APNIC eLearning:
IPv6 Addressing and Subnetting

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APNIC

Overview

- IPv6 Address Text Representation
- IPv6 Addressing Structure
- IPv6 Address Management Hierarchy
- Local Addresses
- Global Addresses
- Interface ID
- IPv6 Autoconfiguration
- Subnetting

IPv6 Addressing

- An IPv6 address is 128 bits long
- So the number of addresses are **2^128** = 340282366920938463463374607431768211455
- In hex, 4 bits (also called a ‘nibble’) is represented by a hex digit
- So 128 bits is reduced down to 32 hex digits

IPv6 Addressing

- 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

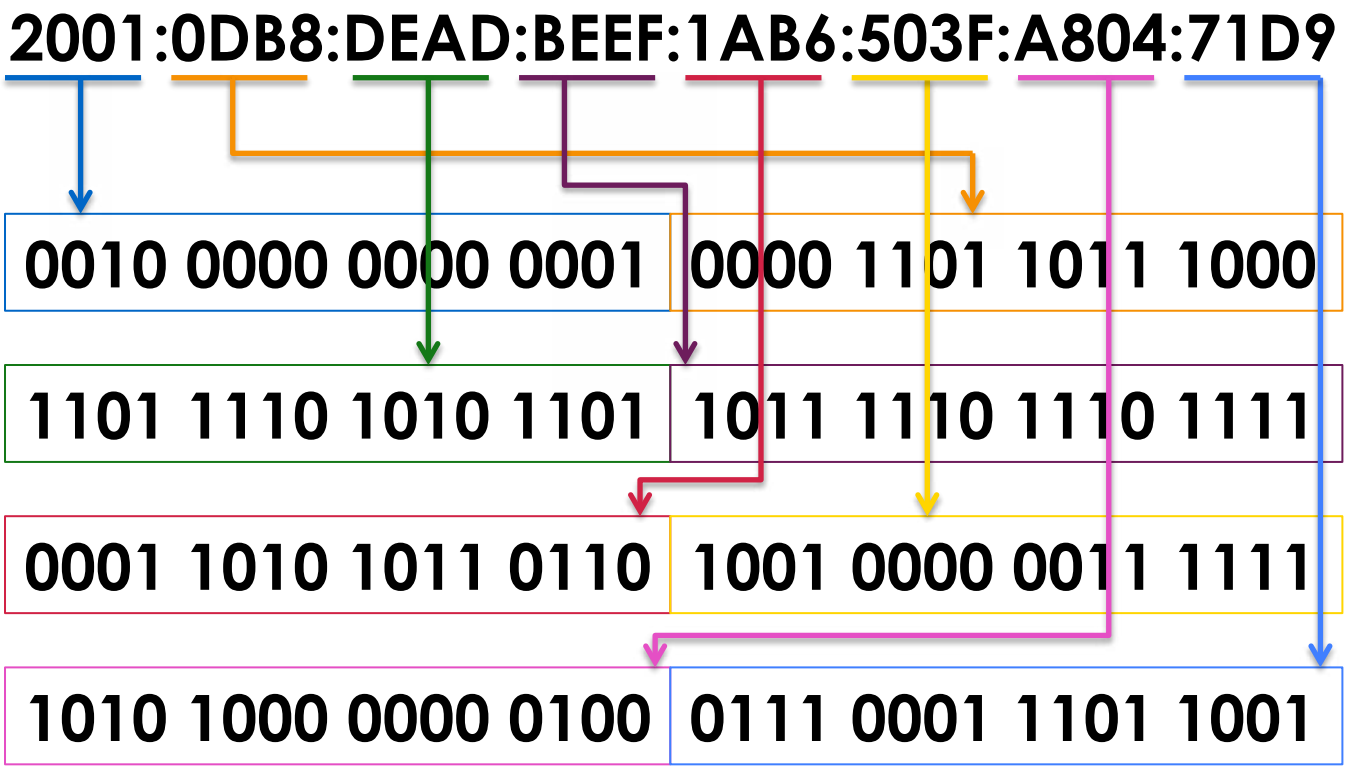
    (Null value can be used only once)

