WOW!!! Hardwired Dual TCP/IP Stack Controller - W6100 [PART I]

by MC

Overview

What, Why, How : IPv6

In **PART I**, Let's learn what IPv6 is, why it is needed, how it is used, and In **PART II**, I will introduce the world's first Hardwired **Dual** TCP/IP Stack Controller called **W6100** .

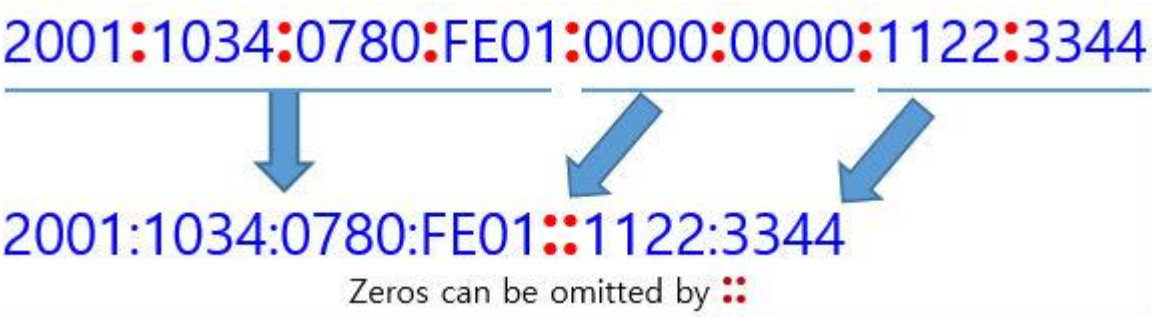
What is IPv6 ?

IPv6 is the next generation Internet Protocol due to the depletion of IPv4 addresses. By changing 4 Bytes IPv4 address to 16 Bytes IPv6 address, it is possible to extend the range of the assignable IP Address.

- IPv6 Address Structure & Type

  The following figures show the structure and notation of IPv6 address

```
|        n bits         |   m bits  |       128-n-m bits          |
+-----------------------+-----------+-----------------------------+
| global routing prefix | subnet ID |       interface ID          |
+-----------------------+-----------+-----------------------------+
```

