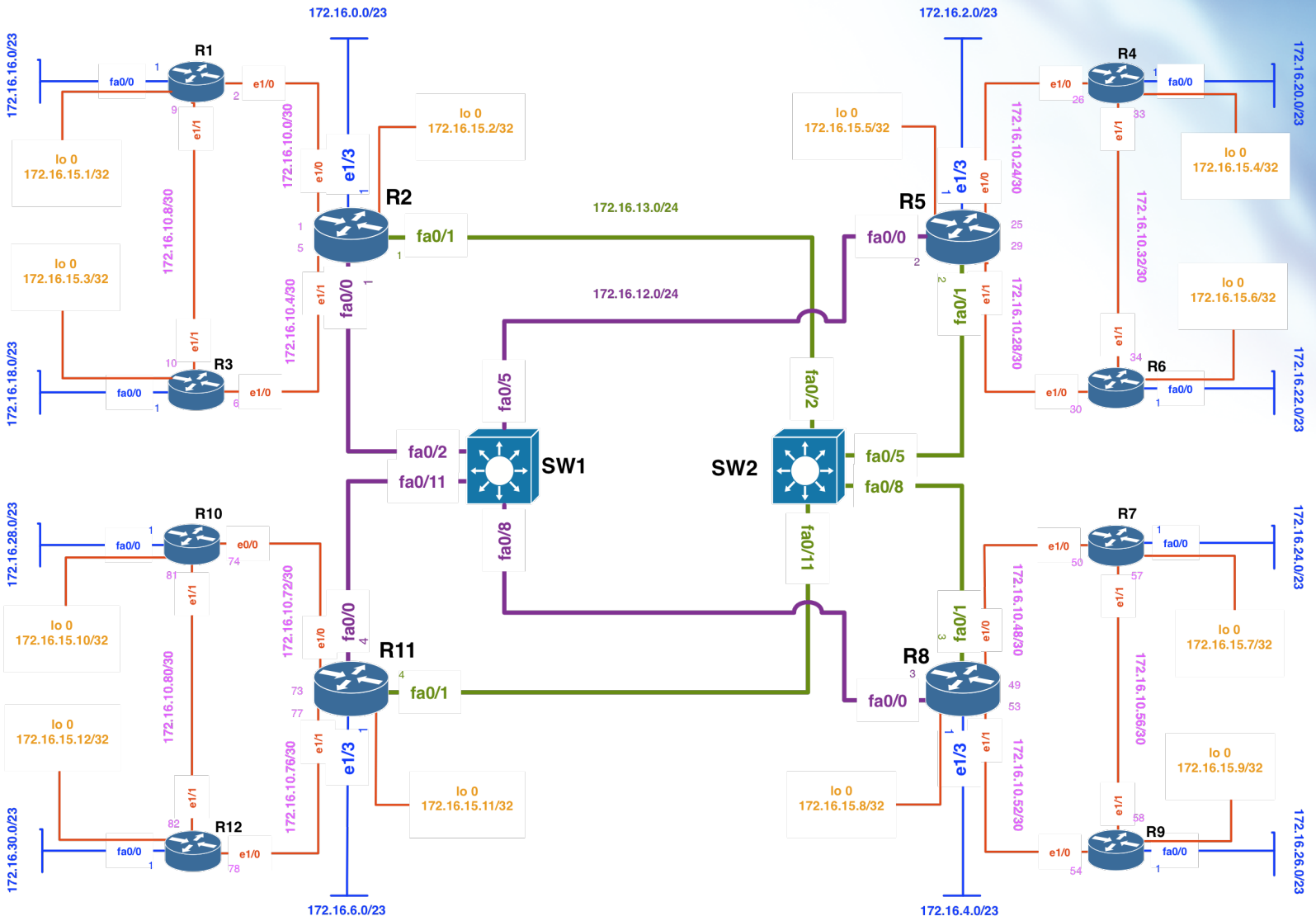
Training ISP IPV4 Addressing Plan

Current IPv4 Addressing Plan:

Detail customer block

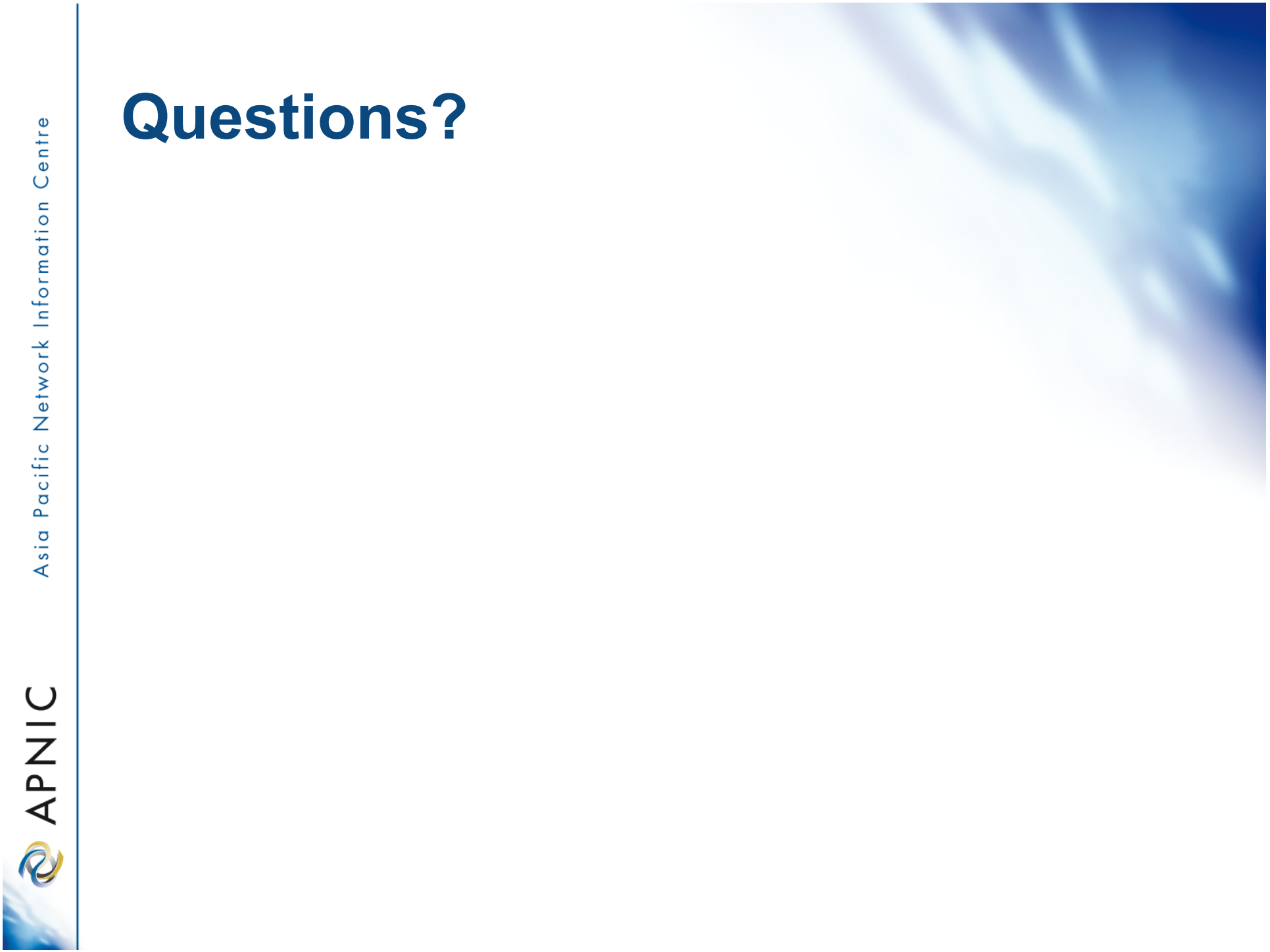
Block#	Prefix	Size	Description	SOR	Register
28	172.16.6.0	/20	Customer network		
29	172.16.16.0	/22	Router2 summary net		
30	172.16.16.0	/23	Router1 CS network	Yes	Must
31	172.16.18.0	/23	Router3 CS network	Yes	Must
32	172.16.20.0	/22	Router5 summary net		
33	172.16.20.0	/23	Router4 CS network	Yes	Must
34	172.16.22.0	/23	Router6 CS network	Yes	Must
35	172.16.24.0	/22	Router8 summary net		
36	172.16.24.0	/23	Router7 CS network	Yes	Must
37	172.16.26.0	/23	Router9 CS network	Yes	Must
38	172.16.28.0	/22	Router11 summary net		
39	172.16.28.0	/23	Router10 CS network	Yes	Must
40	172.16.30.0	/23	Router12 CS network	Yes	Must

