IPv6 and DHCPv6

shin

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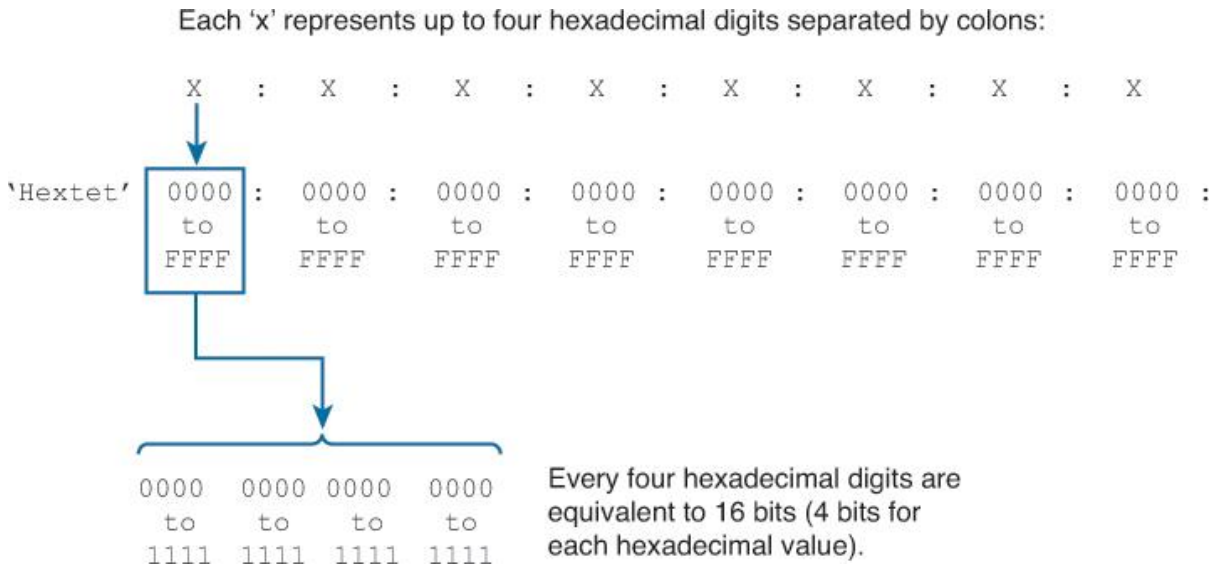
Representation of IPv6 Addresses

- 32 hexadecimal = 4*32 = 128
- not case sensitive



IPv6 Omission rules

1. Omission of Leading 0s.
2. Omission of all-0s hextets (16 bits).
3. Combining Rule 1 and Rule 2.

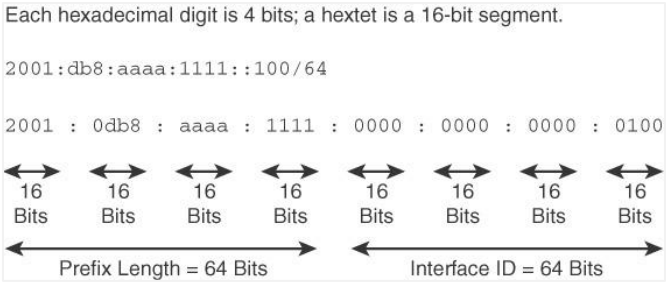
Format	IPv6 Address
Preferred	0000:0000:0000:0000:0000:0000:0000:0000
No Leading 0s	0: 0: 0: 0: 0: 0: 0: 0
":" All-0 segments	::
Preferred	0000:0000:0000:0000:0000:0000:0000:0001
No Leading 0s	0: 0: 0: 0: 0: 0: 0: 1
":" All-0 segments	::1
Preferred	FF02:0000:0000:0000:0000:0000:0000:0001
No Leading 0s	FF02: 0: 0: 0: 0: 0: 0: 1
":" All-0 segments	FF02::1
Preferred	FC00:0001:A000:0B00:0000:0527:0127:00AB
No Leading 0s	FC00: 1:A000: B00: 0: 527: 127: AB
":" All-0 segments	FC00:1:A000:B00::527:127:AB
Preferred	2001:DCBA:1111:000A:00B0:0000:9000:0200
No Leading 0s	2001:DCBA:1111: A: B0: 0:9000: 200
":" All-0 segments	2001:DCBA:1111:A:B0::9000:200
Preferred	2001:0000:0000:0000:ABCD:0000:0000:1234
No Leading 0s	2001: 0: 0: 0:ABCD: 0: 0:1234
":" All-0 segments	2001::ABCD:0:0:1234
Note: This address can also be written as 2001:0:0:0:ABCD::1234.	
Preferred	2001:0DB8:AAAA:0001:0000:0000:0000:0100
No Leading 0s	2001: DB8:AAAA: 1: 0: 0: 0: 100
":" All-0 segments	2001:DB8:AAAA:1::100
Preferred	2001:0DB8:AAAA:0001:0000:0000:0000:0200
No Leading 0s	2001: DB8:AAAA: 1: 0: 0: 0: 200
":" All-0 segments	2001:DB8:AAAA:1::200

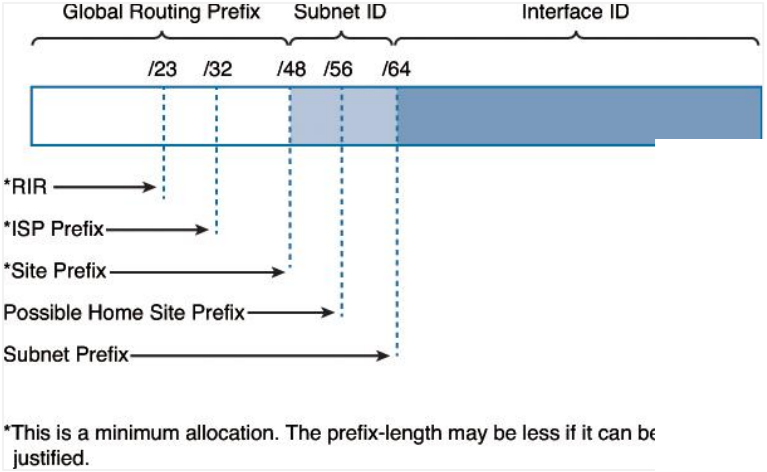
Incorrect address using two double colons

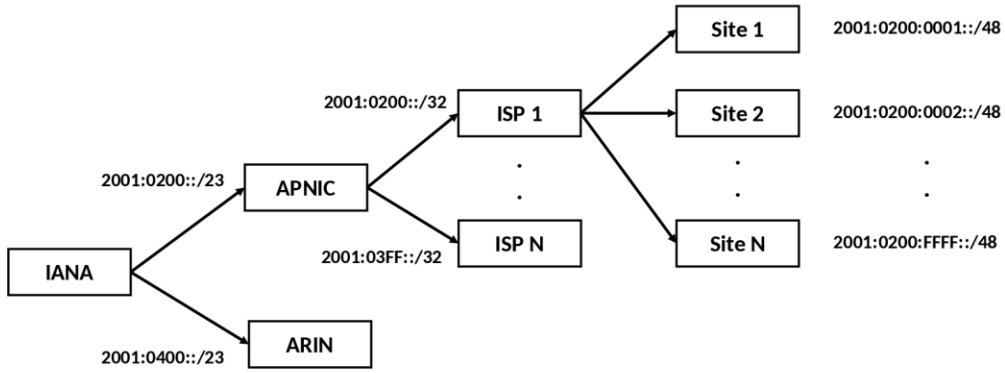
- Only a single contiguous string of all-0 segments can be represented with a double colon.
- **2001::ABCD::1234**
  - 2001:0000:0000:0000:0000:ABCD:0000:1234
  - 2001:0000:0000:0000:ABCD:0000:0000:1234
  - 2001:0000:0000:ABCD:0000:0000:0000:1234
  - 2001:0000:ABCD:0000:0000:0000:0000:1234

Prefix

- ipv6-address/prefix-length
- RIR(Regional Internet Registries)
  - Asia-Pacific Network Information Centre (APNIC) serves East Asia, Oceania, South Asia, and Southeast Asia





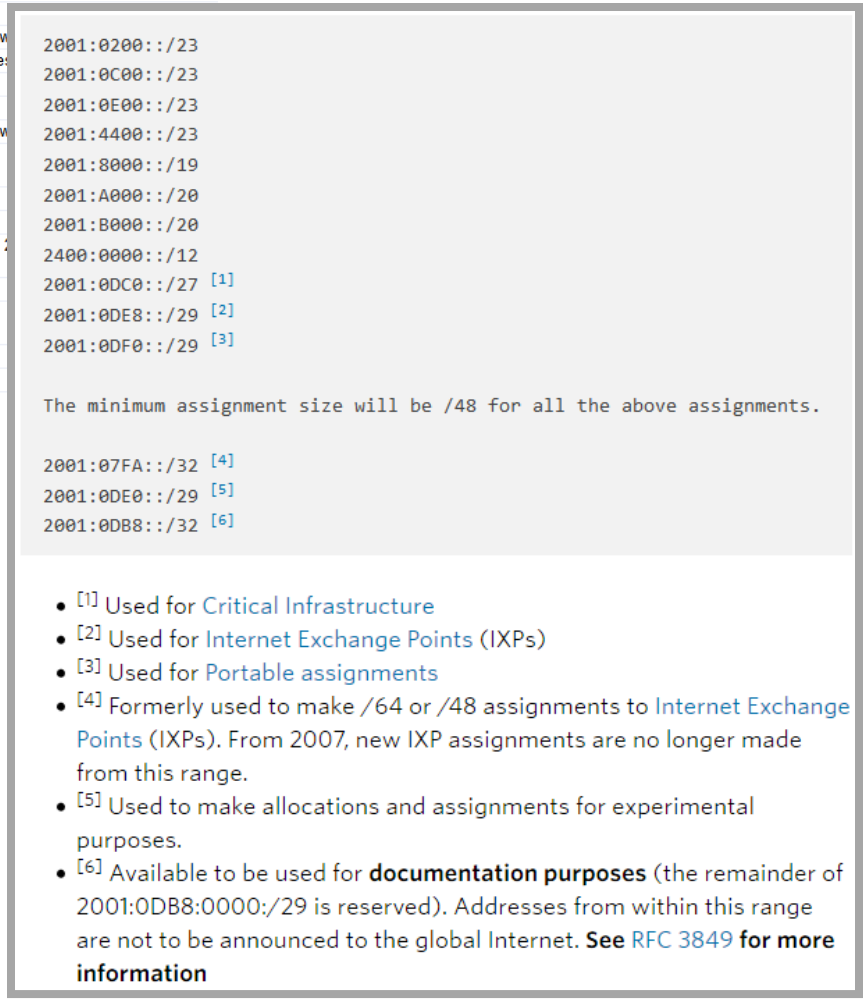


IANA: Internet Assigned Numbers Authority
APNIC: Asia-Pacific Network Information Centre
ARIN: American Registry for Internet Numbers
ISP: Internet Service Provider

IPv6 Global Unicast Address Assignments

Prefix	Designation	Date	WHOIS	RDAP	Status	Note
2001:0000::/23	IANA	1999-07-01	whois.iana.org		ALLOCATED	2001:0000::/23 is reserved for IETF Protocol A Control Protocol Anycast [RFC7723]. 2001:2:: 2001:4:112::/48 is reserved for AS112-v6 [RFC [RFC7343]. 2001:db8::/32 is reserved for Docu
2001:0200::/23	APNIC	1999-07-01	whois.apnic.net	https://rdap.apnic.net/	ALLOCATED	
2001:0400::/23	ARIN	1999-07-01	whois.arin.net	https://rdap.arin.net/registry http://rdap.arin.net/registry	ALLOCATED	
2001:0600::/23	RIPE NCC	1999-07-01	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	
2001:0800::/22	RIPE NCC	2002-11-02	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	2001:0800::/23 w
2001:0c00::/23	APNIC	2002-05-02	whois.apnic.net	https://rdap.apnic.net/	ALLOCATED	2001:db8::/32 re
2001:0e00::/23	APNIC	2003-01-01	whois.apnic.net	https://rdap.apnic.net/	ALLOCATED	
2001:1200::/23	LACNIC	2002-11-01	whois.lacnic.net	https://rdap.lacnic.net/rdap/	ALLOCATED	
2001:1400::/22	RIPE NCC	2003-07-01	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	2001:1400::/23 w
2001:1800::/23	ARIN	2003-04-01	whois.arin.net	https://rdap.arin.net/registry http://rdap.arin.net/registry	ALLOCATED	
2001:1a00::/23	RIPE NCC	2004-01-01	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	
2001:1c00::/22	RIPE NCC	2004-05-04	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	
2001:2000::/19	RIPE NCC	2019-03-12	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	2001:2000::/20, allocations.
2001:4000::/23	RIPE NCC	2004-06-11	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	
2001:4200::/23	AFRINIC	2004-06-01	whois.afrinic.net	https://rdap.afrinic.net/rdap/ http://rdap.afrinic.net/rdap/	ALLOCATED	
2001:4400::/23	APNIC	2004-06-11	whois.apnic.net	https://rdap.apnic.net/	ALLOCATED	
2001:4600::/23	RIPE NCC	2004-08-17	whois.ripe.net	https://rdap.db.ripe.net/	ALLOCATED	
2001:4800::/23	ARIN	2004-08-24	whois.arin.net	https://rdap.arin.net/registry	ALLOCATED	

https://www.iana.org/assignments/ipv6-unicast-address-assignments/ipv6-unicast-address-assignments.xhtml



2001:0200::/23
2001:0C00::/23
2001:0E00::/23
2001:4400::/23
2001:8000::/19
2001:A000::/20
2001:B000::/20
2400:0000::/12
2001:0DC0::/27 [1]
2001:0DE8::/29 [2]
2001:0DF0::/29 [3]

The minimum assignment size will be /48 for all the above assignments.