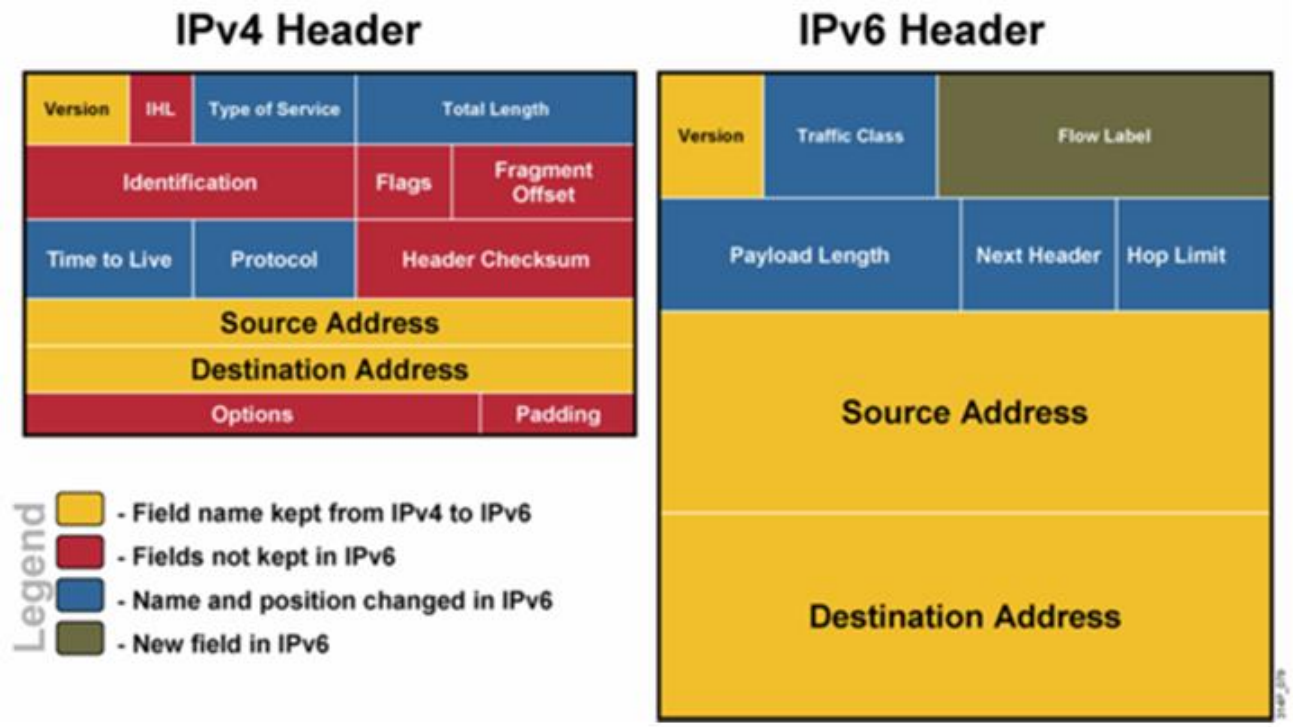


The IPv6 address is generally used as the Subnet Prefix for the upper 64 bits (n bit + m bit) and the Interface ID for the lower 64 bits. Also, it can be divided into Link-Local, Site-Local and Global Unicast Address according to the setting of n bits, and can be classified into Unicast, Anycast, Multicast Address, and the like. The following figure shows the type of IPv6 address according to n-bits.

```
The general format for IPv6 Global Unicast addresses is as follows:

|         n bits          |   m bits   |       128-n-m bits          |
+-------------------------+------------+-----------------------------+
| global routing prefix   | subnet ID  |       interface ID          |
+-------------------------+------------+-----------------------------+

Site-Local addresses have the following format:

|   10     |
|  bits    |         54 bits          |         64 bits             |
+----------+--------------------------+-----------------------------+
|1111111011|        subnet ID         |       interface ID          |
+----------+--------------------------+-----------------------------+

Link-Local addresses addresses have the following format:

|   10     |
|  bits    |         54 bits          |          64 bits            |
+----------+--------------------------+-----------------------------+
|1111111010|           0              |       interface ID          |
+----------+--------------------------+-----------------------------+

Multicast addresses have the following format:

|   8    |  4 |  4 |                  112 bits                     |
+------ -+----+----+-----------------------------------------------+
|11111111|flgs|scop|                  group ID                     |
+--------+----+----+-----------------------------------------------+
```

For more details, Refer to RFC4291.

- IPv4 vs IPv6 Address Format



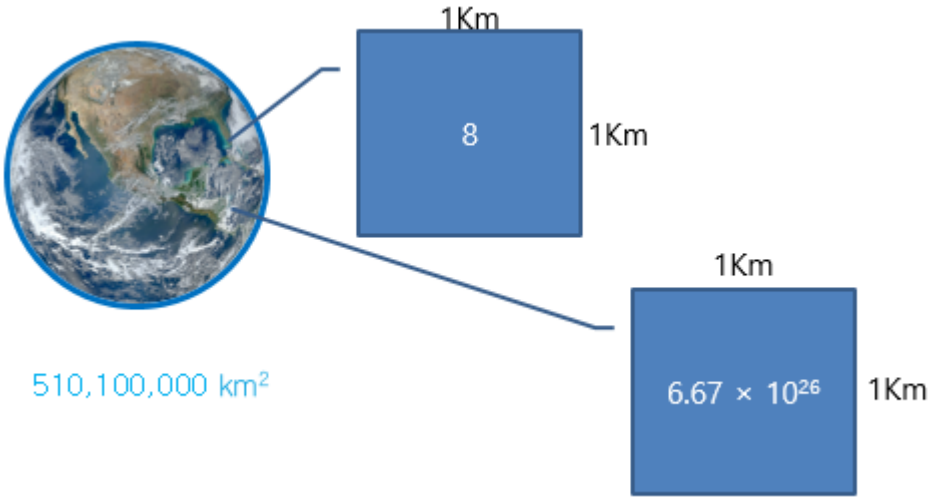
IPv6 Header has a more efficient header structure by modifying and supplementing IPv4 header. The above figure compares between IPv4 and IPv6 header. A major change in IPv6 is the elimination of the ID and Header Checksum and the IPv6 header length fix to 40 Bytes.

- Coverage of IPv4 & IPv6

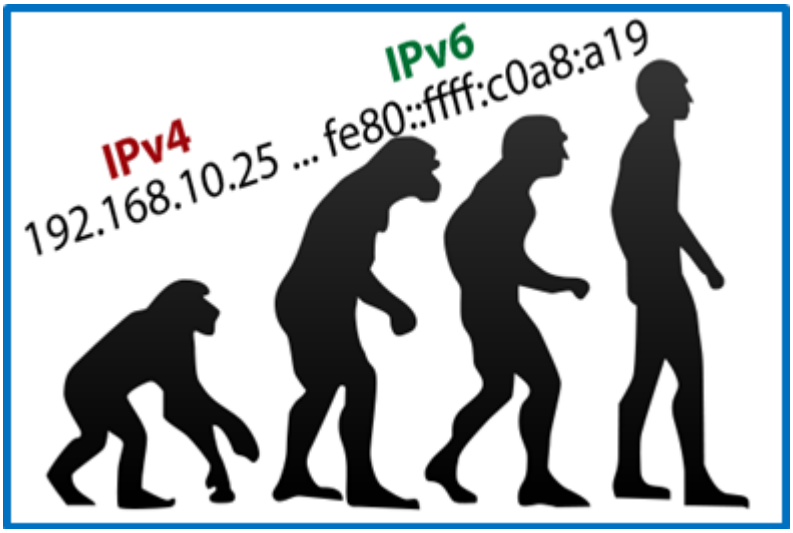
The IPv6 address is so large that it can not be compared with the IPv4 address. The following table compares the assignable number of IPv4 and IPv6.