Leading zeroes

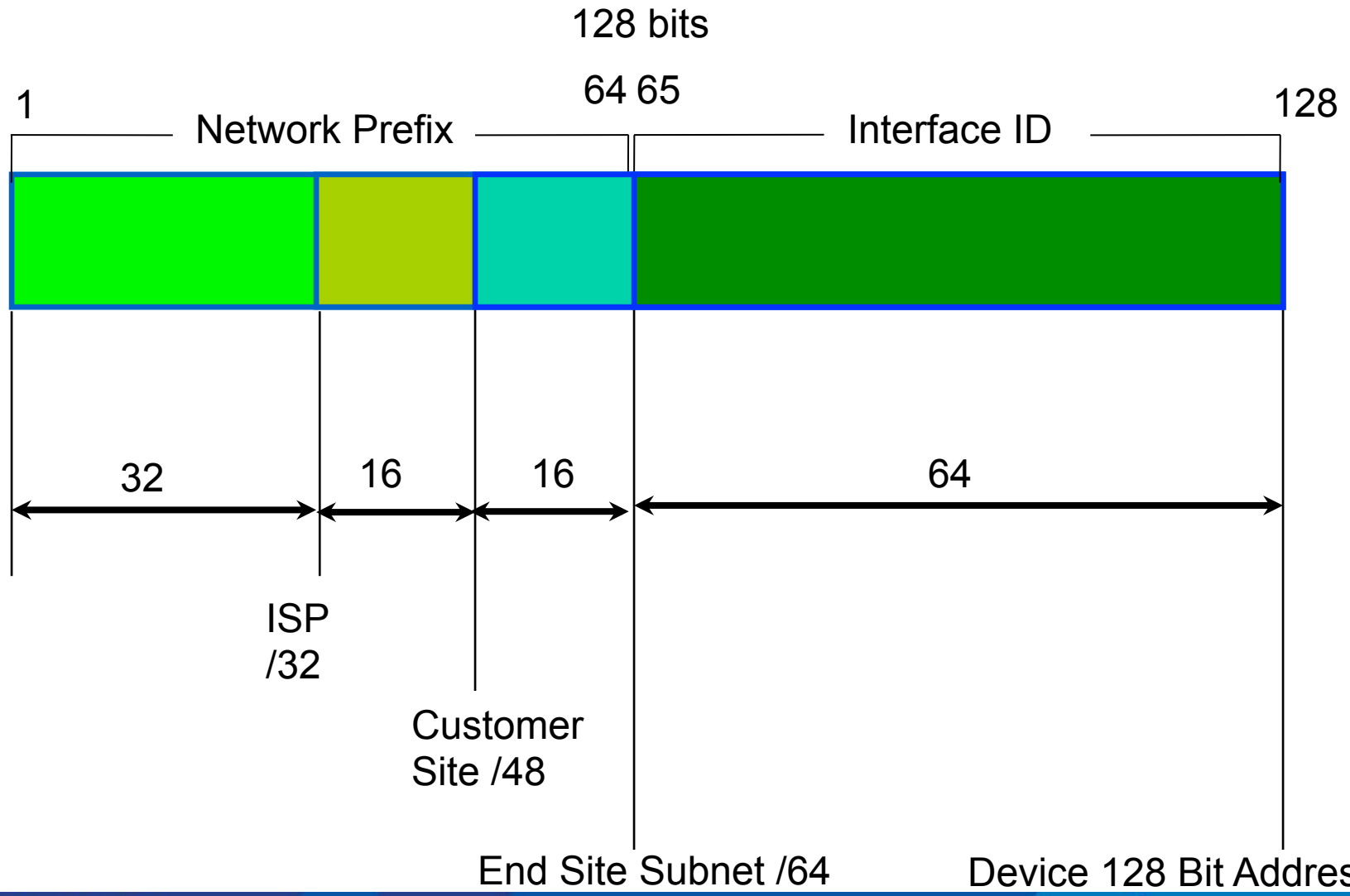
Groups of zeroes

Double colons

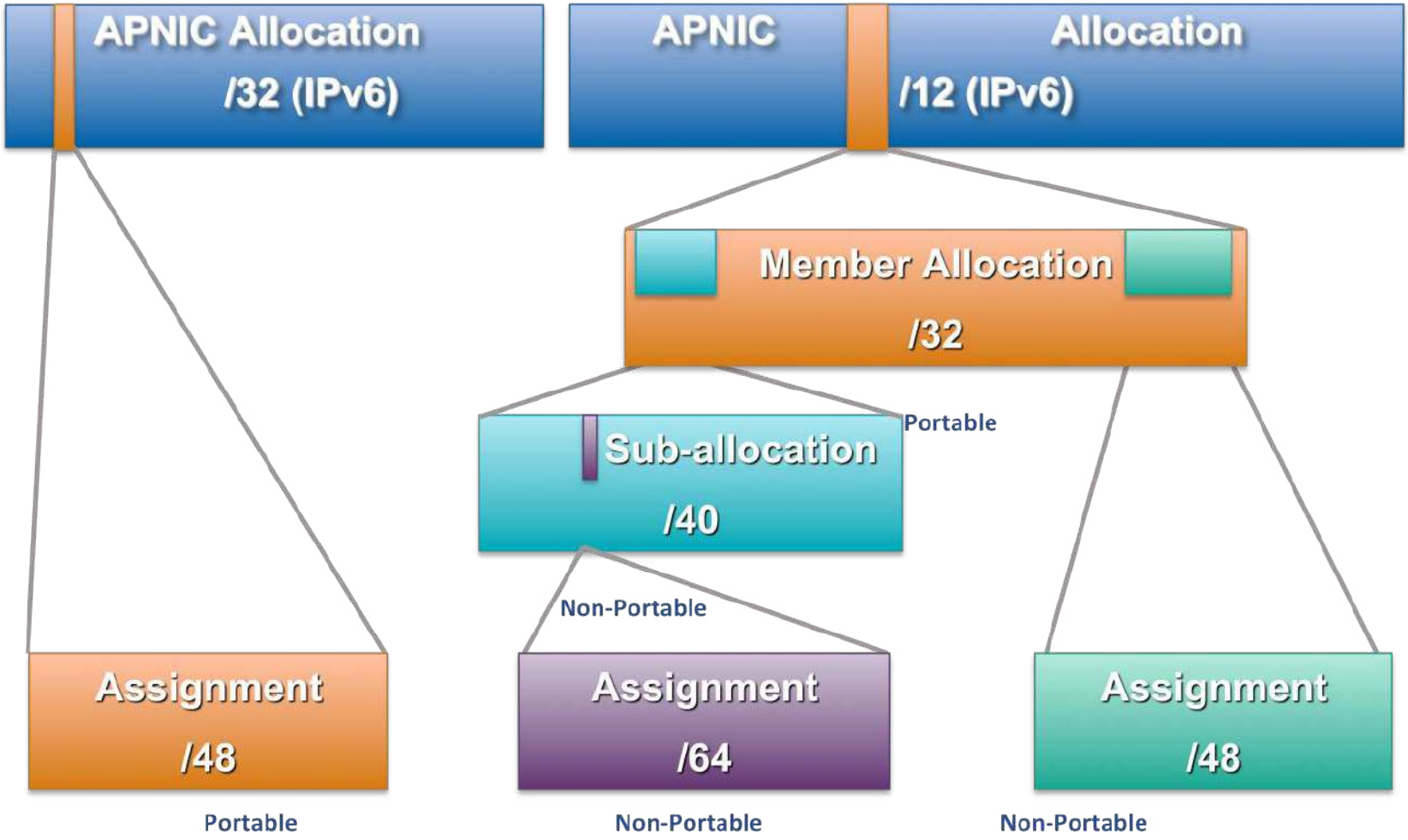
IPv6 Addressing



IPv6 addressing structure



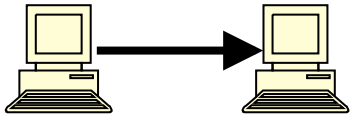
IPv6 Address Management Hierarchy



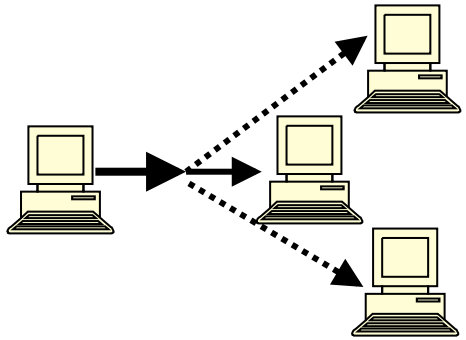
IPv6 addressing model

RFC 4291

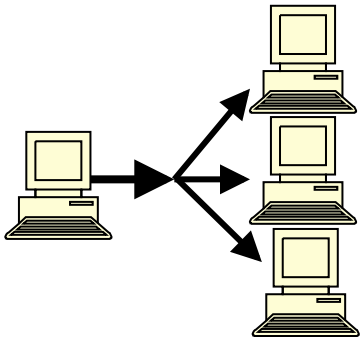
- Unicast
  - Packet is sent to a single interface



- Anycast
  - Packet is sent to the nearest of group interfaces (in terms of routing distance)



- Multicast
  - Packet is sent to multiple interfaces



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]

IPv6 Address Range

- Unspecified Address ::/128
- Loopback ::1/128
- Global Unicast (0010) 2000::/3
- Link Local (1111 1110 10) FE80::/10
- Multicast Address (1111 1111) FF00::/8
- Unique Local Address FC00::/7

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

- 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 3FFF:FFFF:…. :/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
- 6to4 Addresses
  - **2002::/16**
  - Designed for a special tunneling mechanism [RFC 3056] to connect IPv6 Domains via IPv4 Clouds
  - Need 6to4 relay routers in ISP network