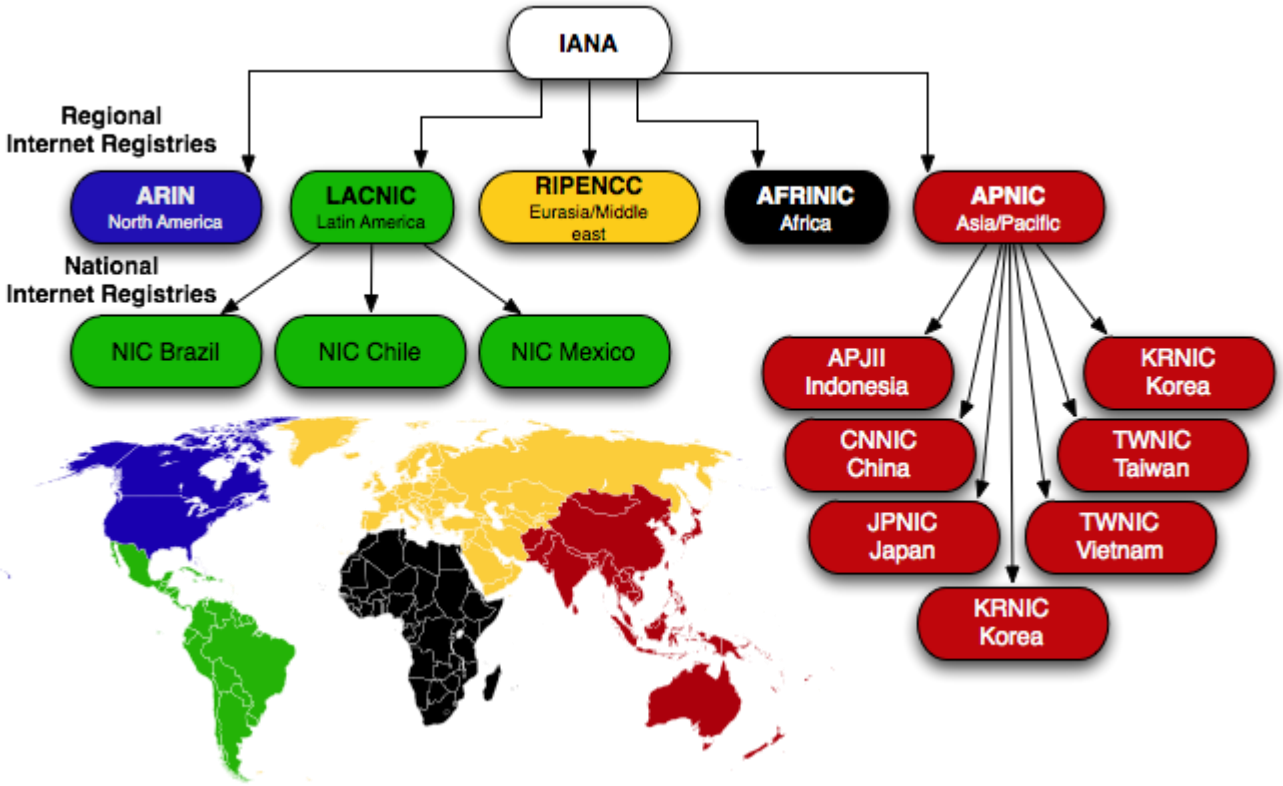
2001:07FA::/32 [4]
2001:0DE0::/29 [5]
2001:0DB8::/32 [6]

- [1] Used for Critical Infrastructure
- [2] Used for Internet Exchange Points (IXPs)
- [3] Used for Portable assignments
- [4] Formerly used to make /64 or /48 assignments to Internet Exchange Points (IXPs). From 2007, new IXP assignments are no longer made from this range.
- [5] Used to make allocations and assignments for experimental purposes.
- [6] Available to be used for **documentation purposes** (the remainder of 2001:0DB8:0000:/29 is reserved). Addresses from within this range are not to be announced to the global Internet. **See** RFC 3849 **for more information**

https://www.apnic.net/manage-ip/manage-resources/address-status/apnic-resource-range/#IPv6

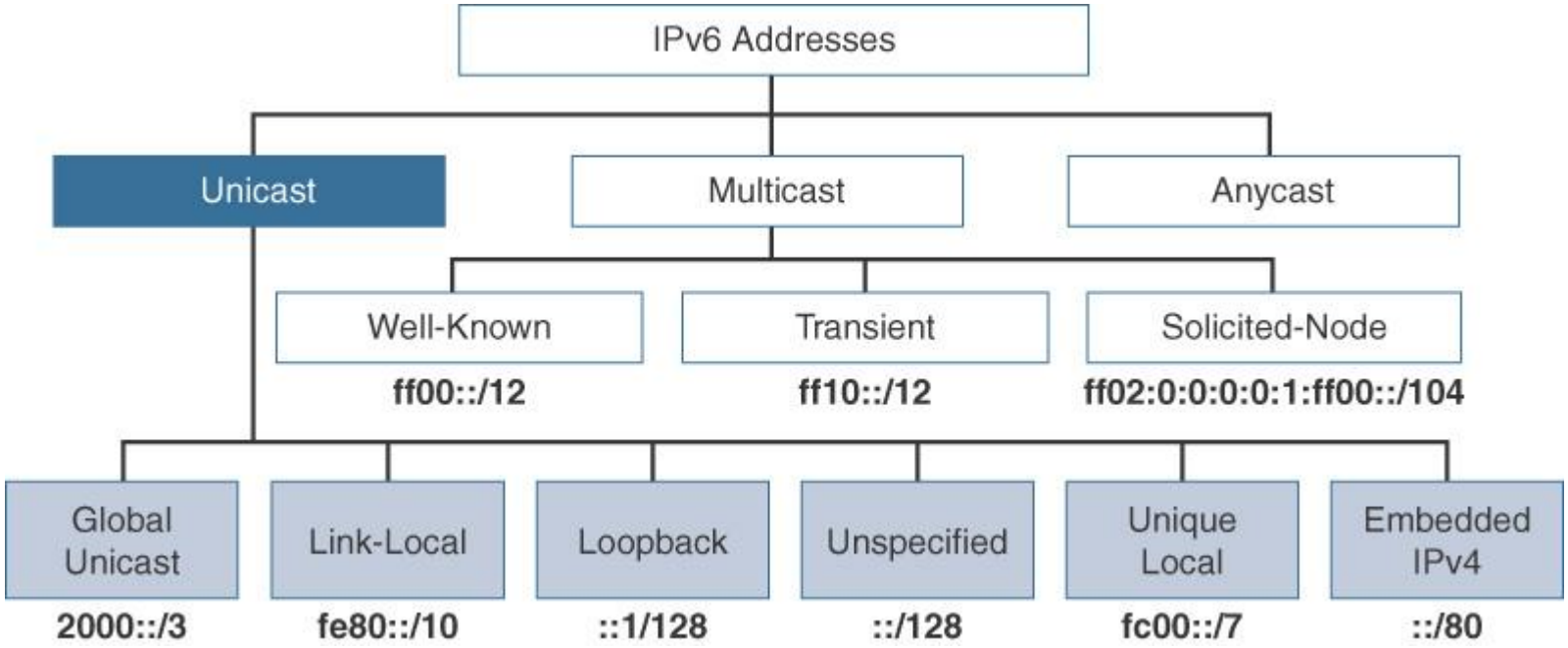
Regional Internet Registries(RIR), National Internet Registries(NIR)

- KRNIC(한국인터넷정보센터)
  - KISA(한국인터넷진흥원)



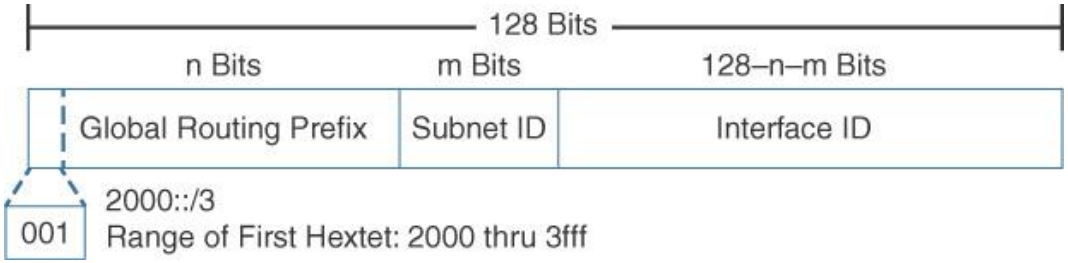
IPv6 Address Types

IPv6 Address Types – Unicast



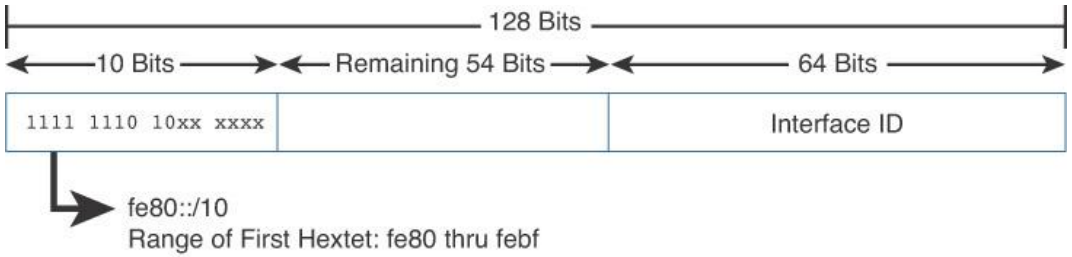
Unicast Addresses – Global Unicast Address (GUA)

- Global Routing Prefix
  - the prefix or network portion of the address assigned by the provider, such as an ISP, to the customer site.
- Subnet ID
  - separate field for allocating subnets within the customer site.
- Interface ID
  - equivalent to the host portion of an IPv4 address.



Unicast Addresses – Link-Local Unicast Address

- confined to a single link, a single subnet
- only need to be unique on the link (subnet) and do not need to be unique beyond the link
- routers do not forward packets with a link-local address.
- Duplicate Address Detection (DAD) to determine whether or not the link-local address is unique.
- Configuration
  - **Dynamic Link-local Address: EUI-64**
  - **Randomly Generated Interface IDs**
  - **Static Link-local Address**



Unicast Addresses – Loopback Address

- equivalent to the IPv4 loopback address 127.0.0.1
- ::1

Windows 10

```
C:₩Users₩shindonghoon>ping -6 ::1

Ping ::1 32바이트 데이터 사용:
::1의 응답: 시간<1ms
::1의 응답: 시간<1ms
::1의 응답: 시간<1ms
```

Ubuntu 18

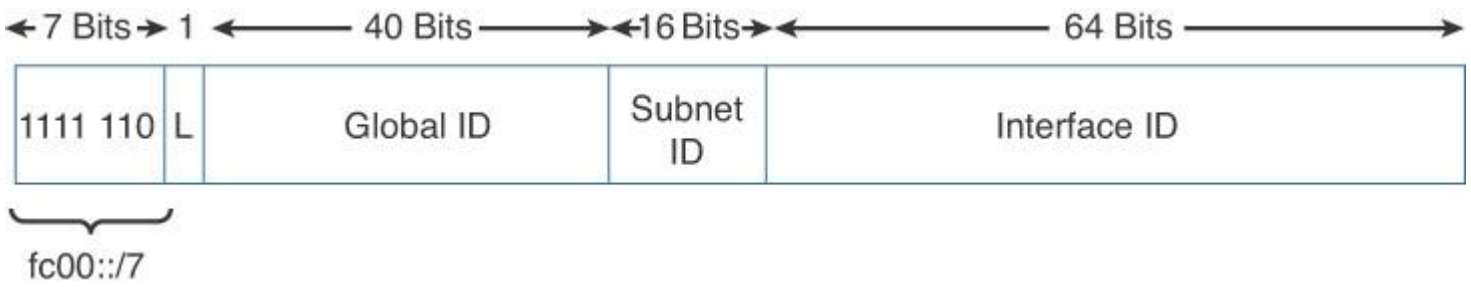
```
root@lyon:~/work/src# ping6 ::1
PING ::1(::1) 56 data bytes
64 bytes from ::1: icmp_seq=1 ttl=64 time=0.028 ms
64 bytes from ::1: icmp_seq=2 ttl=64 time=0.040 ms
64 bytes from ::1: icmp_seq=3 ttl=64 time=0.050 ms
```

Cisco IOS / ExtremeXOS

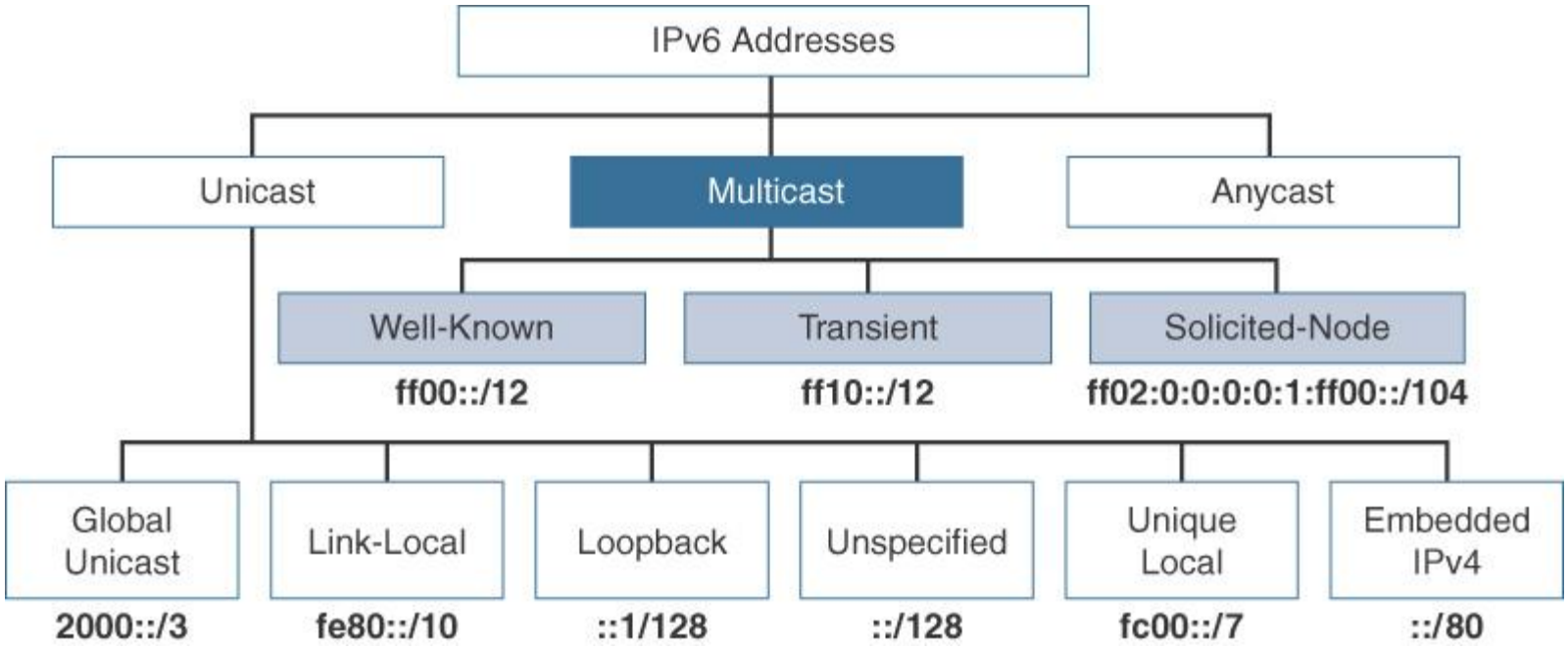
```
BASEIN_BB#1.1 # ping ipv6 ::1
Ping(ICMP6) ::1: 4 packets, 8 data bytes, interval 1 second(s).
16 bytes from ::1: icmp_seq=0 ttl=64 time=0.814 ms
16 bytes from ::1: icmp_seq=1 ttl=64 time=8.308 ms
16 bytes from ::1: icmp_seq=2 ttl=64 time=0.400 ms
16 bytes from ::1: icmp_seq=3 ttl=64 time=0.394 ms
```

Unicast Addresses– Unique Local Addresses (ULA)

- private IPv6 addresses or local IPv6 addresses
- can be used similarly to global unicast addresses but are for private use and should not be routed in the global Internet.