	Power of 10	Real count
IPv4	4.3 X 10 ^9^	4,294,967,296
IPv6	3.4 X 10 ^38^	340,282,366,920,938,463,463,374,607,431,768,211,456

As shown in the figure below, we can see the vastness of the IPv6 address even if we look at the IP address density per 1KM^2.



Why need IPv6 ?



It is not too much to overemphasize the need for IPv6 addresses due to depletion of IPv4 addresses. The transition from IPv4 addresses to IPv6 addresses is accelerating worldwide. Of course, the Network Address Transition (NAT) that can utilize 100% of the IPv4 address by sharing the IP address can solve the exhaustion problem of the IPv4 address, but it has a limitation. In the current IoT world, many devices around the world are connected to the Internet and become intelligent. Although it overcomes the depletion of IPv4 Address by utilizing NAT router or Edge computer technology, it has a problem that it can not directly control the device because peer-to-peer connection is impossible.

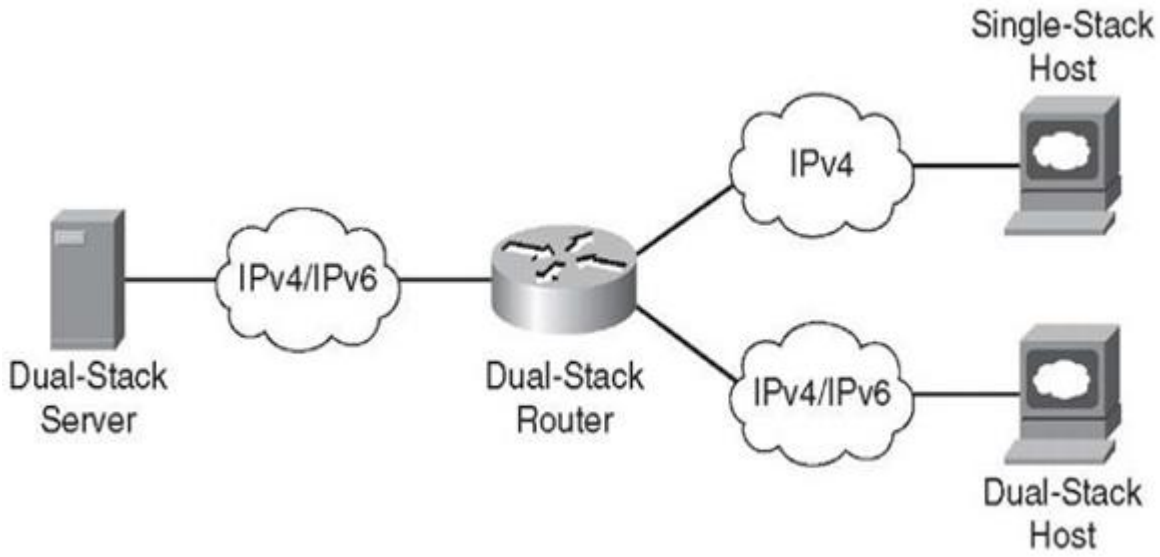
In addition to the address assignment problem, IPv6 improves the communication efficiency by removing the unnecessary header checksum calculation of IPv4, and by fixing the header length, the router overhead is greatly reduced.

Therefore, evolution from IPv4 to IPv6 is quite natural, and many Internet devices will have IPv6 addresses instead of IPv4 addresses in the future.

How to use?