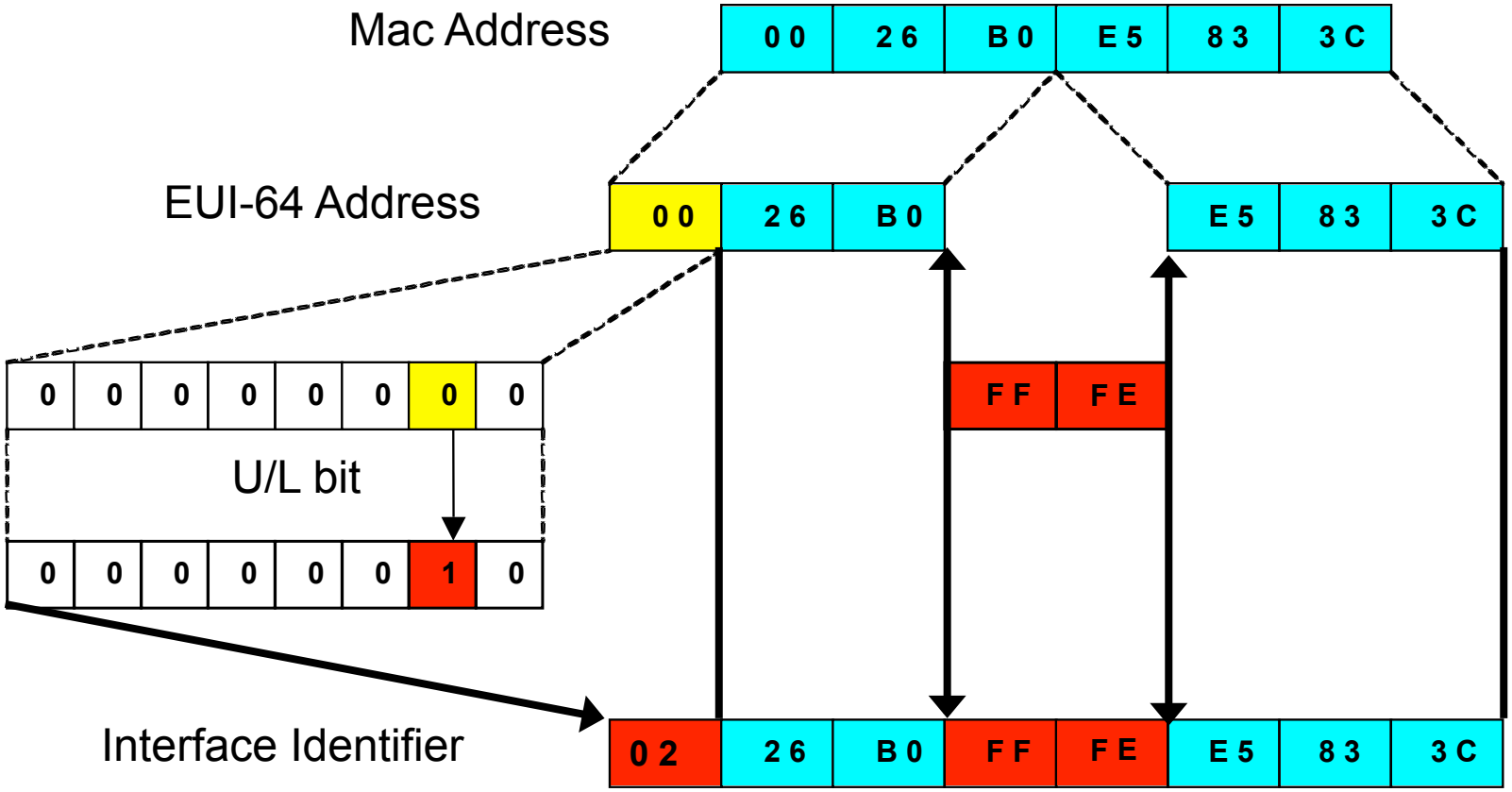
Examples and Documentation Prefix

- Two address ranges are reserved for examples and documentation purpose by RFC 3849
  - For examples, use **3fff:ffff::/32**
  - For documentation, use **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


Mac Address
00 26 B0 E5 83 3C
EUI-64 Address
00 26 B0 E5 83 3C
FF FE
0 0 0 0 0 0 0 0
U/L bit
0 0 0 0 0 0 1 0
Interface Identifier
02 26 B0 FF FE E5 83 3C