IPv6 Address Types – Multicast

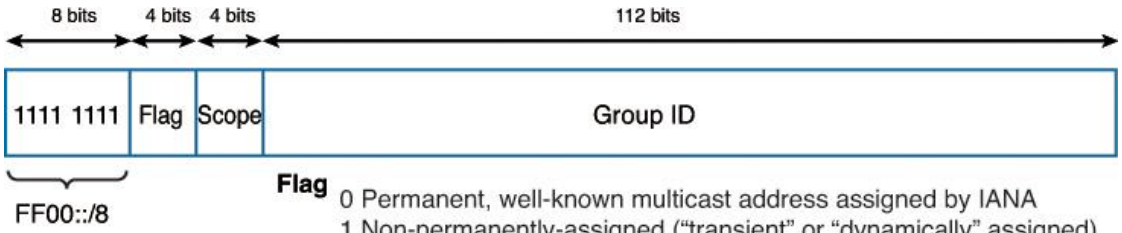


Well-Known Multicast Addresses

/8 Prefix FF	Flag 0	Scope (0–F)	Predefined Group ID	Compressed Format	Description
Interface-local Scope					
FF	0	1	0:0:0:0:0:0:1	FF01::1	All-nodes
FF	0	1	0:0:0:0:0:0:2	FF01::2	All-routers
Link-local Scope					
FF	0	2	0:0:0:0:0:0:1	FF02::1	All-nodes
FF	0	2	0:0:0:0:0:0:2	FF02::2	All-routers
FF	0	2	0:0:0:0:0:0:5	FF02::5	OSPF routers
FF	0	2	0:0:0:0:0:0:6	FF02::6	OSPF designated routers
FF	0	2	0:0:0:0:0:0:9	FF02::9	RIP routers
FF	0	2	0:0:0:0:0:0:A	FF02::A	EIGRP routers
FF	0	2	0:0:0:0:0:1:2	FF02::1:2	All DHCP agents
Site-local Scope					
FF	0	5	0:0:0:0:0:0:2	FF05::2	All-routers
FF	0	5	0:0:0:0:0:1:3	FF05::1:3	All DHCP servers

```
root@lyon:~/work/src# netstat -g
IPv6/IPv4 Group Memberships
Interface       RefCnt Group
--------------- ------ ---------------------
lo              1      all-systems.mcast.net
eth0            1      all-systems.mcast.net
lo              1      ip6-allnodes
lo              1      ff01::1
eth0            3      ff05::1:3
eth0            3      ff02::1:2
eth0            1      ff02::1:ff00:10
eth0            1      ff02::1:ff03:1e2b
eth0            2      ip6-allnodes
eth0            1      ff01::1
root@lyon:~/work/src#
```

Multicast scope

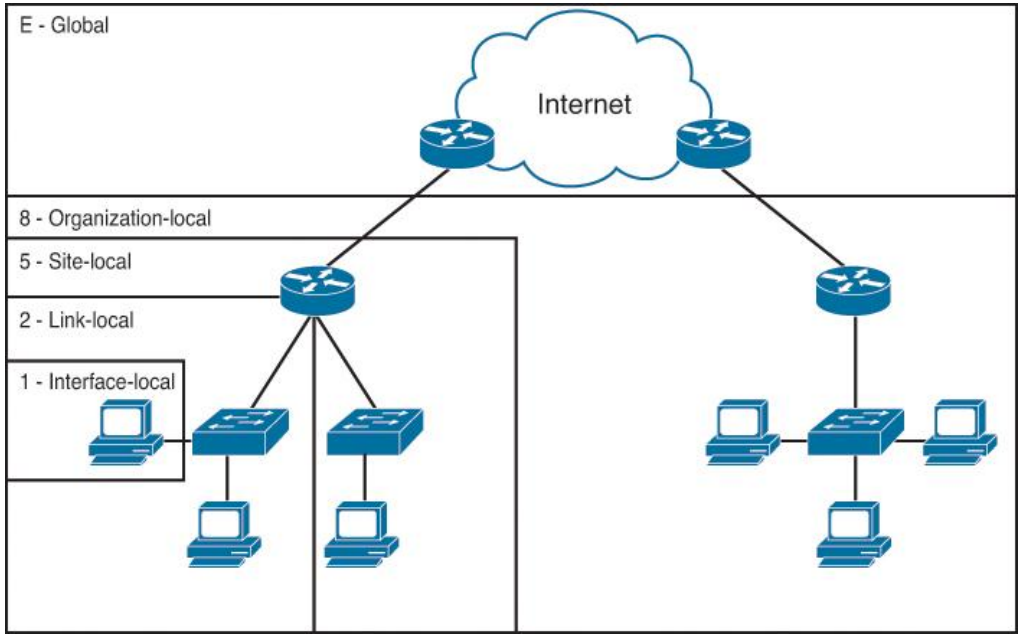


Flag

0 Permanent, well-known multicast address assigned by IANA
1 Non-permanently-assigned ("transient" or "dynamically" assigned) multicast address

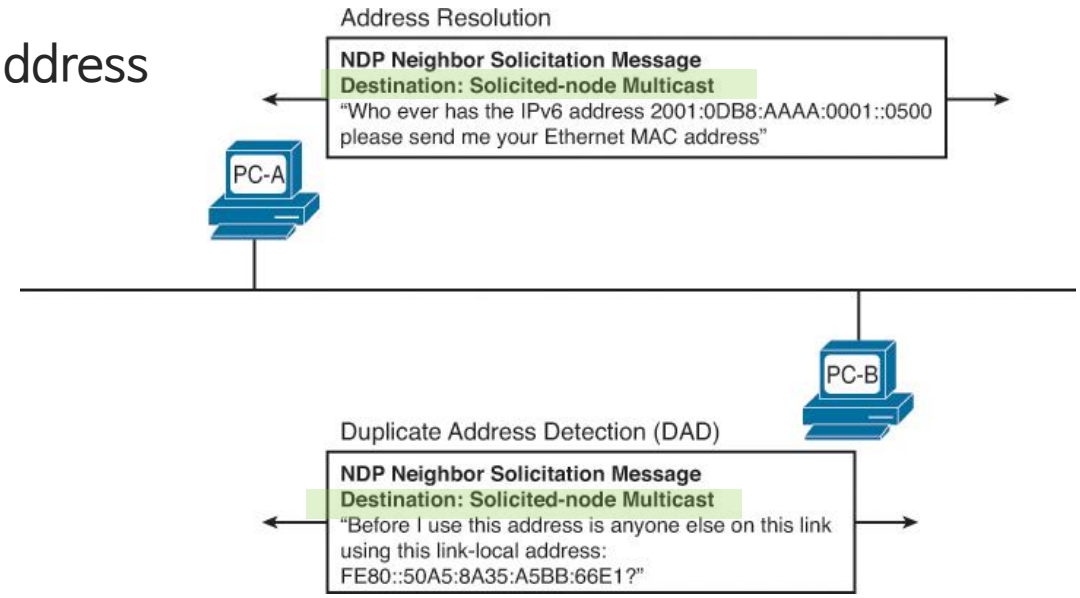
Scope

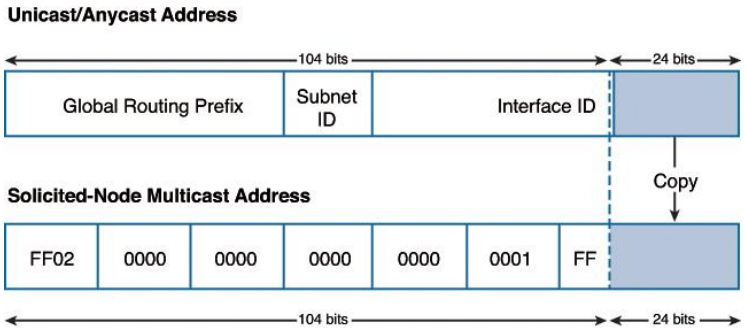
0 Reserved
1 Interface-Local scope
2 Link-Local scope
3 Unicast-prefix-based address
4 Admin-Local scope
5 Site-Local scope
6 Unassigned
7 Rendezvous Point flag
8 Organization-Local scope
9 Thru D Unassigned
E Global scope
F Reserved



Solicited-Node Multicast Addresses

- automatically created
- IPv6 does not have a broadcast address
- used for
  - **Address resolution**
  - **Duplicate Address Detection (DAD)**





FF02:0:0:0:0:1:FF00::/104

Unicast Address		Solicited-Node Multicast Address
Router R1		
Global	2001:DB8:AAAA:1::**1**	FF02::1:FF00:**1**
Link-local	FE80::203:6BFF:FE**E9:D480**	FF02::1:FF**E9:D480**
PC1		
Global	2001:DB8:AAAA:1::**100**	FF02::1:FF00:**100**
Link-local	FE80::50A5:8A35:A5**BB:66E1**	FF02::1:FF**BB:66E1**
PC2		
Global	2001:DB8:AAAA:1::**200**	FF02::1:FF00:**200**
Link-local	FE80::1C00:3EA4:74**FF:A8CF**	FF02::1:FF**FF:A8CF**

IANA's Allocation of IPv6 Address Space

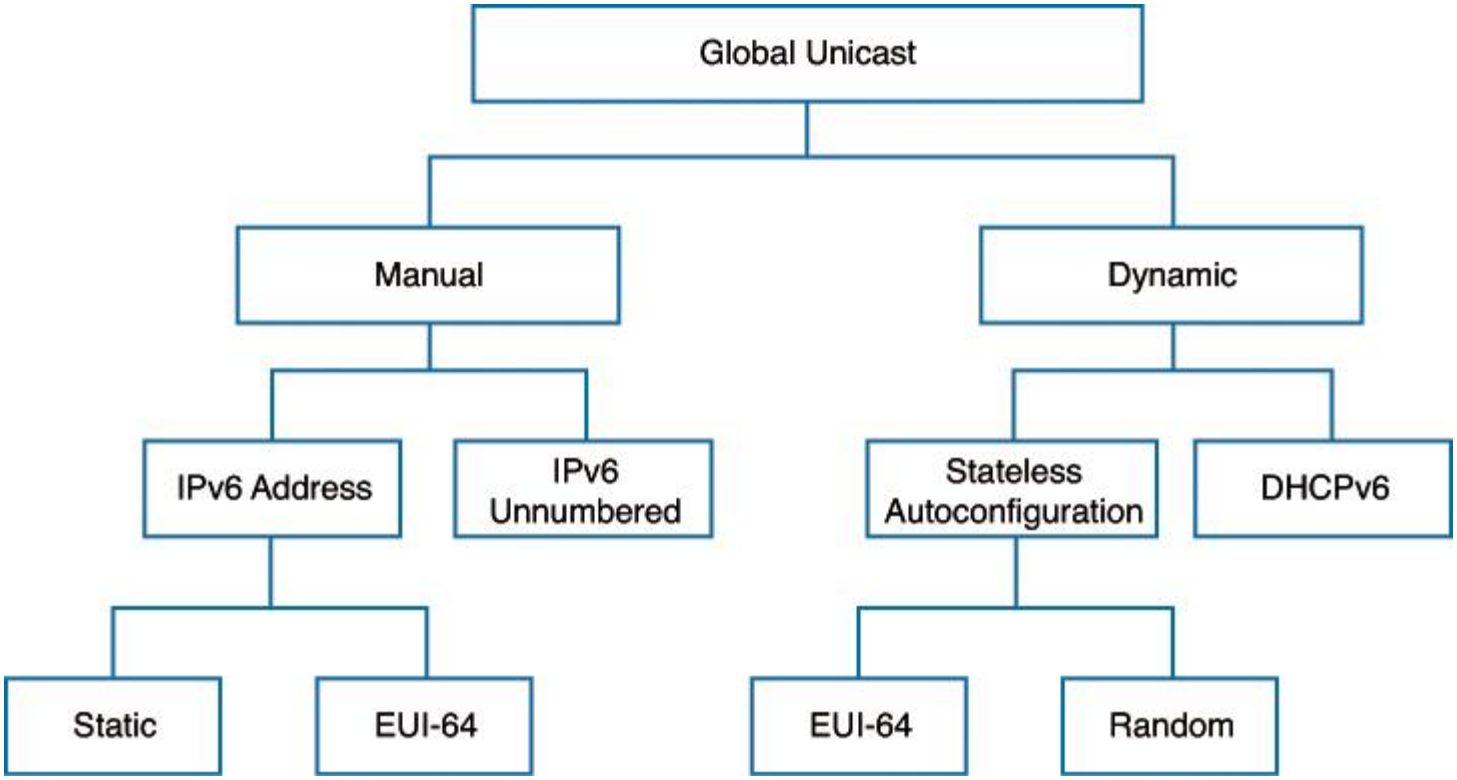
Leading Bits	Address	Range of First Hextet	Allocation	Fraction of Space	
000x					
0000 0000	0000::/8	0000 00FF	Unspecified, Loopback, Embedded IPv4	1/8th	1/256th
0000 0001	0100::/8	0100 01FF	Reserved by IETF		1/256th
0000 001x	0200::/7	0200 03FF	Reserved by IETF		1/128th
0000 010x	0400::/6	0400 05FF	Reserved by IETF		1/64th
0000 1xxx	0800::/5	0800 0FFF	Reserved by IETF		1/32nd
0001 xxxx	1000::/4	1000 1FFF	Reserved by IETF		1/16th
001x	2000::/3	2000 3FFF	Global Unicast	1/8th	
010x	4000::/3	4000 5FFF	Reserved by IETF	1/8th	
011x	6000::/3	6000 7FFF	Reserved by IETF	1/8th	