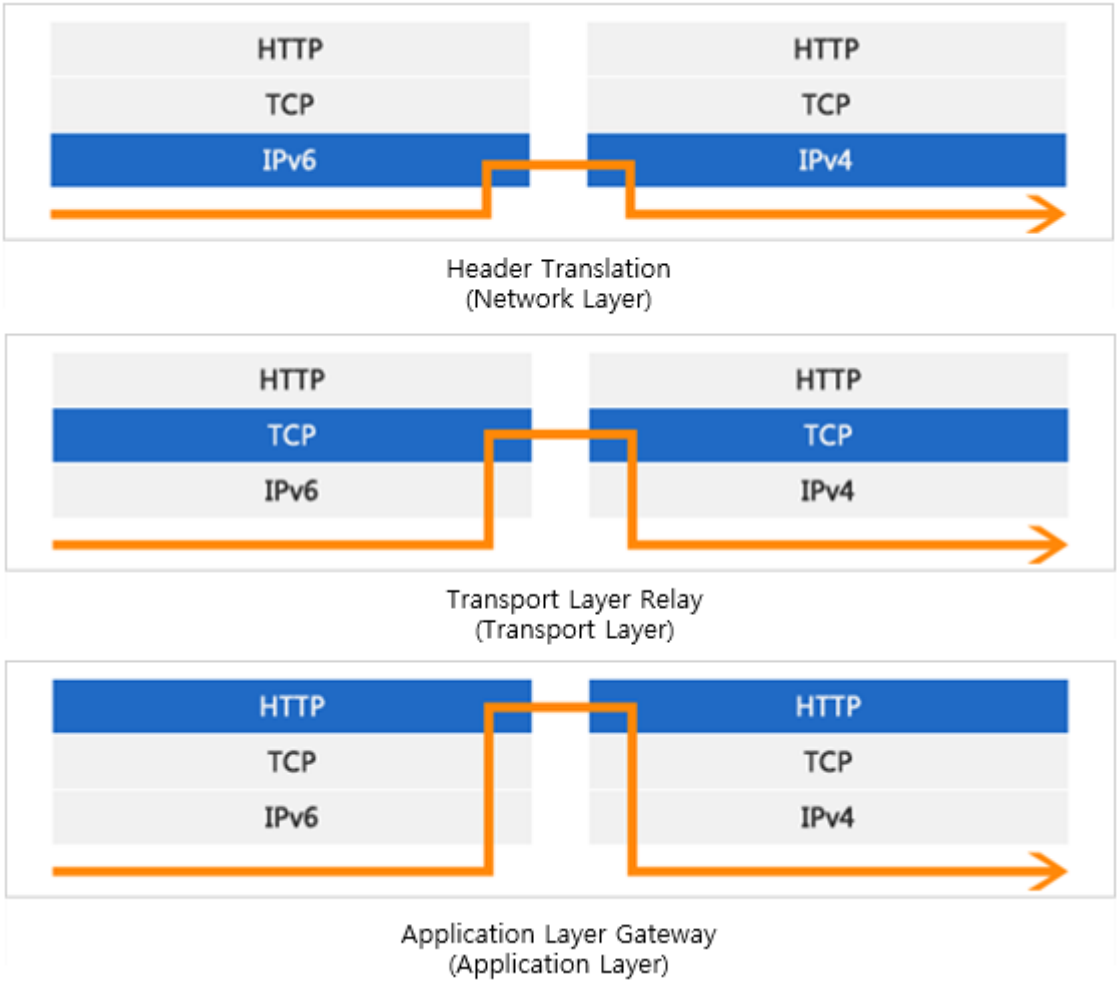
There are three major ways to transition from IPv4 to IPv6:

- Dual Stack



It literally has both IPv4 and IPv6 stack, and it is a method to correspond to communication according to the corresponding IP version. W6100 uses only dual stack method. W6100 will describe more detail in PART II.

- Translation



Translation method converts IPv4 packet to IPv6 packet through a specific communication layer, vice versa. The above 3 figures explain well how to covert packets in each layer. For more details, refer to Cisco Aritcle

1. Header Translation

The header translation is to convert IPv6 header into IPv4 header or vice versa. At this time, it is necessary to adjust (recalculate) the checksum to maintain packet integrity. For examples, NAT-PT (Network Address Translation Protocol Translation) and SIIT (Stateless IP/ICMP Translation) use this method.

2. Transport Relay

Transport relay method translate IPv4 or IPv6 packets through transport layer such as TCP and UDP. For examples, TRT (Transport Relay Translator) and SOCKS Gateway use this method.

3. Application Gateway 방식 (ALG)

ALG method is a conversion at the application layer such as HTTP. Since each service is independent for each IPv4 and IPv6, It is not necessary to convert header of packet. However, the ALG for each service must to run on both IPv4 and IPv6. A typical example is the SQUID which is an IPv4/IPv6 web proxy. This method determines the quality of service according to the performance of the ALG.

- Tunneling

Tunneling IPv6 in IPv4

IPv6/IPv4 terminals and routers can encapsulate IPv6 datagrams in IPv4 packets and the encapsulated packet can be transmitted through IPv4 networks, vice versa. That is, tunneling method provides how to transmit IPv6 traffic through the existing IPv4 network infrastructure. For examples, 6to4, ISATAP, Teredo, and DSTM use this method.