Training ISP IPV4 Addressing Plan



Training ISP IPv4 Address Plan

Questions?



Overview

IPv6 Deployment Tutorial

- IPv6 Protocol Architecture Overview
- IPV6 Addressing and Sub-netting
- IPv6 Addressing plan case study
- **IPv6 Host Configuration**

Configuration of IPv6 Node Address

- There are 3 ways to configure IPv6 address on an IPv6 node:
  - Static address configuration
  - DHCPv6 assigned node address
  - Auto-configuration [New feature in IPv6]

Configuration of IPv6 Node Address

Quantity	Address	Requirement	Context
One	Loopback [::1]	Must define	Each node
One	Link-local	Must define	Each Interface
Zero to many	Unicast	Optional	Each interface
Zero to many	Unique-local	Optional	Each interface
One	All-nodes multicast [ff02::1]	Must listen	Each interface
One	Solicited-node multicast ff02:0:0:0:0:1:ff/104	Must listen	Each unicast and anycast define
Any	Multicast Group	Optional listen	Each interface

ULA are unicast address globally unique but used locally within sites. Any sites can have /48 for private use. Each /48 is globally unique so no Collision of identical address in future when they connect together

Source: Migrating to IPv6, Marc Blanchet

Exercise 1: IPv6 Host Configuration

- Windows XP SP2
- *netsh interface ipv6 install*

- Windows XP
- *ipv6 install*

Exercise 1: IPv6 Host Configuration

- Configuring an interface
  - *netsh interface ipv6 add address "Local Area Connection" 2406:6400::1*

- Prefix length is not specified with address which will force a /64 on the interface

Exercise 1: IPv6 Host Configuration

Verify your Configuration

- c:\>ipconfig

Verify your neighbor table

- c:\>netsh interface ipv6 show neighbors

Exercise 1: IPv6 Host Configuration

- Disable privacy state variable

C:\> netsh interface ipv6 set privacy state=disable

OR

C:\> netsh interface ipv6 set global randomizeidentifiers=disabled

Exercise 1: IPv6 Host Configuration

Testing your configuration

- *ping fe80::260:97ff:fe02:6ea5%4*

Note: the Zone id is YOUR interface index

Exercise 1: IPv6 Host Configuration

- Enabling IPv6 on Linux
  - Set the NETWORKING_IPV6 variable to yes in /etc/sysconfig/network

```
# vi /etc/sysconfig/network
NETWORKING_IPV6=yes
# service network restart
```

- Adding IPv6 address on an interface

```
# ifconfig eth0 add inet6 2406:6400::1/64
```

Exercise 1: IPv6 Host Configuration

- Configuring RA on Linux
  - Set IPv6 address forwarding on

```
# echo “1” /proc/sys/net/ipv6/conf/all/forward
```

  - Need radvd-0.7.1-3.i386.rpm installed
  - On the demon conf file /etc/radvd.conf

```
# vi /etc/radvd.conf
Interface eth1 {
advSendAdvert on;
prefix 2406:6400::/64 {
AdvOnLink on;
};
};
```

Exercise 1: IPv6 Host Configuration

- Enabling IPv6 on FreeBSD
  - Set the ipv6_enable variable to yes in the /etc/rc.conf

  # vi /etc/rc.conf

  Ipv6_enable=yes
- Adding IPv6 address on an interface

  # ifconfig fxp0 inet6 2406:6400::1/64

Exercise 1: IPv6 Host Configuration

- Configuring RA on FreeBSD
  - Set IPv6 address forwarding on

```
# sysctl -w net.inet6.ip6.forwarding=1
```