IANA's Allocation of IPv6 Address Space – cont'd

100x	8000::/3	8000 9FFF	Reserved by IETF	1/8th
101x	A000::/3	A000 BFFF	Reserved by IETF	1/8th
110x	C000::/3	C000 DFFF	Reserved by IETF	1/8th
111x				
1110 xxxx	E000::/4	E000 EFFF	Reserved by IETF	1/16th
1111 0xxx	F000::/5	F000 F7FF	Reserved by IETF	1/32nd
1111 10xx	F800::/6	F800 FBFF	Reserved by IETF	1/64th
1111 110x	**FC00::/7**	**FC00 FDFF**	**Unique Local Unicast**	**1/128th**
1111 1110 0	FE00::/9	FE00 FE74	Reserved by IETF	1/512th
1111 1110 10	**FE80::/10**	**FE80 FEBF**	**Link-Local Unicast**	**1/1024th**
1111 1110 11	FEC0::/10	FEC0 FEFF	Reserved by IETF; previously Site-Local (deprecated)	1/1024th
1111 1111	**FF00::/8**	**FF00 FFFF**	**Multicast**	**1/256th**

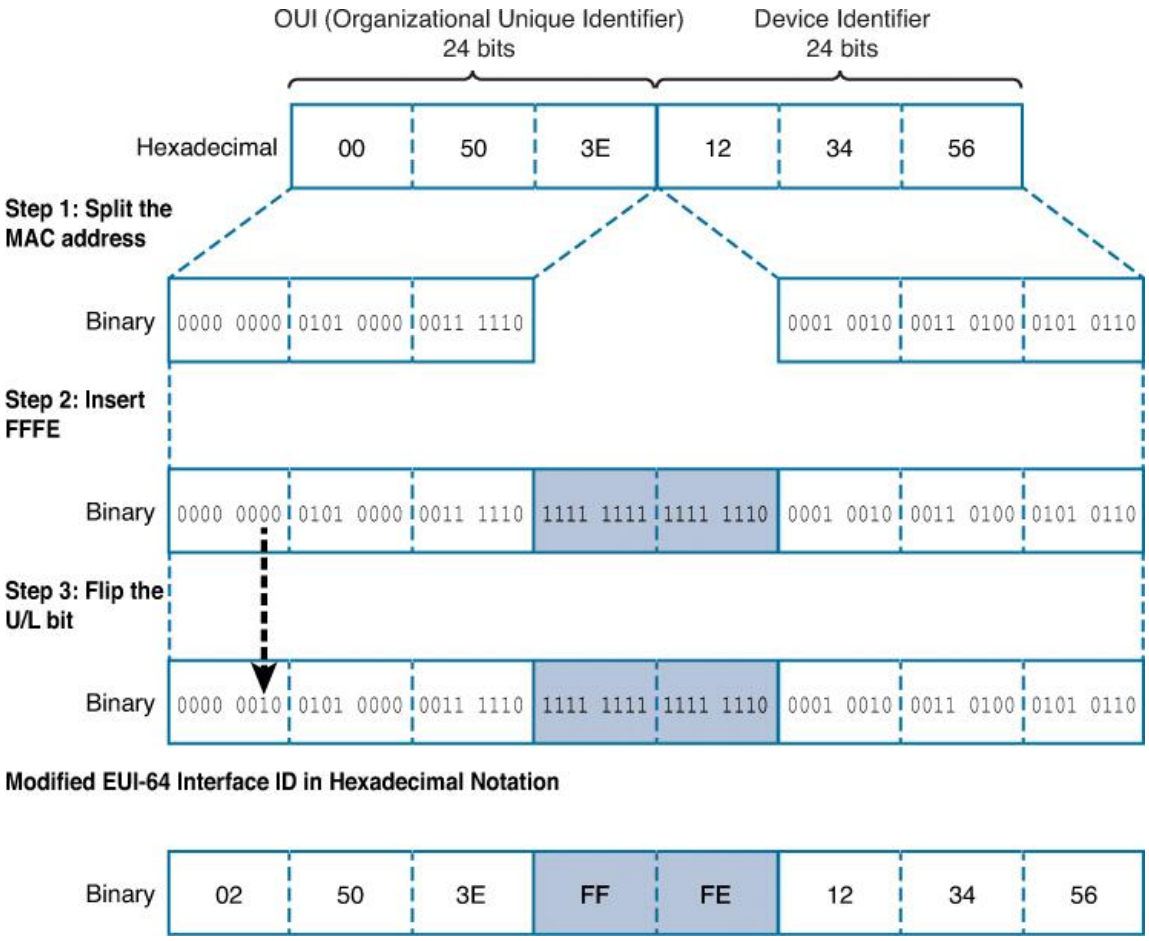
Address Configurations

Global Unicast configurations



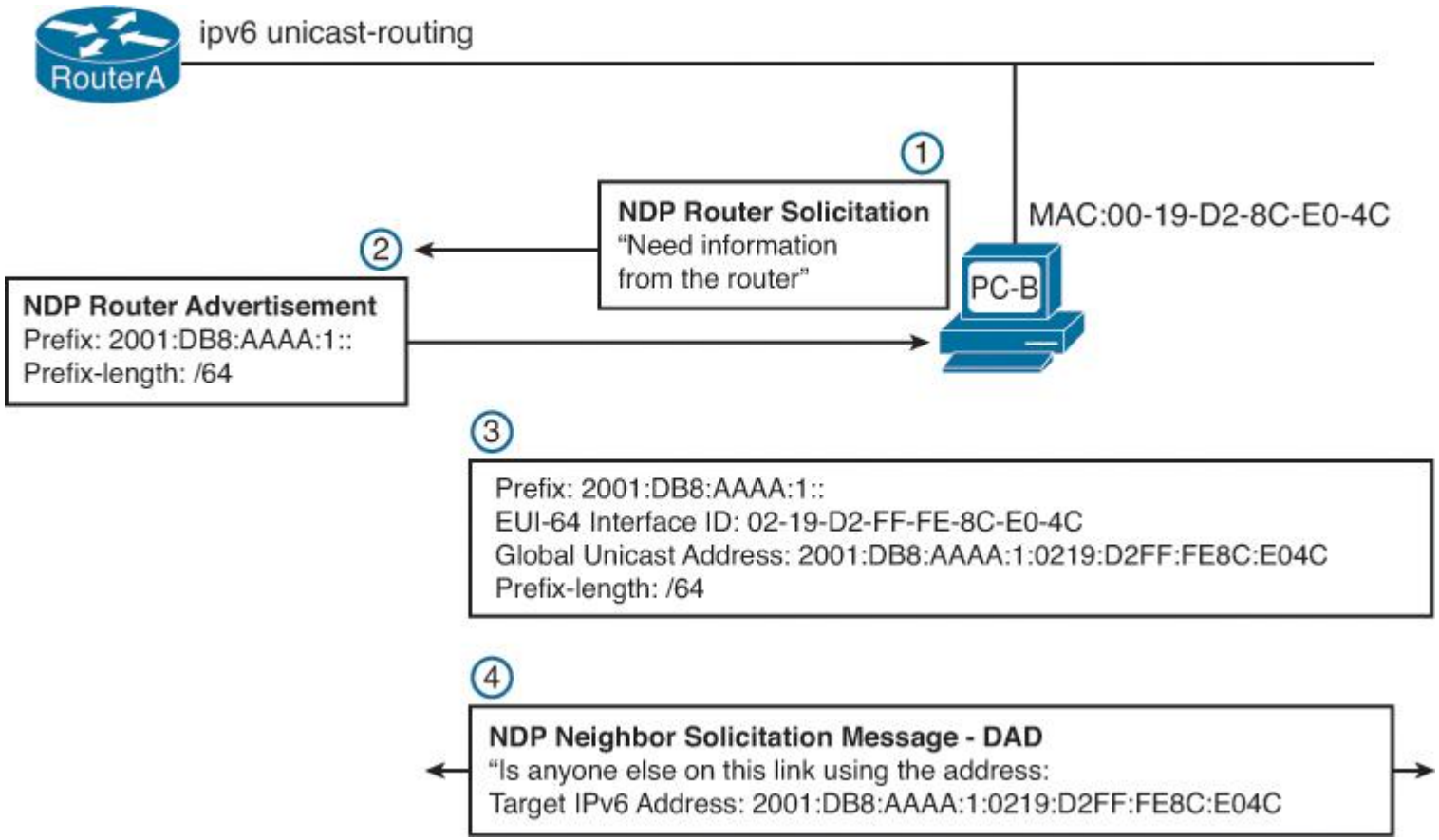
EUI-64

- IEEE Extended Unique Identifier
- Generate a 64-bit Interface ID From the interface's Ethernet MAC address.



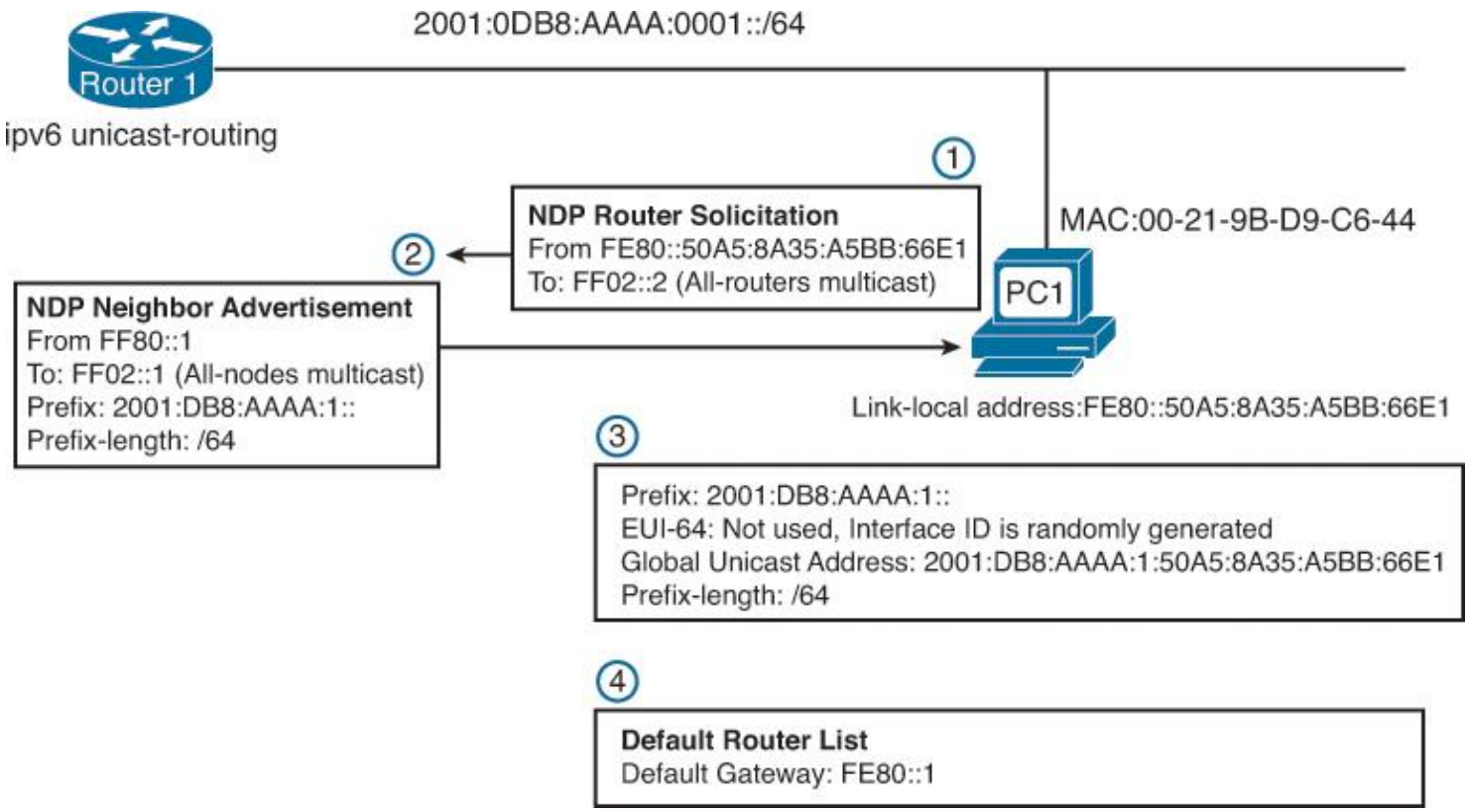
Dynamic GUA – SLACC(EUI-64)

- stateless Address Autoconfiguration
- Neighbor Discovery Protocol (ND or NDP)
- Duplicate Address Detection (DAD)



Dynamic GUA – SLACC (Randomly generated)

- not all operating systems utilize the EUI-64
  - Windows XP, and Windows Server 2003 use EUI-64
  - Windows Vista and newer versions create a random 64-bit Interface ID



Address Configurations – DHCPv6

Dynamic GUA – DHCPv6 services

	Stateful DHCPv6 services	Stateless DHCPv6 services
address	DHCPv6 Server	Router Advertisements
configuration information	DHCPv6 Server	DHCPv6 Server

Unlike SLAAC, the DHCPv6 server DOES keep track of the address assignments therefore knows the state of the devices, which means DHCPv6 is classed as stateful.