ICMPv6

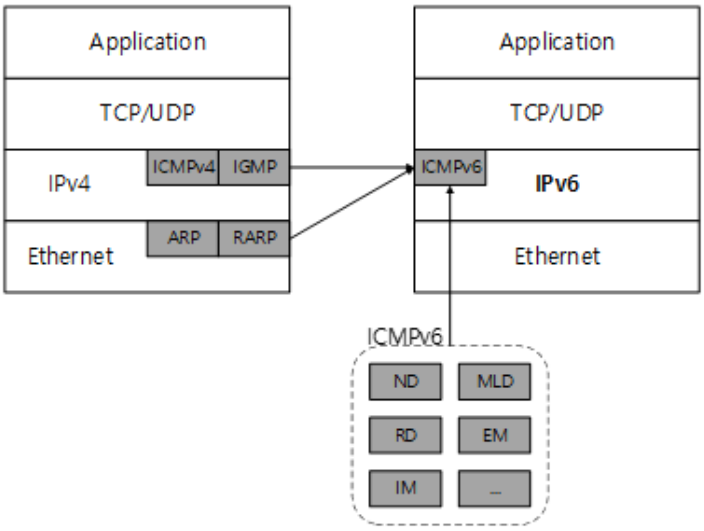
The biggest change of IPv6 is ICMPv6. ICMPv6 incorporates not only IPv4 based ICMPv4 protocol, but also ARP and IGMP protocols together, integrating the entire network configuration and management.

The follwing figure shows the representative functions of ICMPv6 and integration of ICMPv6 with IPv4-based protocools such as IGMP, ARP and RARP.

Error Message **Information Message**

Multicast Listener Discovery **Router Discovery**

Neighbor Discovery **Redirect Message**



- Replacement function
  - Error Message : Same as ICMPv4
    1. Type 1 : Destination Unreachable Error
    2. Type 2 : Packet Too Big Error
    3. Type 3 : Time Exceeded Error
    4. Type 4 : Parameter Problem Error
  - Information Message : Same as PING
    1. Type 128 : Echo Request (NS)
    2. Type 129 : Echo Reply (NA)
  - Neighbor Discovery (ND) : Same as ARP
    1. Type 135 Neighbor Solicitation (NS)
    2. Type 136 Neighbor Advertisement (NA)
  - Multicast Listener Discovery(MLD) : Same as IGMP
    1. Type 130 : Multicast Listener Query (MLQ)
    2. Type 131 : Multicast Listener Report (MLR)
    3. Type 132 : Multicast Listener Done (MLD)
  - Redirect Message
    1. Type 137 Redirect
- New Function
  - Router Discovery(RD)
    1. Type 133 Router Solicitation (RS)
    2. Type 134 Router Advertisement (RA)
  - Router Renumbering (RR)
    1. Type 138

Auto Address Configuration (AAC)

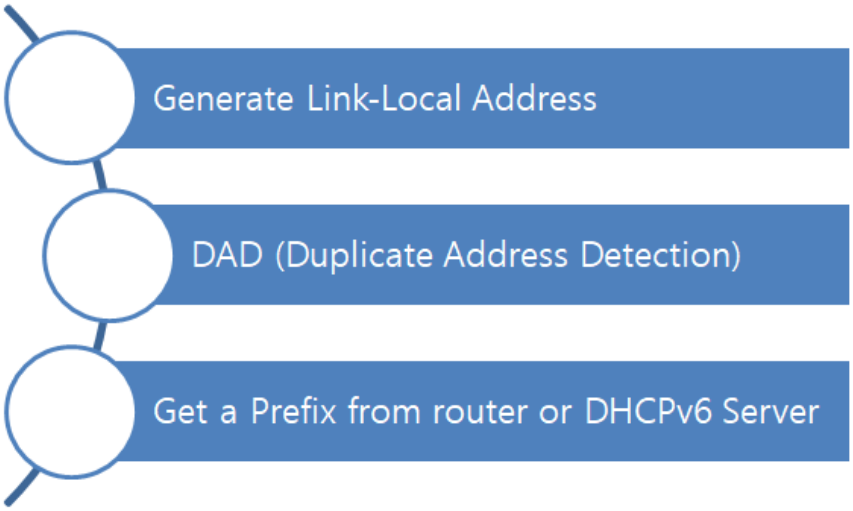
Another feature of IPv6 is the ability to assign own IP address automatically. IPv4 addresses can be assigned automatically from DHCPv4 Server. Of course, IPv6 address can also be assigned from DHCPv6 server.

However, it is worth noting that IPv6 can be allocated by itself without a DHCPv6 server. This is called State-less Auto Address Configuration (SLAAC).