- Assign IPv6 address on an interface

```
# ifconfig en1 inet6 2001:07F9:0400:010E::1 prefixlen
    64
```

- RA on an interface

```
# rtadvd en1
```

Exercise 1: IPv6 Host Configuration

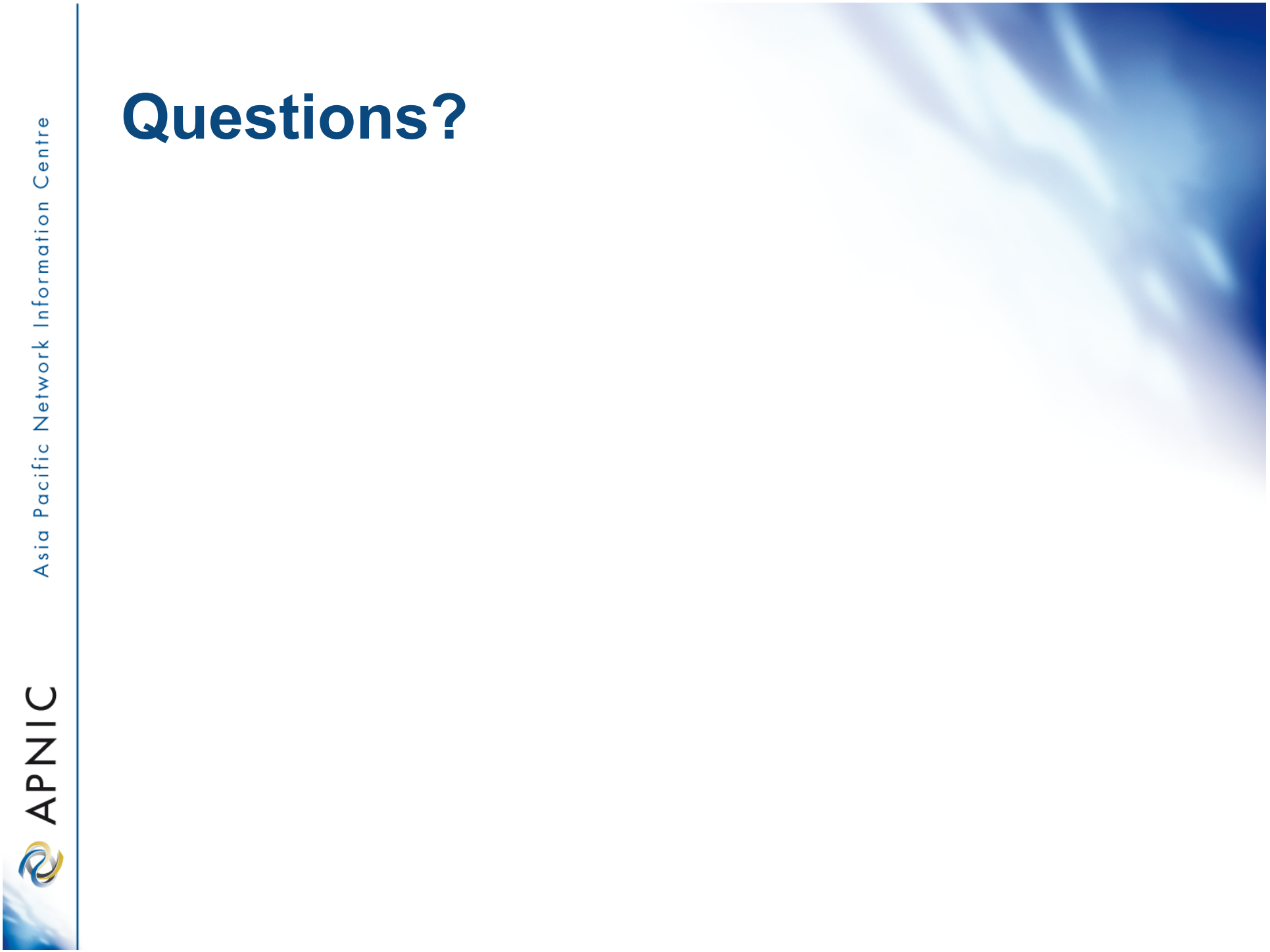
- Configure RA on Cisco

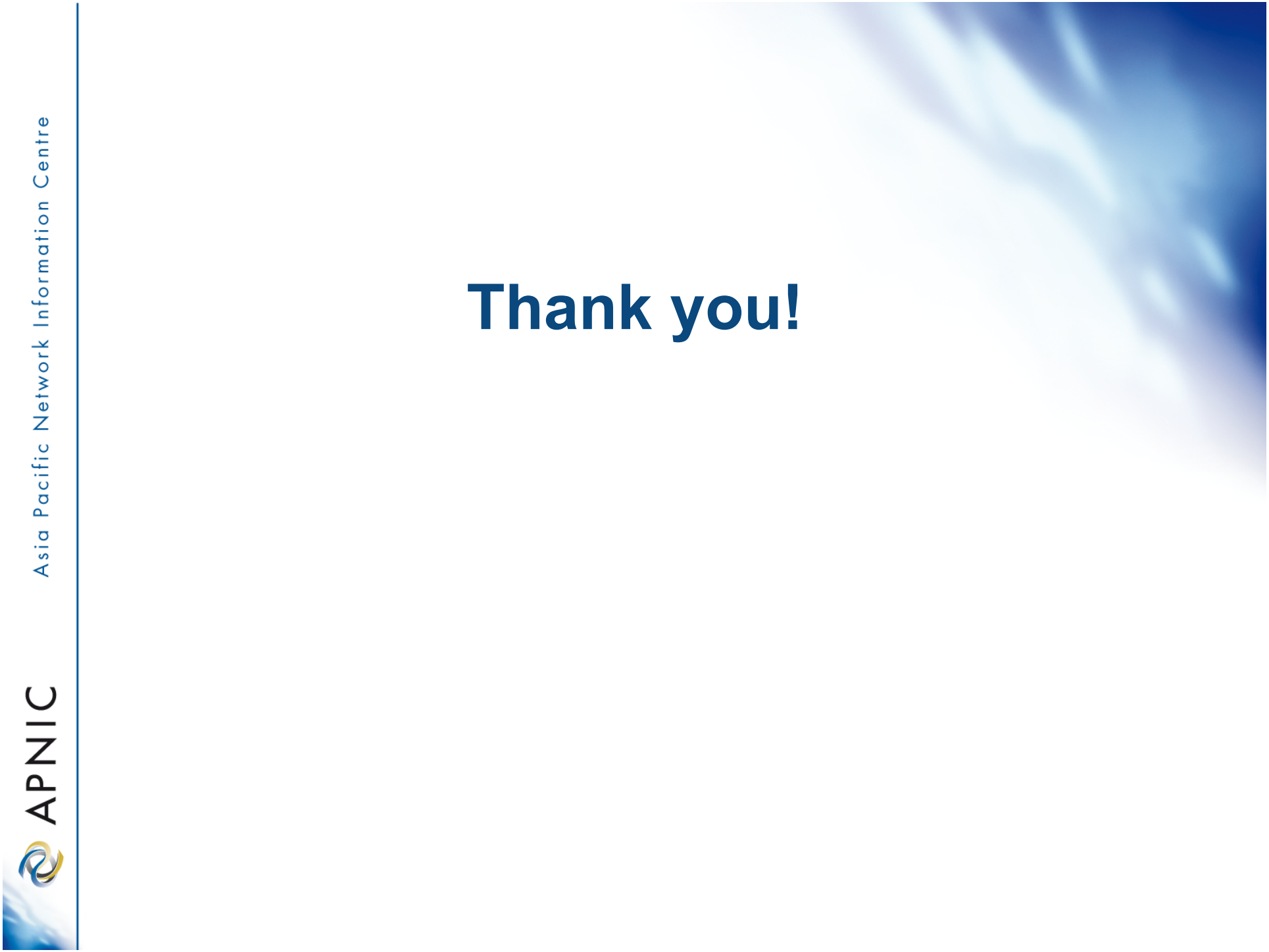
Config t

Interface e0/1

Ipv6 nd prefix-advertisement 2406:6400::/64

Questions?





Thank you!