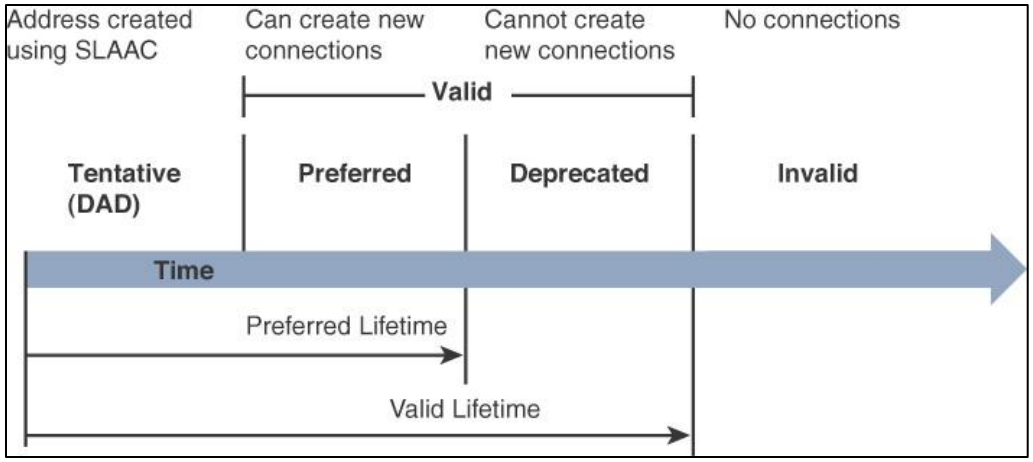
- Networking Fundamentals by Gordon Davies

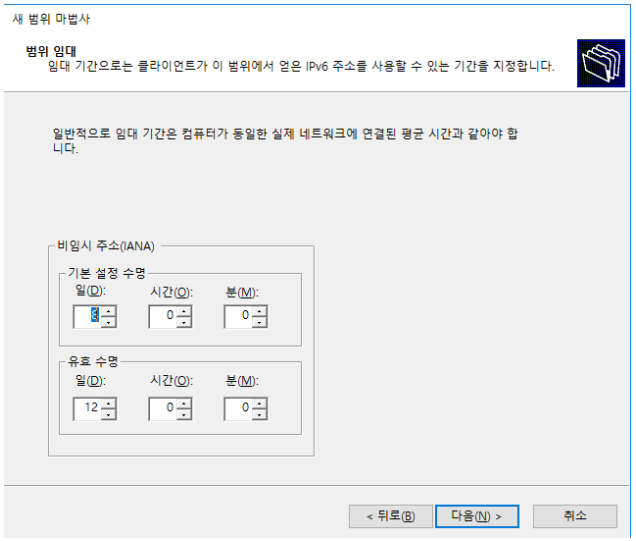
Request for Comments: **8415**, November 2018
Obsoletes: 3315, 3633, 3736, 4242, 7083, 7283, 7550

[ISC]T. Mrugalskim, M. Siodelski
[Cisco] B. Volz, A. Yourtchenko
[SSW] M. Richardson
[Huawei] S. Jiang
[Nibbhaya Consulting] T. Lemon
[UNH-IOL] T. Winters

lifetime – rfc4862

- Preferred lifetime(기본 수명)
  - This time span is equal to or less than the valid lifetime also assigned to the address.
  - If this time expires without the address being refreshed, the address becomes deprecated.
  - In the deprecated state, an address can continue to be used as a destination for existing communication exchanges but is not used for new exchanges or as a source for traffic sent from the interface.
- Valid lifetime(유효 수명)
  - The valid lifetime, which is the total time the address is available, is equal to or greater than the preferred lifetime.
  - The valid lifetime enables communication to continue for transactions that began before the address became deprecated.
  - However, in this time frame, the address should no longer be used for new communications.
  - If this time expires without the deprecated address being refreshed, the address becomes invalid and may be assigned to another interface.
- T1 = preferred lifetime*0.5 T2 = preferred lifetime*0.8
- infinity lifetime: 0xffffffff





DHCPv6 Messages

DHCPv6 Message Type	Description
SOLICIT (1)	A client sends a SOLICIT message to locate servers.
ADVERTISE (2)	A server sends an ADVERTISE message to indicate that it is available for DHCP service, in response to a SOLICIT message received from a client.
REQUEST (3)	A client sends a REQUEST message to request configuration parameters, including IP addresses, from a specific server.
CONFIRM (4)	A client sends a CONFIRM message to any available server to determine whether the addresses it was assigned are still appropriate to the link to which the client is connected.
RENEW (5)	A client sends a RENEW message to the server that originally provided the client's addresses and configuration parameters to extend the lifetimes on the addresses assigned to the client and to update other configuration parameters.
REBIND (6)	A client sends a REBIND message to any available server to extend the lifetimes on the addresses assigned to the client and to update other configuration parameters; this message is sent after a client receives no response to a RENEW message.
REPLY (7)	A server sends a REPLY message containing assigned addresses and configuration parameters in response to a SOLICIT, REQUEST, RENEW, or REBIND message received from a client. A server sends a REPLY message containing configuration parameters in response to an INFORMATION-REQUEST message. A server sends a REPLY message in response to a

DHCPv6 Messages – cont'd

	CONFIRM message, confirming or denying that the addresses assigned to the client are appropriate to the link to which the client is connected. A server sends a REPLY message to acknowledge receipt of a RELEASE or DECLINE message.
RELEASE (8)	A client sends a RELEASE message to the server that assigned addresses to the client to indicate that the client will no longer use one or more of the assigned addresses.
DECLINE (9)	A client sends a DECLINE message to a server to indicate that the client has determined that one or more addresses assigned by the server are already in use on the link to which the client is connected.
RECONFIGURE (10)	A server sends a RECONFIGURE message to a client to inform the client that the server has new or updated configuration parameters, and that the client is to initiate a RENEW/REPLY or INFORMATION-REQUEST/REPLY transaction with the server to receive the updated information.
INFORMATION-REQUEST (11)	A client sends an INFORMATION-REQUEST message to a server to request configuration parameters without the assignment of any IP addresses to the client.
RELAY-FORW (12)	A relay agent sends a RELAY-FORWARD message to transfer messages to servers, either directly or through another

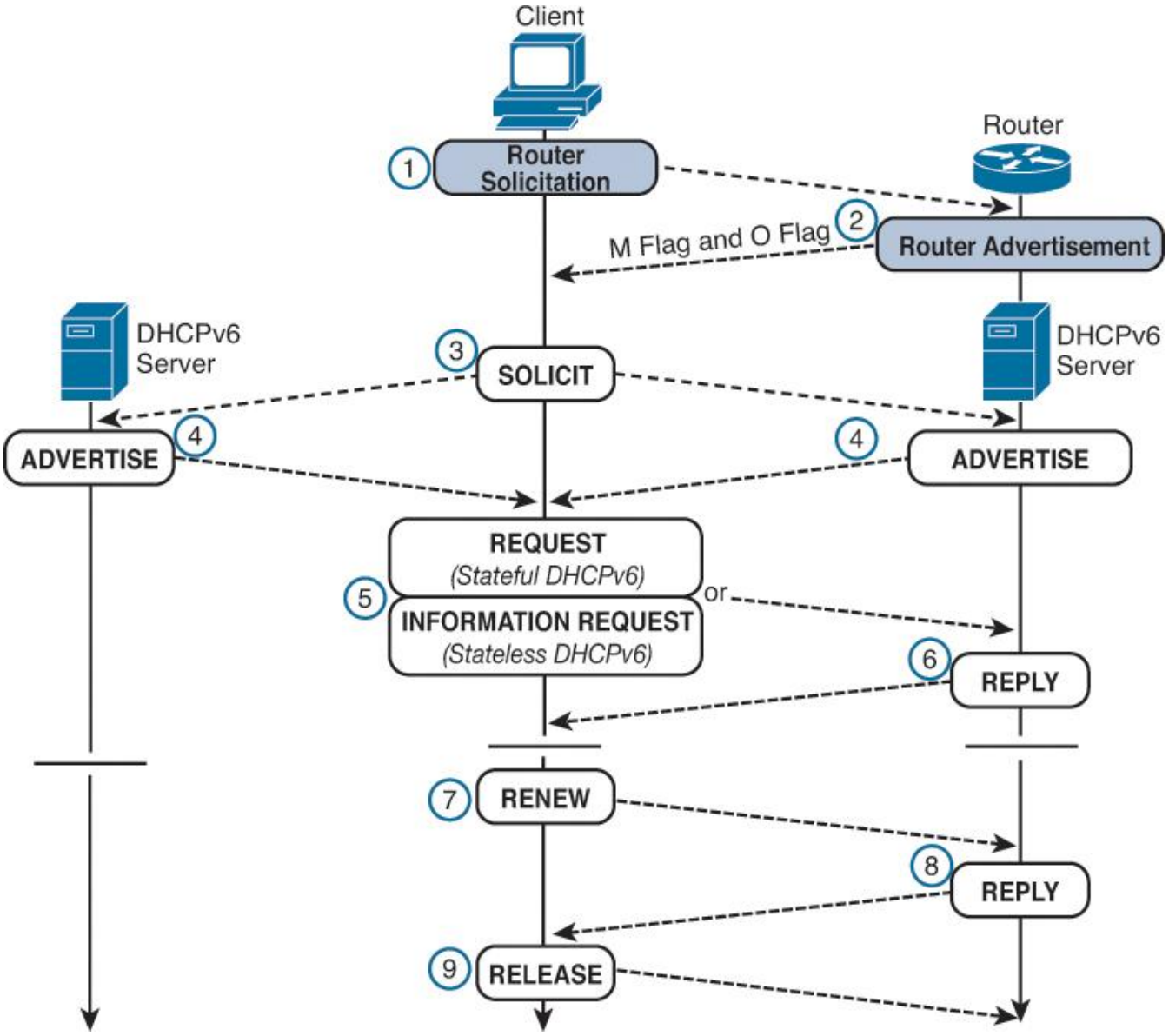
DHCPv6 Messages – cont'd

	relay agent. The received message, either a client message or a RELAY-FORWARD message from another relay agent, is encapsulated in an option in the RELAY-FORWARD message.
RELAY-REPL (13)	A server sends a REPLAY-REPLY message to a relay agent containing a message that the relay agent delivers to a client. The REPLAY-REPLY message can be passed on by other relay agents for delivery to the destination relay agent. The server encapsulates the client message as an option in the REPLAY-REPLY message, which the relay agent extracts and sends to the client.

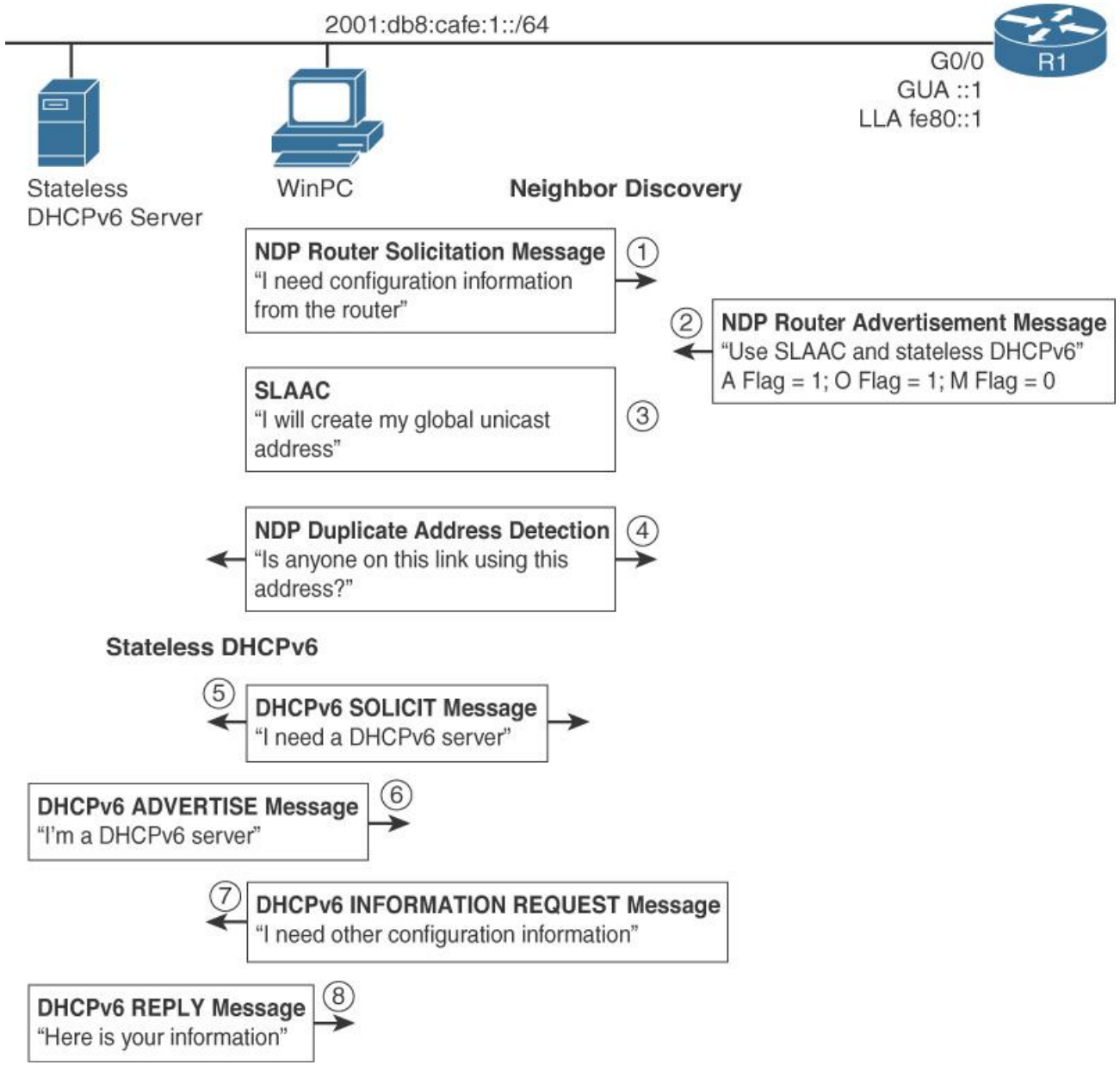
DHCPv6 Messages – cont'd

- **Four DHCPv6 message** types are the **primary messages** used to communicate between a DHCPv6 client and server:
  - **SOLICIT (1):** A SOLICIT message is used by DHCPv6 clients to locate servers.
  - **ADVERTISE (2):** An ADVERTISE message is sent by a server in response to a client's SOLICIT message to indicate that it is available for DHCPv6 service.
  - **REQUEST (3):** A REQUEST message is sent by a client to request configuration parameters, including IP addresses, from a specific DHCPv6 server.
  - **REPLY (7):** A server sends a REPLY message containing assigned addresses and configuration parameters in response to a client's REQUEST message.
    - also be sent in response to a SOLICIT message when the Rapid Commit Option is used.
    - also be sent in response to an INFORMATION-REQUEST, CONFIRM, RELEASE, or DECLINE message.