IPv6 can be assigned an IP address two way manner state-less or stateful as shown below.

- State-less Auto Address Configuration (SLAAC)
    - SLLAC without DHCPv6
    - SLAAC with DHCPv6
- Stateful Auto Address Configuration with DHCPv6

The Auto Address Configuration of IPv6 is generally done in the following way.



As shown in the figure, state-less and stateful are distinguished according to whether the prefix information is received from the router or the DHCPv6 server. To be more precise, it is classified according to whether it maintains the allocated IP address pool information.

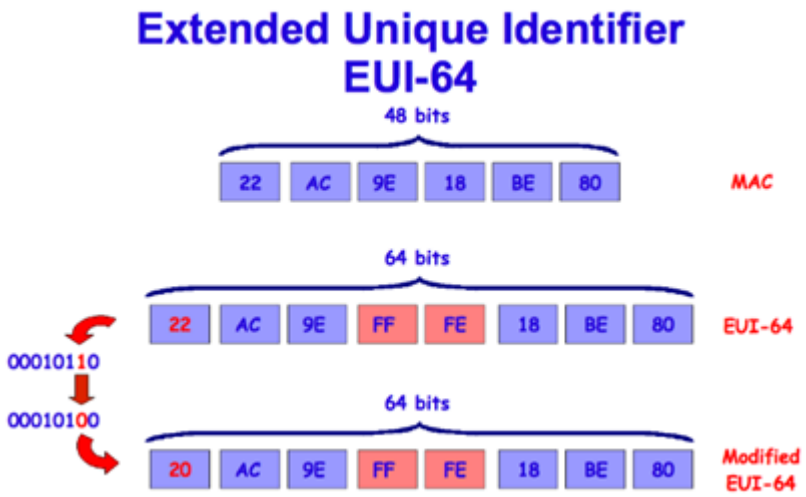
Router does not manage the assigned IP address. However, in case of DHCPv6 Server, the assigned IP address is maintained by the server.

When AAC mode is the State-less Auto Address Configuration with DHCPv6, the DHCPv6 Server does not manage the information about the IP addresses assigned to terminals. That is, Terminals receive the prefix from routers, but they receive other information such as DNS from DHCPv6 servers.

Generate Link-Local Address

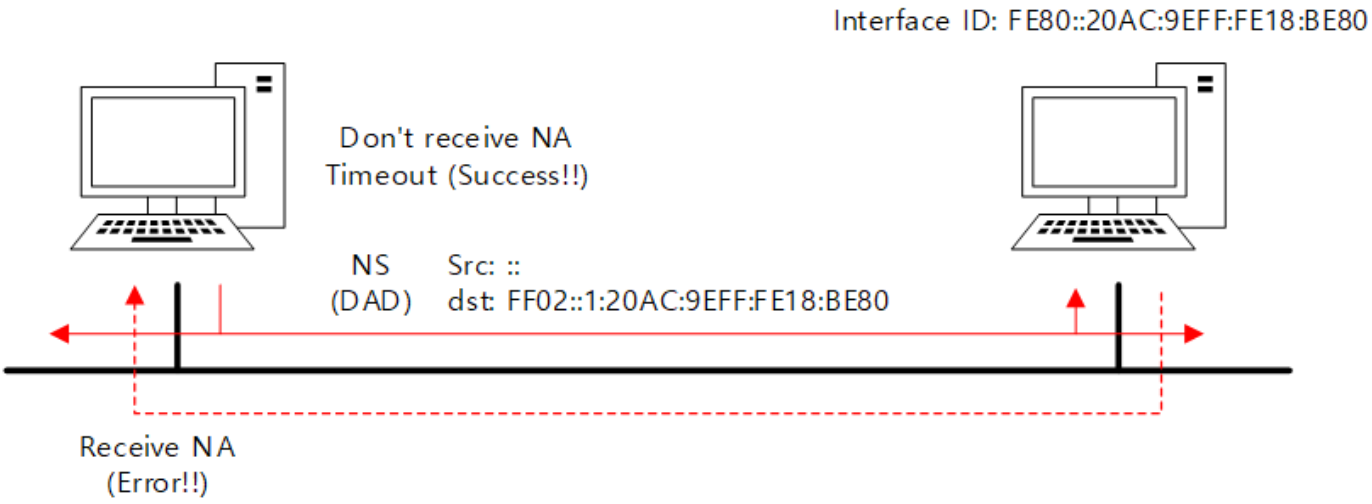
The Link-Local Address is generated by the terminal itself and can only be used in Link-Local. Link-Local refers to the area that communicates in the same network without external communication. It is similar to a VPN address such as 192.168.0.100 which is usually assigned arbitrarily and uses in local area.