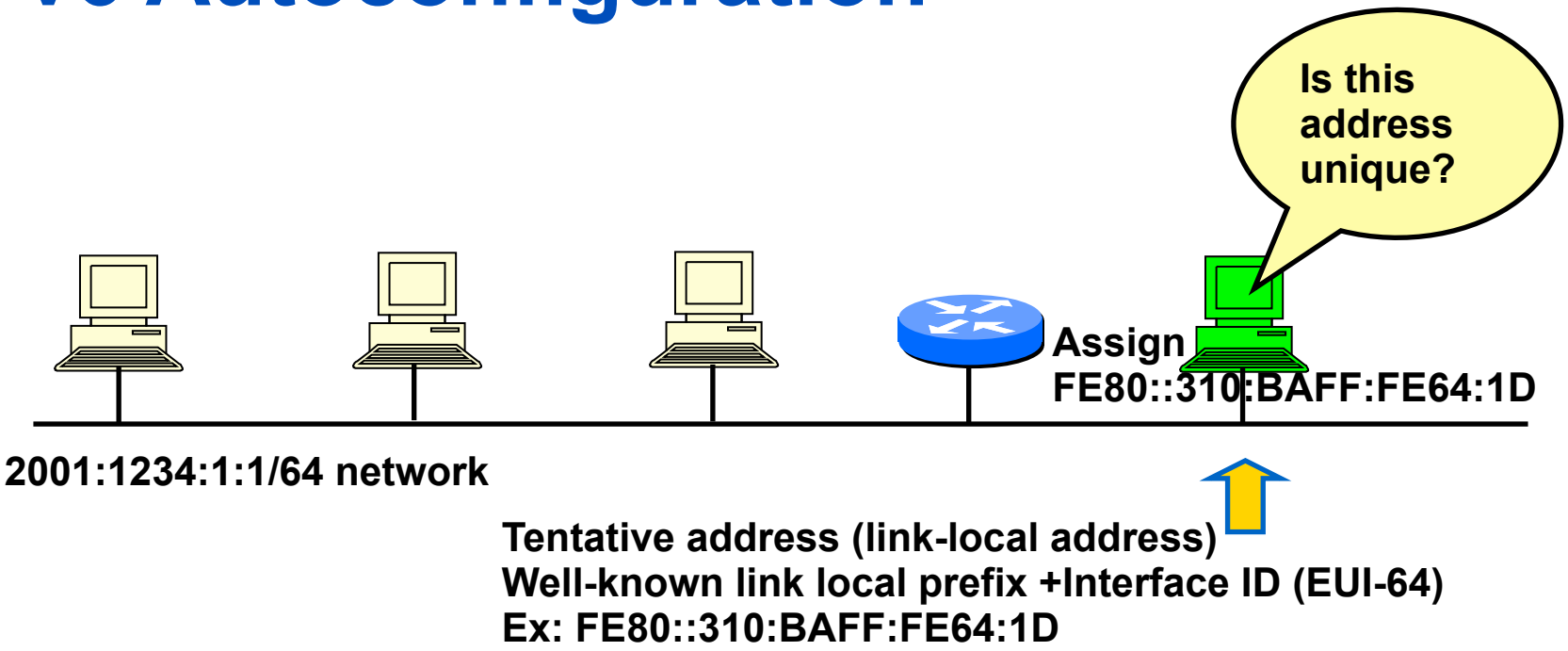
Zone IDs for Local-use Addresses

- 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

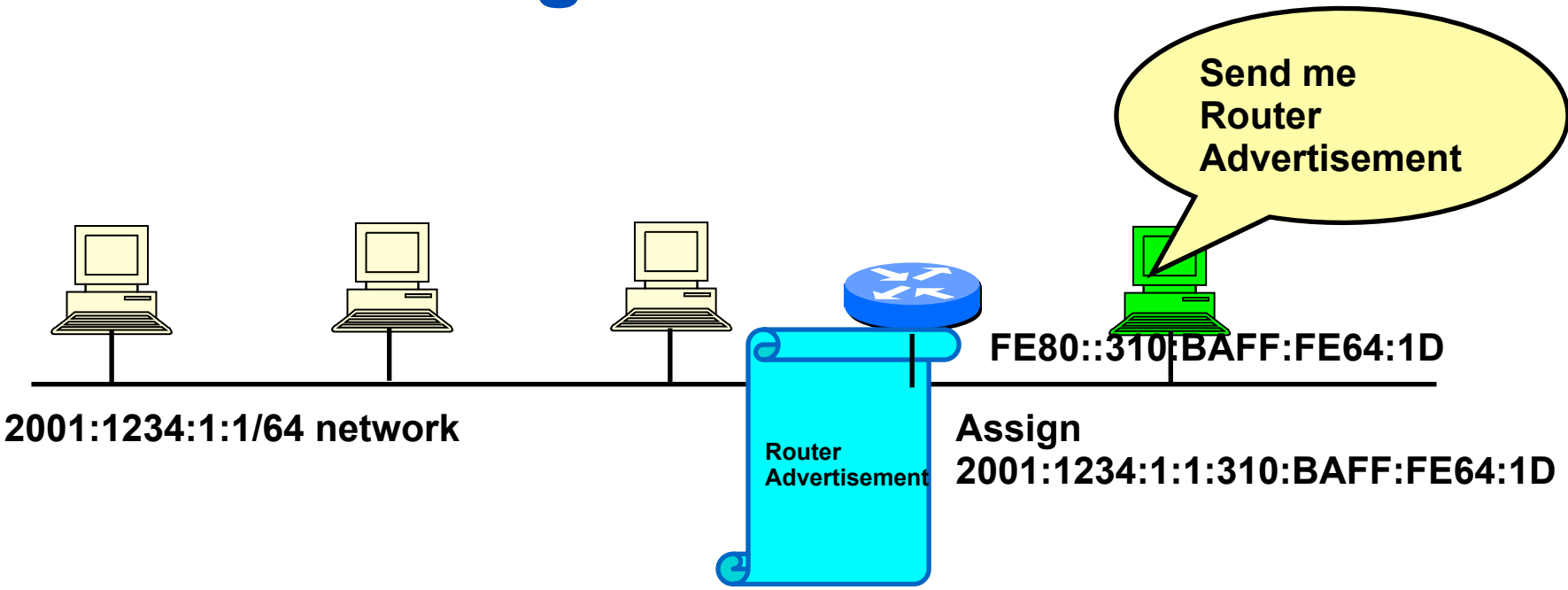
- Stateless mechanism
  - For a site not concerned with the exact addresses
  - No manual configuration required
  - Minimal configuration of routers
  - No additional servers
- Stateful mechanism
  - For a site that requires tighter control over exact address assignments
  - Needs a DHCP server
  -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