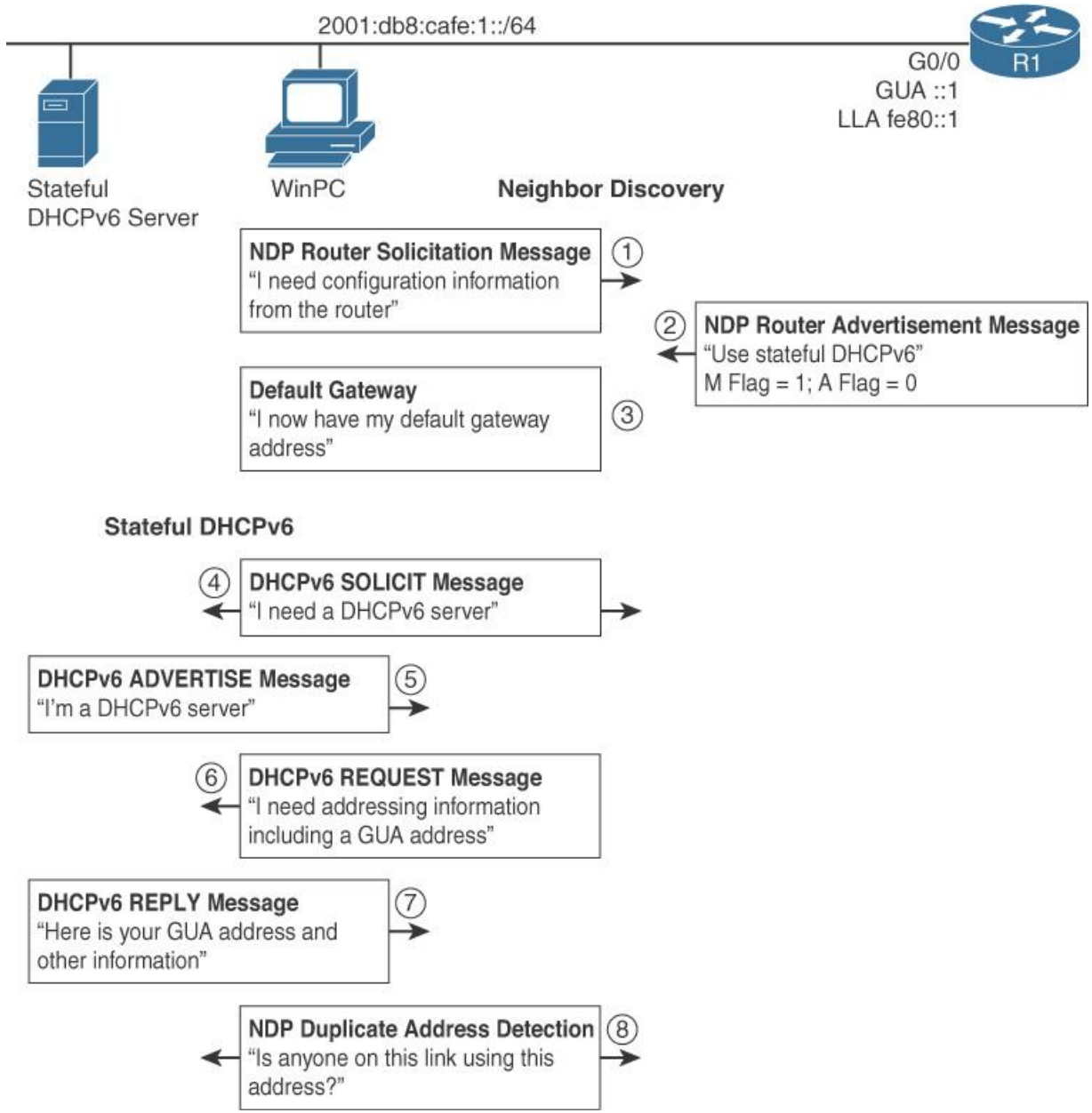
DHCPv6 Communications



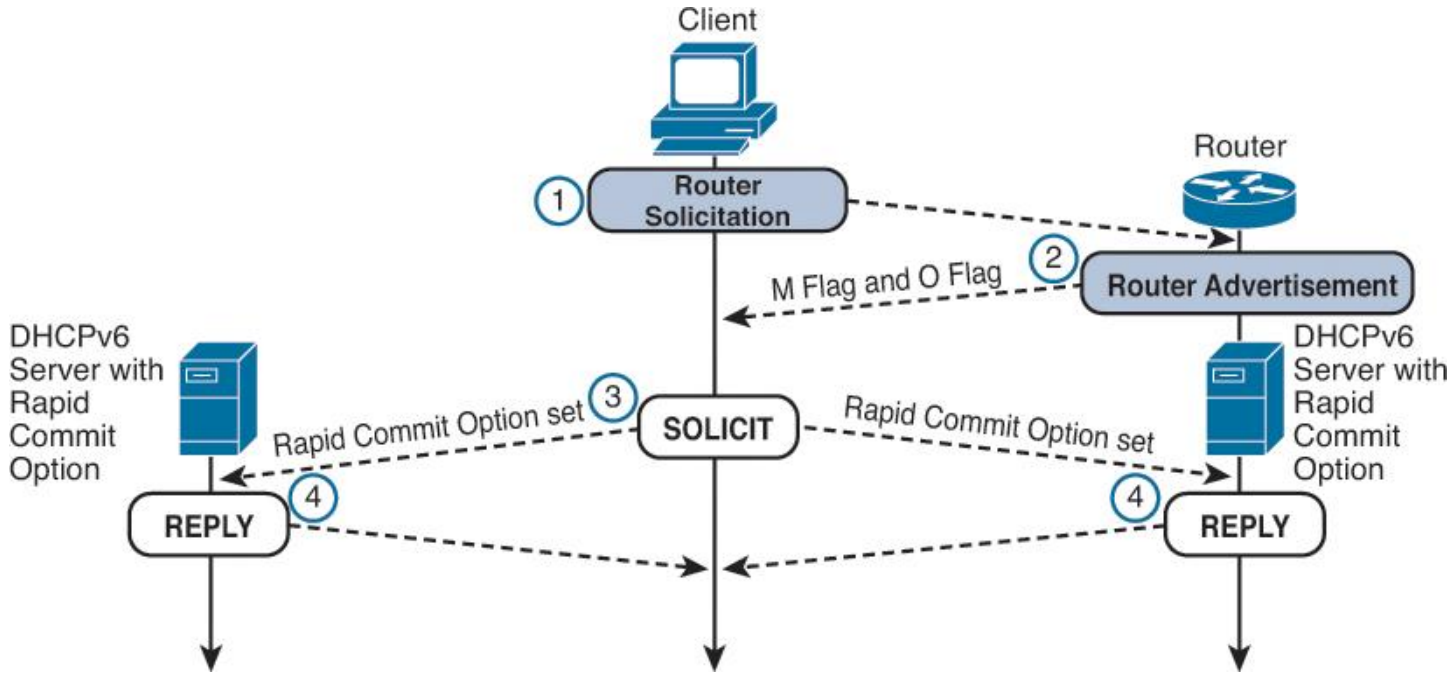
Stateless DHCPv6



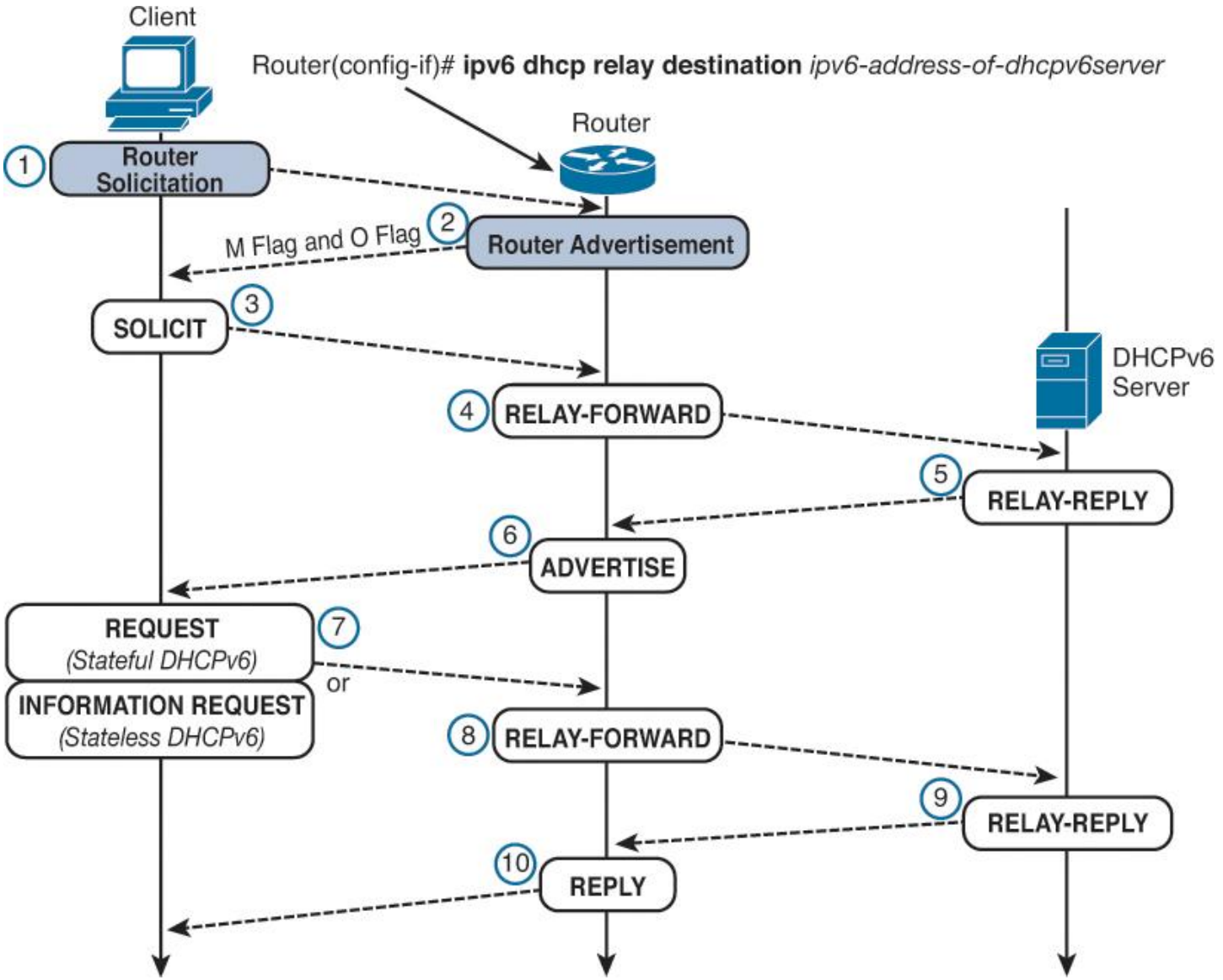
Stateful DHCPv6



DHCPv6 with Rapid Commit Option



DHCPv6 Relay Agent Communications



DHCPv6 Services

- Temporary address – SLAAC
- Non Temporary address – DHCP
- Prefix delegation* – DHCP

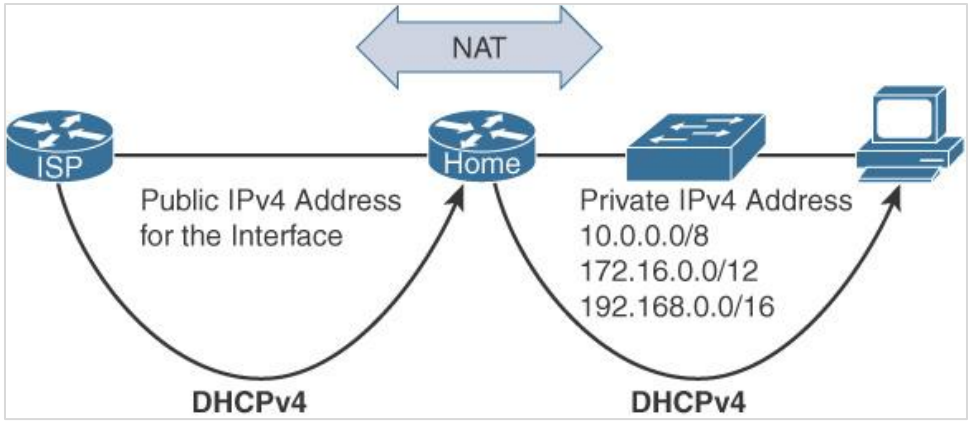
```
//ISC DHCP
default-lease-time 600;
max-lease-time 7200;
subnet6 2001:db8:0:1::/64 {
        # Range for clients
        range6 2001:db8:0:1::129
                2001:db8:0:1::254;

        # Range for clients requesting a temporary address
        range6 2001:db8:0:1::/64 temporary;

        # Additional options
        option dhcp6.name-servers fec0:0:0:1::1;
        option dhcp6.domain-search "domain.example";

        # Prefix range for delegation to sub-routers
        prefix6 2001:db8:0:100:: 2001:db8:0:f00:: /56;
}
```

Temporary IPv6 address – rfc4941

- for security reasons, temporary addresses are used.
  - make it difficult to link the address to different actions over time.
- has no explicit "lifetime" or "lease length“
  - A client MAY request that the valid lifetime in a Renew or Rebind message to a server
    - to continue to use an established TCP connection.
      - but not the preferred,
      - lifetime means the address will end up in a deprecated state eventually.
      - Existing connections could continue, but no new ones would be created using that address.
- lifetime
  - TEMP_VALID_LIFETIME: Default 1 week.
  - TEMP_PREFERRED_LIFETIME: Default 1 day.

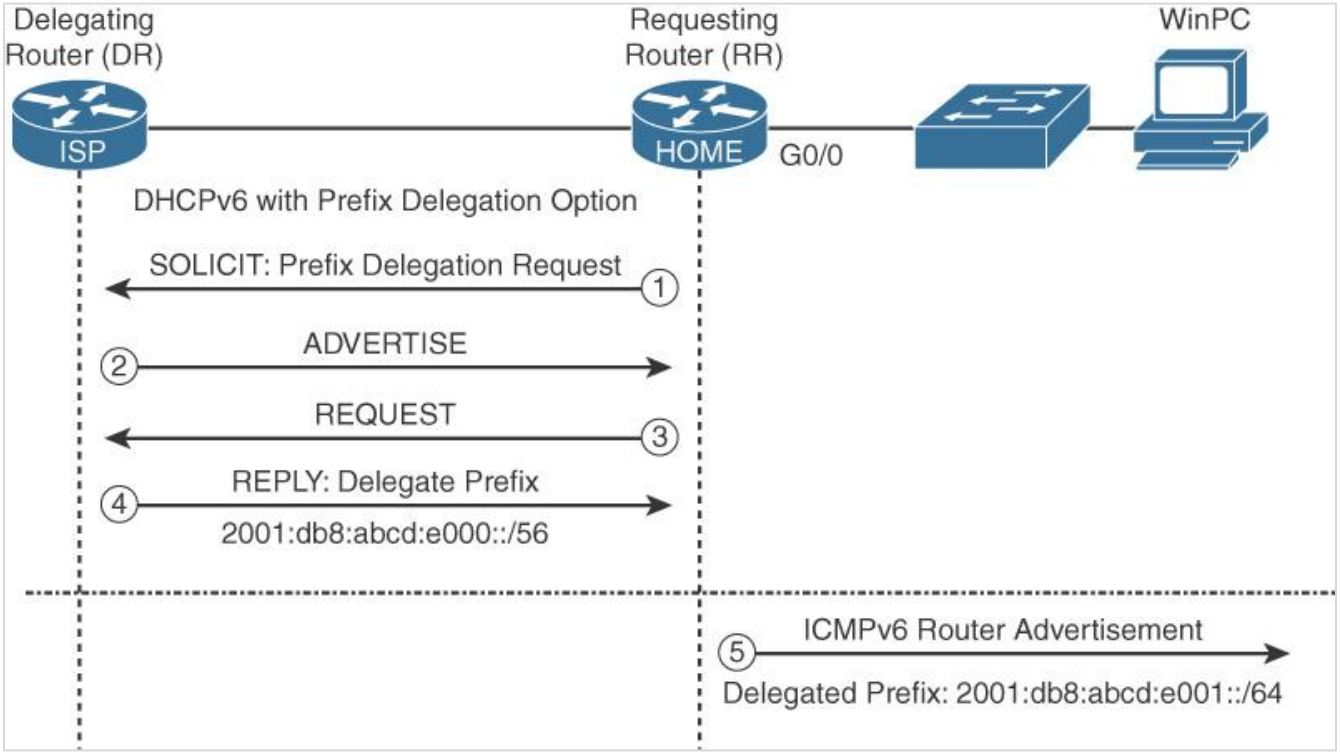
```
WinPC> ipconfig
Ethernet adapter Local Area Connection:
IPv6 Address. . . . . . . . . . . : 2012:65:fd85:5712:e0ca:9e76:661f:c4f1
Temporary IPv6 Address. . . . . . : 2012:65:fd85:5712:74:5cd9:163c:69ef
Temporary IPv6 Address. . . . . . : 2012:65:fd85:5712:e3:52fd:b15f:6d7d
[...over 600 more entries...]
Temporary IPv6 Address. . . . . . : 2012:65:fd85:5712:fda8:816e:6d3:7713
Temporary IPv6 Address. . . . . . : 2012:65:fd85:5712:fdc9:7a6b:d2c5:e880
Temporary IPv6 Address. . . . . . : 2012:65:fd85:5712:fdf4:11ed:9aba:9e27
Link-local IPv6 Address . . . . . : fe80::e0ca:9e76:661f:c4f1%3
IPv4 Address. . . . . . . . . . . : 192.168.178.22
Subnet Mask . . . . . . . . . . . : 255.255.255.0
Default Gateway . . . . . . . . . : fe80::a96:d7ff:fe1f:cb26%3
                                    192.168.178.1
```