Generally, EUI-64 method is recommended for link local address generation method, but it is not necessarily follow this. The following figure shows how to generate Link-Local Address using EUI-64 method.



Duplicated Address Detection

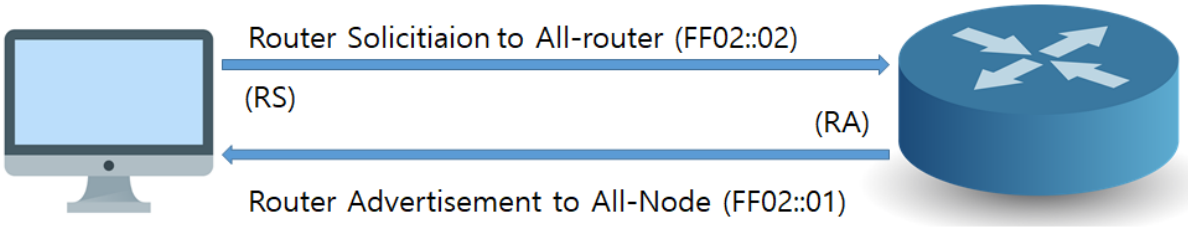
The link-local address generated by EUI-64 or other methods must be verified as being Neighbor Discovery (ND). This is a method that prevents inadvertent collisions of the Link-Local Address generated by itself and guarantees good communication without colliding with each other.



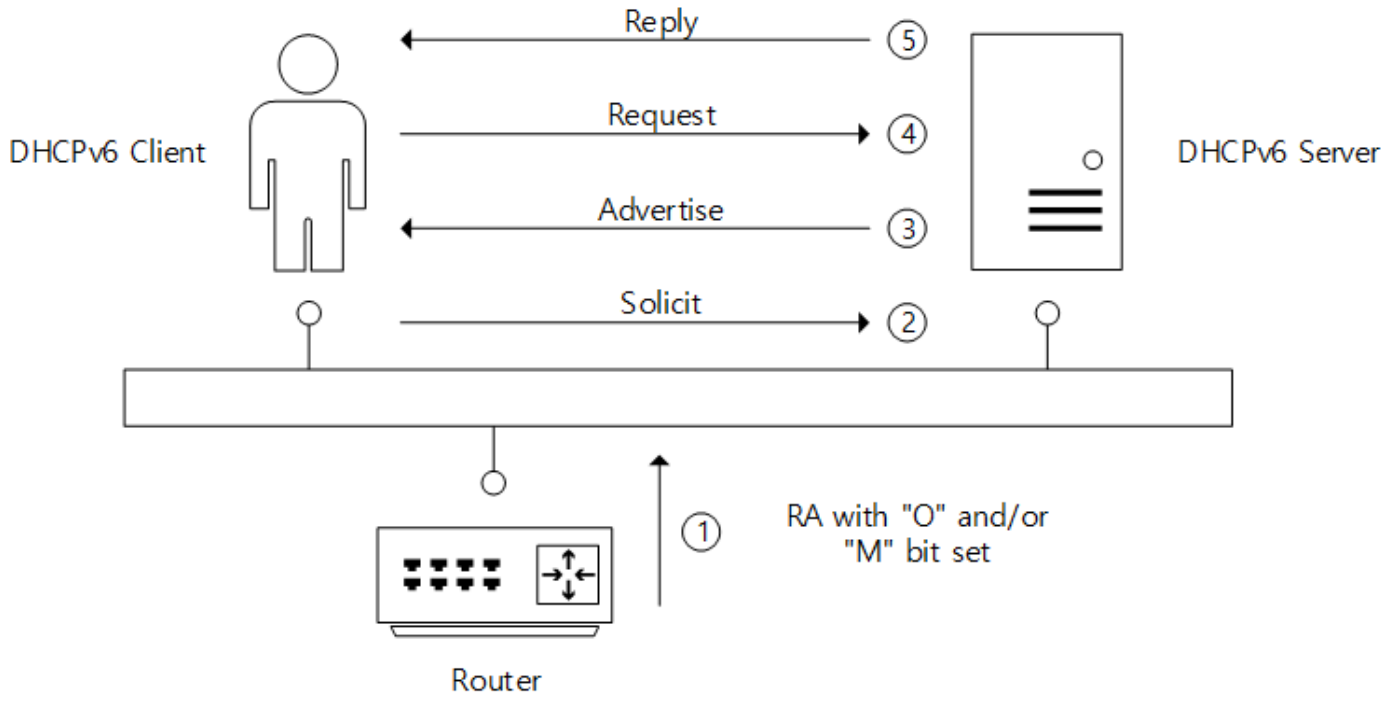
Get a Prefix

There are two ways to obtain Prefix Information as mentioned above.

