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What information is needed?

- Address prefix
- Interface identifier
- Default gateway
- DNS server
- Hostname
- Domain name
- MTU (Maximum Transmission Unit)
- ...

IPv6-configuration - 3
Options

- Manual configuration
- Stateful configuration
  - All information obtained through DHCP
- Stateless configuration
  - Autogenerated
  - Address prefix obtained from router
- Hybrid (Stateless DHCP)
  - Information other than address obtained through DHCP
Interface Identifier

- Manually configured
- Obtained through DHCPv6
- Automatically generated
  - From EUI-64 MAC address
  - Privacy aware
EUI-48 to EUI-64 mapping

EUI = Extended Unique Identifier

48 bit MAC address (EUI-48 format)

```
cccccc0gcccccccccccccccccccc
```

OUI

“Universal” bit

```
cccccc1gcc...............cc
```

Interface ID (from EUI-64 format)

```
0xFF 0xFE manufacturer-selected
```

```
111111111111110 xxxxxx...xxxxxxx
```

manufacturer-selected
Privacy Concerns

- Traceability
  - The least significant 64 bits of the IPv6 address of an interface never change when MAC address is used

- RFC 4941, “Privacy Extensions for Stateless Address Autoconfiguration in IPv6”
Privacy Extension Algorithm

64 bit Random or previous “privacy” address

64 bit Interface ID from MAC address

MD5

1111110111111111

+ +

Interface ID

Stored for next configuration
Address Usage

- A host may have several different addresses
  - “default”
  - “privacy aware”
- Usable to accept/initiate connections
- Selection of address may be available to the user/application
Address Prefix

- Manually configured
- Obtained from DHCPv6
- Automatically generated
  - Link local
- Obtained from a router
Router/Prefix Discovery

- ICMP Router Advertisement message
  - Sent by routers

- Solicited
  - Answering to Router Solicitation by host

- Unsolicited: periodic
# Router Solicitation

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Options</td>
</tr>
</tbody>
</table>

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© M. Baldi: see page 2
## Router Advertisement

<table>
<thead>
<tr>
<th>Type (134)</th>
<th>Code (0)</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cur Hop Limit</td>
<td>M</td>
<td>O</td>
</tr>
</tbody>
</table>

### Options
- **M (Managed Address Configuration)**
  - 1 – address available through DHCP
- **O (Other configuration)**
  - E.g., DNS server
Options

- General Format
- Length in multiple of 8 bytes
### Prefix Information Option

<table>
<thead>
<tr>
<th>Type (3)</th>
<th>Length</th>
<th>Prefix Length</th>
<th>L</th>
<th>A</th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valid Lifetime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preferred Lifetime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **L** – prefix is on-link
- **A** – prefix can be used for autonomous configuration
MTU Option

Ensures all hosts on-link use the same MTU value
## Link Layer Address Option

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Link-Layer Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Link-Layer Address . . .</td>
</tr>
</tbody>
</table>
ICMP Redirect

- Sent by a router to advise a host about a best first-hop
- The first-hop is always on-link, irrespective of prefix
## ICMP Redirect Message Format

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Checksum</th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

- **Target Address**
- **Destination Address**
- **Options**
Redirect Header Option

Information about the packet being redirected

<table>
<thead>
<tr>
<th>Type (4)</th>
<th>Length</th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserved</td>
<td>Reserved</td>
<td>IP header + data</td>
</tr>
</tbody>
</table>
Duplicate Address Detection (DAD)

- Probe uniqueness of an IPv6 address
- Neighbor solicitation with address being probed as target
  - Sent to corresponding IPv6 Solicited Node Multicast Address
  - Corresponding MAC multicast address
- Wait for a response for at least 1 sec
  - If no answer is received, the address is considered valid
Stateless Configuration: Basic Step

- Generate a link local address
- Probe for its uniqueness (DAD)
- Subscribe to the corresponding IPv6 Solicited Node Multicast Address
  - Configure reception of corresponding multicast MAC
  - Send ICMP Multicast Listener Report
- On-link communication enabled
Stateless Configuration: With Router

- Possibly send Router Solicitation
- Listen to Router Advertisements
- Create address from advertised prefix
- Probe for its uniqueness
- Subscribe to the corresponding IPv6 Solicited Node Multicast Address
  - Configure reception of corresponding multicast MAC
  - Send ICMP Multicast Listener Report
Stateless Configuration: Renumbering

- Keep listening to Router Advertisements
  - Host can be re-configured any time
- State of addresses
  - Preferred
  - Deprecated
- Easier renumbering
  - Possible to switch from a previous (ISP) global address to a new one
Stateful Configuration: Dynamic Host Configuration Protocol

- Client/server model
- M flag = 1 in Router Advertisement
- Messages:
  - Solicit
  - Advertise
  - Request
  - Reply
  - Release
  - Reconfigure
DHCP Stateless Configuration

- M flag = 0 in Router Advertisement
  - Address autoconfigured from prefix in Router Advertisement

- O flag = 1 in Router Advertisement
  - Other information configured through DHCP
Autoconfiguration for routers

- Router Renumbering (RFC 2894)
- Router Renumbering packets
  - they include PCOs (Prefix Control Operations)
    - Match-Prefix: specifies the operation
    - Use-Prefix
  - They are transported in ICMPv6 packets
- Two types of Router Renumbering messages
Scoped Addresses
Why is a scope required?

FE80::0237:00FF:FE02:a7FD -> FE80::0237:00FF:FE02:a7FD
Sintax

- A scoped address is composed of an IPv6 address followed by a % and a number identifying the interface

Example:
- FE80::0237:00FF:FE02:a7FD%19

The choice of the actual value of the scope is implementation-specific
Examples of Scoped Addresses

c:\>netsh interface ipv6 show address
Interface 1: Loopback Pseudo-Interface 1
Addr Type | DAD State | Valid Life | Pref. Life | Address
-----------|-----------|------------|------------|------------
Other      | Preferred | infinite   | infinite   | ::1

Interface 10: Wireless Network Connection
Addr Type | DAD State | Valid Life | Pref. Life | Address
-----------|-----------|------------|------------|------------
Other      | Preferred | infinite   | infinite   | fe80::9832:45b1:98e9:f44f:10

Interface 9: Local Area Connection
Addr Type | DAD State | Valid Life | Pref. Life | Address
-----------|-----------|------------|------------|------------
Other      | Deprecated| infinite   | infinite   | fe80::9158:6fc2:4155:3564%9

Interface 12: Local Area Connection* 12
Addr Type | DAD State | Valid Life | Pref. Life | Address
-----------|-----------|------------|------------|------------
Public     | Preferred | infinite   | infinite   | 2001:0:5ef5:79fd:14b0:f4d:f50d:a9a9
Other      | Preferred | infinite   | infinite   | fe80::14b0:f4d:f50d:a9a9%12

Interface 27: Bluetooth Network Connection
Addr Type | DAD State | Valid Life | Pref. Life | Address
-----------|-----------|------------|------------|------------
Other      | Deprecated| infinite   | infinite   | fe80::9961:aca4:ff3:3374%27

Interface 31: Local Area Connection* 25
Addr Type | DAD State | Valid Life | Pref. Life | Address
-----------|-----------|------------|------------|------------
Other      | Deprecated| infinite   | infinite   | fe80::5efe:10.242.86.86%31