Prefix Delegation

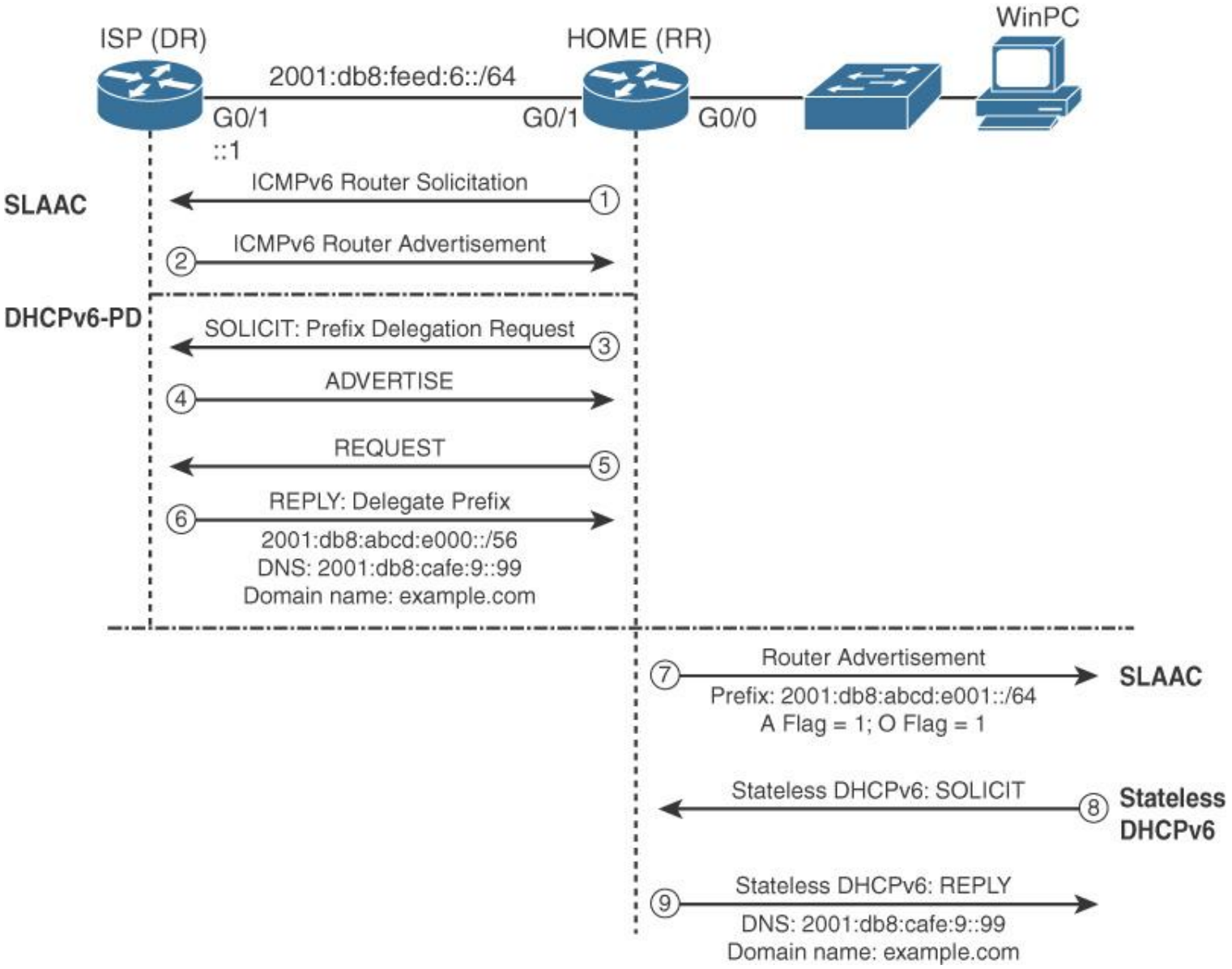


IPv4

IPv6



Prefix Delegation – cont'd



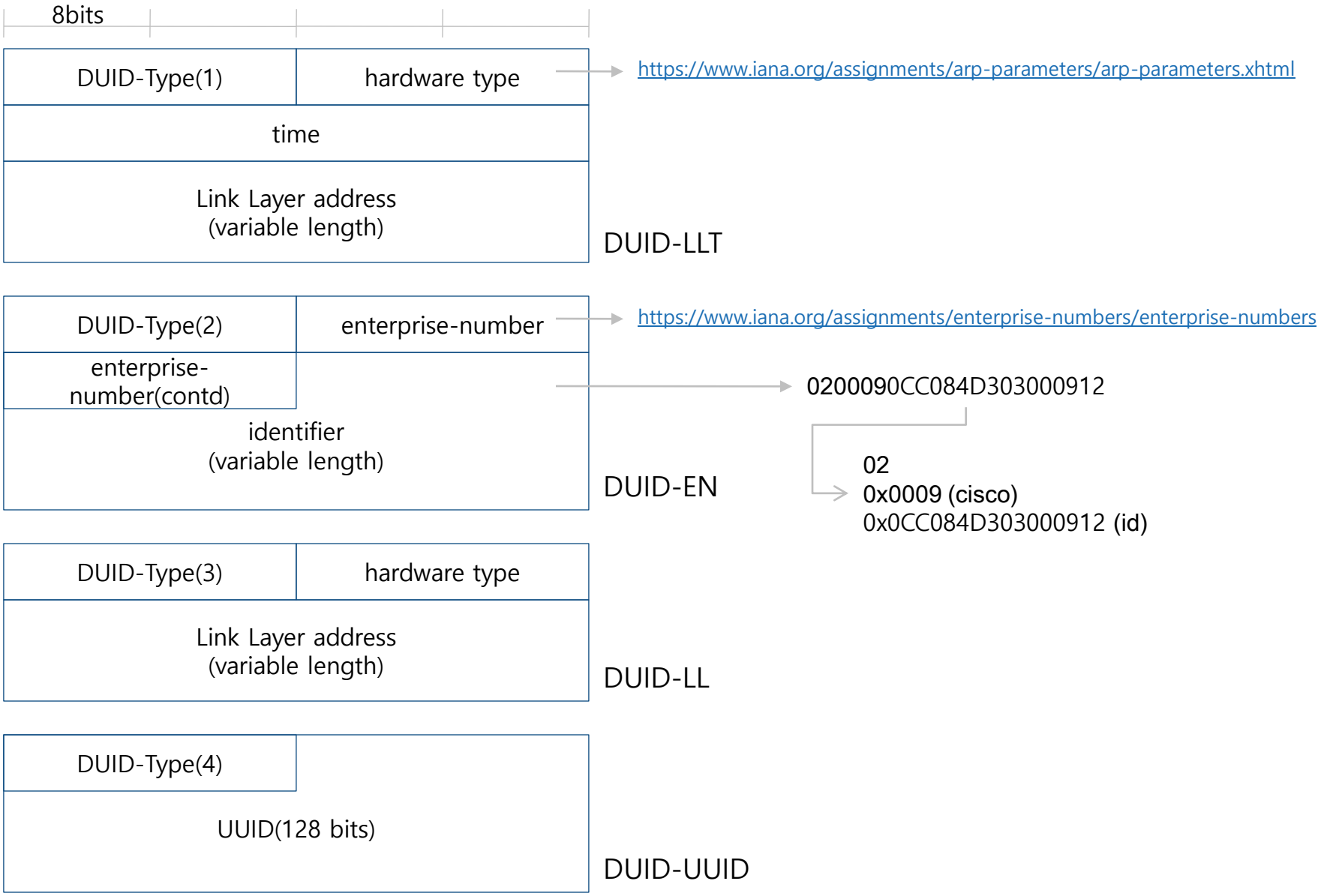
DUID

- client's DHCP Unique Identifier
- to identify clients
  - MAC address(Link-lyaer address) to identify clients in DHCPv4.
- RFC 3315 defines three types of DUIDs
  - [1] Link-layer address plus time(DUID-LLT)
  - [2] Vendor-assigned unique ID based on Enterprise Number(DUID-EN)
  - [3] Link-layer address(DUID-LL)
  - [4] Universally Unique Identifier(DUID-UUID)
    - rfc 6355

```
설명. . . . . : Intel(R) Ethernet Connection I217-LM
물리적 주소 . . . . . : 98-90-96-A9-89-C9
DHCP 사용 . . . . . : 아니요
자동 구성 사용. . . . . : 예
링크-로컬 IPv6 주소 . . . . : fe80::613e:c277:ef4a:3ef5%2(기본 설정)
IPv4 주소 . . . . . : 192.168.3.51(기본 설정)
서브넷 마스크 . . . . . : 255.255.255.0
기본 게이트웨이 . . . . . : 192.168.3.1
DHCPv6 IAID . . . . . : 60330134
DHCPv6 클라이언트 DUID. . . : 00-01-00-01-24-C1-95-FF-98-90-96-A9-89-C9
```

DUID TYPE(0x0001)
H/W TYPE(0x0001)
TIME(0x24C195FF): Seconds since midnight (UTC), January 1, 2000
Link Layer address(MAC address)

DUID FORMAT

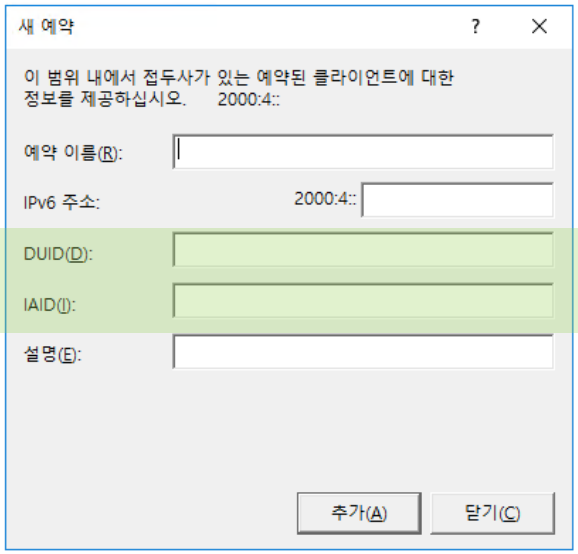

8bits
DUID-Type(1)
hardware type
time
Link Layer address
(variable length)
DUID-LLT
https://www.iana.org/assignments/arp-parameters/arp-parameters.xhtml
DUID-Type(2)
enterprise-number
enterprise-
number(contd)
identifier
(variable length)
DUID-EN
https://www.iana.org/assignments/enterprise-numbers/enterprise-numbers
0200090CC084D303000912
02
0x0009 (cisco)
0x0CC084D303000912 (id)
DUID-Type(3)
hardware type
Link Layer address
(variable length)
DUID-LL
DUID-Type(4)
UUID(128 bits)
DUID-UUID

DUID and link-layer address (MAC)

- a client's link-layer address from a DUID is unreliable.
- to get link-layer address
  - Link-Layer Address option [RFC6939].