1. Router Discovery (RR)



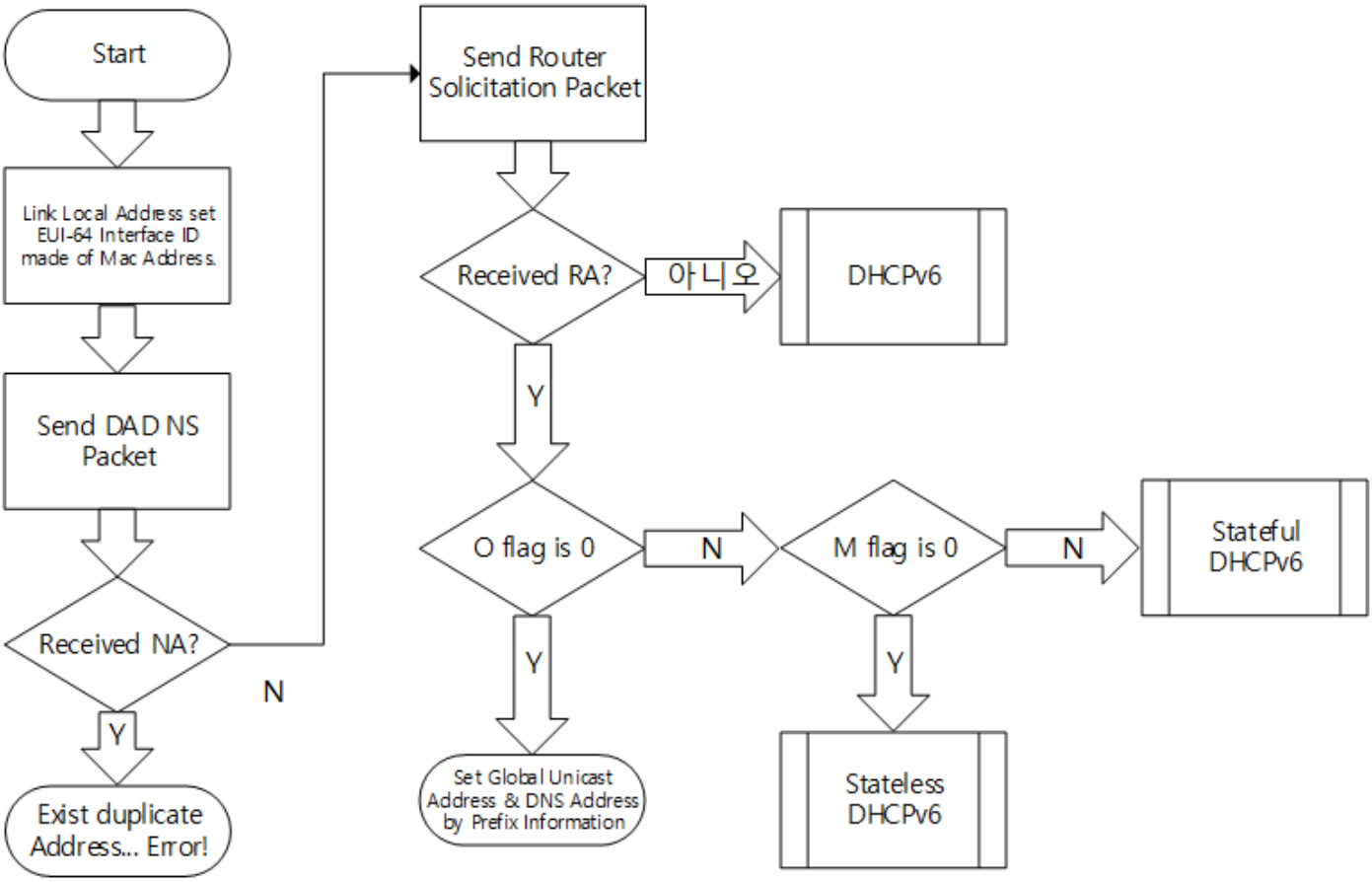
2. DHCPv4



AAC mode will be decided to whether state-less or stateful by the M and O bit of RA flag from a router.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Code      |          Checksum             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Cur Hop Limit |M|O| Reserved |       Router Lifetime         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Reachable Time                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Retrans Timer                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Options ...
+-+-+-+-+-+-+-+-+-+-+-+-
```

The following figure shows the Auto Address Configuration process according to the M and O bit settings.



Conclusion

We have briefly reviewed IPv6 to help you understand it. In **PART II**, we will see how these IPv6 features are implemented and applied to the W6100.

I did not explain everything about the W6100 in Part II. For first user of W6100, I briefly looked at a few basic features. For more detail information, you can refer to W6100 Datasheet

I hope this article will help W6100 users. Enjoy your W6100!!!