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:FF64:1D) 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

Subnetting (Example)

- Provider A has been allocated an IPv6 block

  2001:DB8::/32

- Provider A will delegate /48 blocks to its customers
- Find the blocks provided to the first 4 customers

Subnetting (Example)

Original block: **2001:0DB8::/32**

Rewrite as a /48 block: **2001:0DB8:0000:/48**

This is your network prefix!

How many /48 blocks are there in a /32?

$$\frac{/32}{/48} = \frac{2^{128-32}}{2^{128-48}} = \frac{2^{96}}{2^{80}} = 2^{16}$$

Find only the first 4 /48 blocks…

Subnetting (Example)

Start by manipulating the LSB of your network prefix – write in BITS

2001:0DB8:0000::/48

In bits

2001:0DB8:	**0000 0000 0000 0000**	**::/48**	➡	**2001:0DB8:0000::/48**
2001:0DB8:	**0000 0000 0000 0001**	**::/48**	➡	**2001:0DB8:0001::/48**
2001:0DB8:	**0000 0000 0000 0010**	**::/48**	➡	**2001:0DB8:0002::/48**
2001:0DB8:	**0000 0000 0000 0011**	**::/48**	➡	**2001:0DB8:0003::/48**

Then write back into hex digits

Appendix:
IPv6 Addressing Exercise

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

Questions

- Please remember to fill out the feedback form
  - <survey-link>
- Slide handouts will be available after you fill out the survey

IPv6@APNIC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IPv6 Transition Stories
IPv6 Best Current Practices
IPv4 exhaustion
IPv6@APNIC
IPv6
VIA IPv4 NOW
IPv6 is a top issue for the Asia Pacific Internet community. APNIC engages in activities throughout the region to help facilitate a smooth transition. The greater goal is to support the Asia Pacific in deploying IPv6 to maintain a scalable Internet for everyone.
APNIC reached the last /8 of IPv4 addresses in April 2011, and now delegates IPv4 resources according to the "last /8 policy". The scarcity of IPv4 makes IPv6 deployment critical for all networks and organizations in the Asia Pacific. Here's what APNIC is doing to support the community in achieving real and tangible IPv6 deployment:
Get your IPv6 addresses!
Distributing IPv6 addresses
Getting an IPv6 block is the first step in your transition, and the process is very simple.
Kickstart IPv6 - one click to IPv6
IPv6 training and education
Is your technical staff ready to deploy IPv6? Gaining technical knowledge does not happen overnight. Plan and implement training for your personnel. APNIC Training is constantly updating our IPv6 content, to reflect the industry's best current practices.
Upcoming training events
Related links
IPv6 news feed
IPv6 Info
Curated by APNIC
MicroNugget: 3 Basic Tasks For Building an IPv6 Network
Scoop.it
IPv4 Exhaustion Counter
Present Status (RIR)
X-day and Reserved Blocks
(Remaining /8)
AfriNIC
Jan 22, 2021 3.03
APNIC
Apr 15, 2011 0.89
ARIN
Jun 13, 2014 5.52
LACNIC
Oct 01, 2014 2.37
RIPE NCC

APNIC Helpdesk Chat

Thank You!

End of Session

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