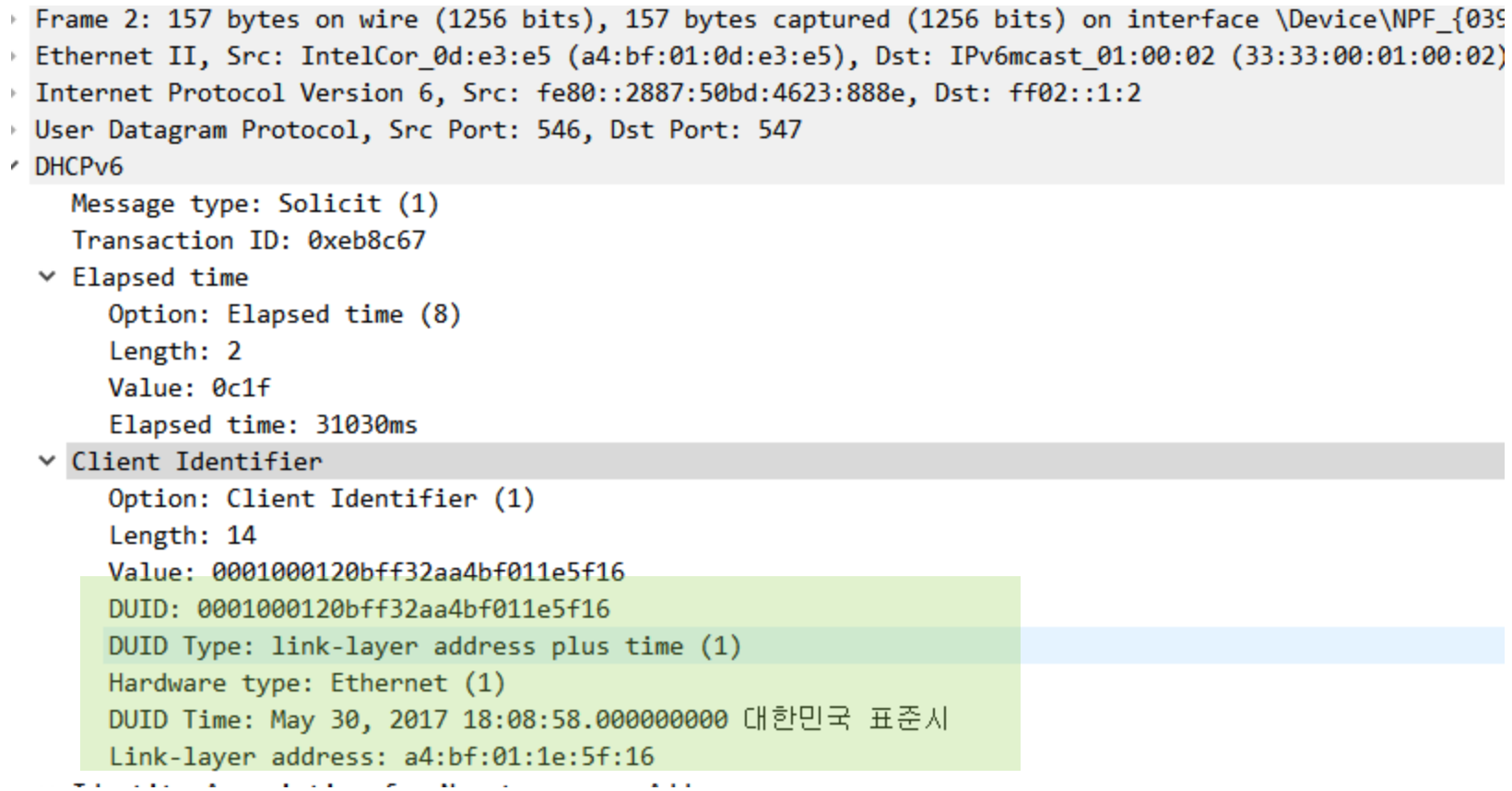
DHCPv6 예약

// Window server 2016, 2019



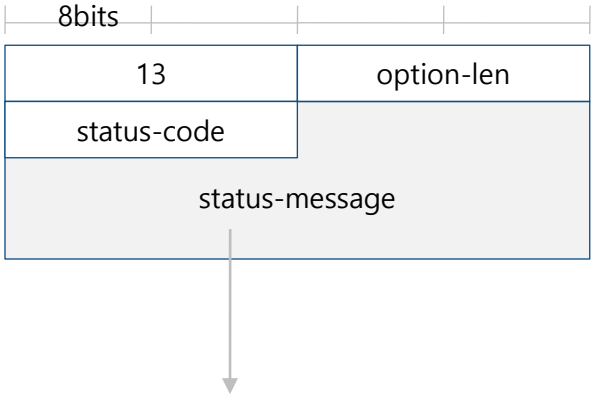

```
//ISC DHCP
default-lease-time 600;
max-lease-time 7200;
subnet6 2001:db8:0:1::/64 {
        # Example for a fixed host address
        host specialclient {
                host-identifier option dhcp6.client-id   00:01:00:01:4a:1f:ba:e3:60:b9:1f:01:23:45;
                fixed-address6 2001:db8:0:1::127;
    }
}
```

DUID Wireshark



Status Code

- the success or failure of operations requested in messages from clients and servers
- provide additional information about the specific cause of the failure of a message
- If the Status Code option does not appear,
  the status of the message is assumed to be Success.



A UTF-8 encoded [RFC3629] text string
suitable for display to an end user.
MUST NOT be null-terminated.

Name	Code	Description
Success	0	Success
UnspecFail	1	Failure, reason unspecified
NoAddrsAvail	2	The server has no addresses available
NoBinding	3	Client record (binding) unavailable
NotOnLink	4	The prefix for the address is not appropriate for the link to which the client is attached.
UseMulticast	5	Sent by a server to a client to force the client to sen d messages to the server using the All_DHCP_Relay_ Agents_and_Servers(ff02::1:2) multicast address.
NoPrefixAvail	6	The server has no prefixes available

https://www.iana.org/assignments/dhcpv6-parameters/dhcpv6-parameters.xhtml

Selecting addresses for assignment

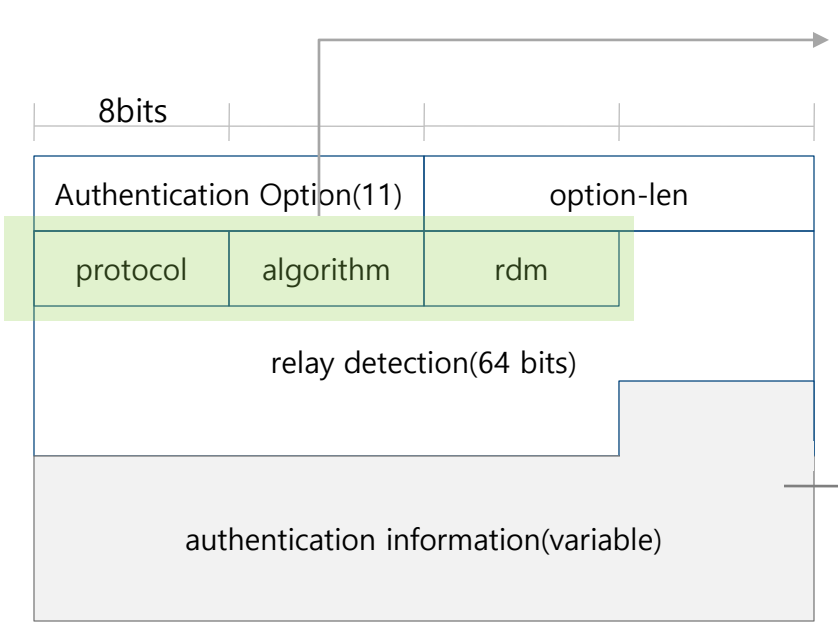
- rfc 7721, 4.7
  - Recent releases of most popular DHCPv6 server software typically
    - lease random addresses
      - https://tools.ietf.org/html/draft-ietf-dhc-stable-privacy-addresses-02
  - some DHCPv6 software
    - leases sequential addresses (typically low-byte addresses)
    - they follow specific patterns, they enable IPv6 address scans.

preference option

- sent by a server to a client to control the selection of a server by the client.
- A server MAY include a Preference option in an Advertise message to control th e selection of a server by the client.
- If a client receives multiple advertise message then the client select a message that has highest preference value.

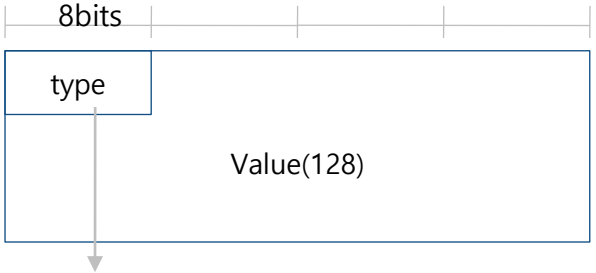
Authentication

- protection against misconfiguration of a client caused by a Reconfigure message sent by a malicious DHCP server
- Reconfiguration Key Authentication Protocol (RKAP)



https://www.iana.org/assignments/auth-namespaces/auth-namespaces.xhtml
0 configuration token [RFC3118]
1 delayed authentication [RFC3118]
2 Delayed Authentication (Obsolete) [RFC8415]
3 Reconfigure Key [RFC8415]

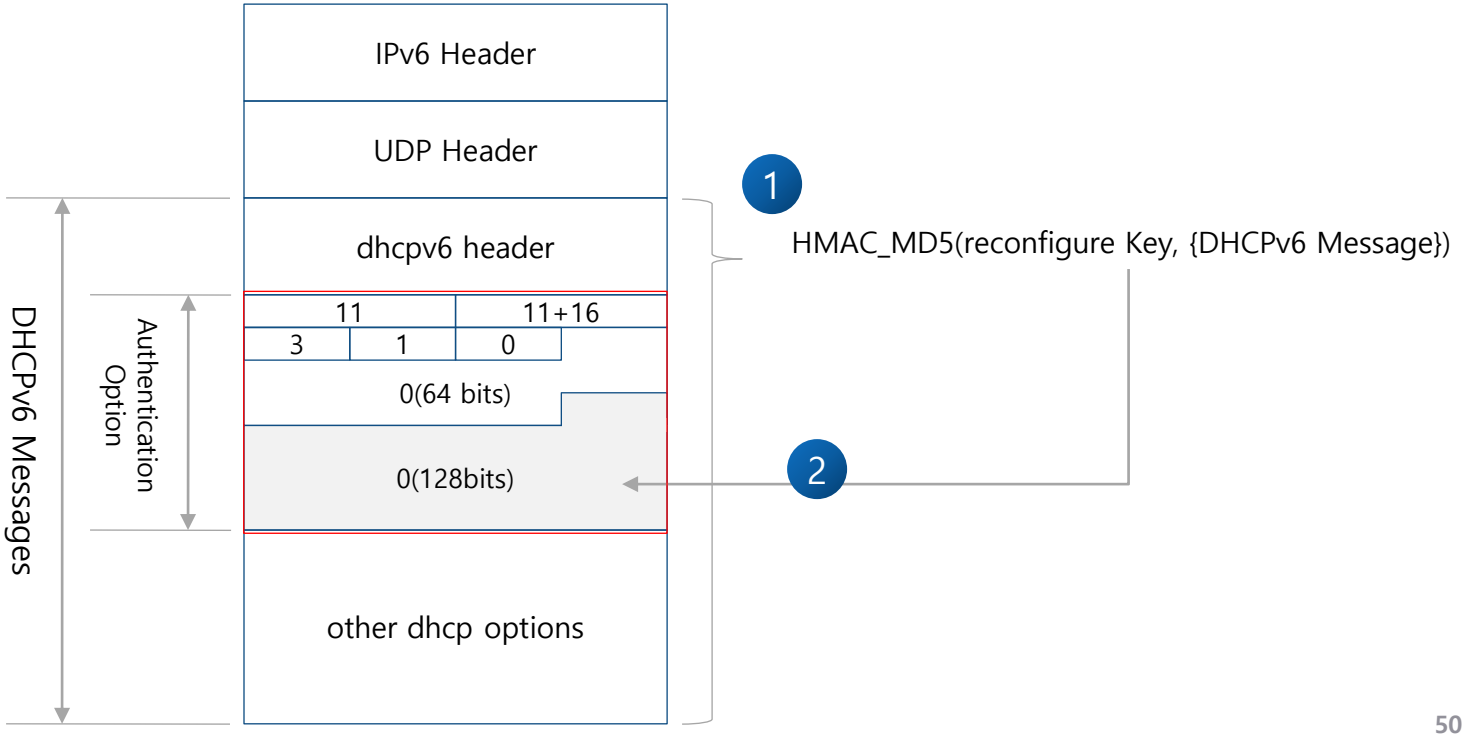
0 configuration token [RFC3118]
1 HMAC-MD5 [RFC3118][RFC8415]



1 Reconfigure key value (used in the Reply message).
2 HMAC-MD5 digest of the message (used in the Reconfigure message).

Reconfiguration Key Authentication Protocol (RKAP)

- The reconfigure key
  - server selects a reconfigure key for a client during the Request/Reply, Solicit/Reply, or Information-request/Reply message exchange
  - The reconfigure key is 128 bits long and MUST be
    - a cryptographically strong random
    - or pseudorandom number that cannot easily be predicted.
    - ex) 0x00112334455667788 99AABBCCDDEEFF: must be keep at database!
- HMAC-MD5 digest of the message



DHCPv6 Options

- 값의 형태가 여러 가지 형식으로 지정 될 수 있다.
  - Text 형태를 유지?
- 예로 IPv6 NTP Server Option이 그러하다.
  - 하나의 옵션에 다음과 같이 여러 형태로 포함될 수 있다.
    - Unicast IPv6
    - Multicast IPv6
    - FQDN (Fully-Qualified Domain Name)
      - myntp.com
      - IPv6 형태가 아니다.
- 개발 범위
  - 초기에는 필수적으로 필요한 옵션만 정의해 가능하게 하고 추가적으로 계속 업그레이드를 한다.
    - 옵션 개수가 너무 많고 랜 환경에서 사용이 되지 않는 옵션이 많다.

Name: options Database: lyon_dhcp

Engine: INNODB

Columns

Name	Data Type	Unsigned	Auto Increment	Not Null	Default	Collation
options_id	INT(11)	☑	☑	☑		
code	INT(11)	☑	☐	☑		
ipver	ENUM('4','6')	☐	☐	☑		utf8mb4_general_ci
name	VARCHAR(200)	☐	☐	☑		utf8mb4_general_ci
desc	TEXT	☐	☐	☐	NULL	utf8mb4_general_ci
data_type	ENUM('IPV4','IPV6','LONG','TEXT','BYTE','SHORT')	■	■	■	NULL	utf8mb4_general_ci
		▣	▣	▣		

Others

- User Class Option
  - https://docs.microsoft.com/en-us/openspecs/windows_protocols/ms-dhcpe/88176fde-8e86-4d21-a6d5-1964ff5cf5c1
- DHCPv6 Failover Protocol
  - rfc8156
- OPTION_RADIUS
  - rfc7037

For more…

- [rfc8415] Dynamic Host Configuration Protocol for IPv6 (DHCPv6)
- [rfc4862] IPv6 Stateless Address Autoconfiguration
- [rfc6221] Lightweight DHCPv6 Relay Agent
- [rfc7824] Privacy Considerations for DHCPv6
- [rfc4941] Privacy Extensions for Stateless Address Autoconfiguration in IPv6
- [rfc8156] DHCPv6 Failover Protocol
- IPv6 Fundamentals: A Straightforward Approach to Understanding IPv6, 2nd Edition
  - by Rick Graziani Published by Cisco Press, 2017
- IPv6 Fundamentals: A Straightforward Approach to Understanding IPv6
  - by Rick Graziani Published by Cisco Press, 2012
- Networking Fundamentals
  - by Gordon Davies, Publisher: Packet Publishing, December 2019
- [I-D.ietf-dhc-stable-privacy-addresses] A Method for Generating Semantically Opaque Interface Identifiers with Dynamic Host Configuration Protocol for IPv6 (DHCPv6)
- [StackExchange] Why does my Windows have hundreds of temporary IPv6 addresses?
- [StackExchange] Is there an renew after the lease-time or after the half of the lease-time in DHCPv6?
- [wiki] DHCPv6
- [wiki] IPv6
- [wiki] Regional_Internet_registry
  - IANA
- [wiki] Asia-Pacific_Network_Information_Centre
- IPv6 DHCPv6 Prefix Delegation
- IANA DHCPv6 parameters