Efficiency-aware IPv6 Neighbor Discovery Optimizations

draft-chakrabarti-nordmark-6man-efficient-nd-00
[Earlier draft-chakrabarti-nordmark-energy-aware-nd-02.txt]

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Summary

- Leverages 6lowpan-nd [RFC 6775] for general IPv6 links
  - No periodic multicast RA
  - Replaces DAD with Address Registration Option [ARO]
  - No multicast NS messages
  - Host-driven refresh of RA information – unicast RS to refresh

- Adds support for mixed-mode links
  - Combining RFC 4861 and efficiency-aware nodes on same link
  - Defines a new E-bit in the RA so hosts know the efficiency-aware routers

- Allows for sleeping hosts
  - ARO is used to check for duplicates at the router

- ND host scan attack removed/reduced
  - As more hosts use ARO the rate limit for sending multicast NS can be reduced reaching zero when all hosts on link use ARO
Recent changes

• Changes from draft-chakrabarti-nordmark-energy-aware-nd-02
  – Replaced “energy-aware” with “efficiency-aware” which covers both energy efficiency and other operational efficiency
  – Added consideration for DNA and clarified that this is useful for networks with MLD-snooping switches as well
  – Added use-cases, Support for Mixed-mode operations and a diagram for bootstrapping scenario.
  – Clarified its applicability when DHCP is used for address allocation.

• 6lowpan-nd approved as an RFC
Basic Ideas

RFC 4861 ND

- Link-local DAD (mcast)
- RS (mcast)
- Unicast RA
- DAD for Global Address (mcast)
- NS (multicast) address resolution
- Periodic RA (mcast)

Proposed Optimizations

- RS (mcast)
- Unicast RA
- Registration (unicast) NS+ARO
- NA (ack registration)
- Re-registration at registration lifetime expiry (unicast NS/NA)
- Query at router lifetime expiry (unicast RS/RA)
Address Registration [RFC 6775]

- Address Registration Option (ARO) is sent by the efficiency-aware hosts in a unicast NS message
- Can be combined on NUD probes to verify router reachability

```
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |   Length = 2  |    Status     |   Reserved          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Reserved            |     Registration Lifetime               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                                                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            EUI-64                                                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
Terminology

- ND efficiency-aware Router (NEAR)
  - Specified in this document
- Efficiency-Aware Host (EAH)
  - Ditto
- Legacy router
  - RFC 4861
- Legacy host
  - Ditto
Mixed-Mode Operation

- efficiency-aware Router and legacy IPv6 hosts along with efficiency-aware IPv6 hosts
- Legacy Router and efficiency-aware hosts
The E-bit in RA

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hop-limit</td>
<td>M</td>
<td>O</td>
</tr>
<tr>
<td>Reachable Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrans Timer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Options

New E-bit
NEAR and EAH in Mixed-Mode

**NEAR**
- Sends periodic RAs for legacy hosts
- Supports ARO for EAH
- Advertises E-bit in RA
- Manages both Registered NCE entries and Legacy entries
- SHOULD have configuration knobs for Mixed vs. Efficiency-aware-only mode
- Recommended default mode for NEAR is Mixed-Mode
- NEAR MUST NOT set ‘L’ bit in RA

**EAH**
- First sends Multicast RS to the link to detect presence of NEAR if it did not hear a RA with E-bit upon joining the network already
- If it hears from both NEAR and legacy IPv6 Router, the NEAR(s) gets preference as a default router(s)
- Registers with more than one NEAR (if multiple are available)
- Efficiency-aware hosts SHOULD de-register before it moves away or switches to legacy mode
Mixed-mode

- Legacy host multicasts DAD probe
  - In mixed mode, NEAR proxies based on registered NCEs
- Legacy host sends data packet to any router since L=0
  - Legacy router would multicast NS
  - NEAR would proxy with an NA based on registered NCEs
  - [Alternative is to require that a mixed link has only NEAR routers]
- EAH uses ARO for DAD
  - In mixed mode, NEAR should multicast DAD probe before ack’ing ARO
Interaction

• Detecting Network Attachment (DNA)
  – Orthogonal
  – DNA sends a unicast NS to previously known router(s)
  – That can now include an ARO
  – DNA also sends a multicast RS (in case moved to new link)
  – Same as a regular RS/RA on power-on

• DHCPv6
  – ARO is used for link-local address
  – DHCPv6 client SHOULD check DAD for assigned address. If ARO is available use that instead of multicast DAD probe

• Secure ND
  – RFC 37971 recommends allowing un-secured DAD on first try
  – Allows for NEAR to proxy DAD response

• MLD snooping
  – No use of solicited-node multicasts means less MLD snooping state
Open Issues

- 6lowpan-nd has a “SHOULD NOT” for sending redirects
  - To avoid hidden terminal issues in radio networks
- On general IPv6 links redirects are useful
  - Avoids sending all packets via routers
  - NUD will detect and remove stale redirects
- Should we allow redirects in this specification?
Next Step

• Accept as 6man working group document?

• Comments are welcome

Thanks!
Backup slides
NCE Management

- **Two Types of NCE**
  - Legacy (RFC 4861 NCE)
  - Registered (in mixed-mode and efficiency-aware only mode)

- **NCE types are orthogonal to NCE states**

- **All NCE are started with Legacy NCE**
  - Turns into ‘Registered’ NCE upon successful processing of ARO

- **Registered NCE are NOT garbage-collectable**
  - Registered NCE has its own life-time
  - Registered NCE are renewed by the EAH via Registration refresh before it expired

- In efficiency-aware only mode a TENTATIVE legacy NCE is created for a short time and deleted if the entry does not get registered

- Registration lifetime and EUI-64 are recorded for Registered NCE

- Only one type of NCE can exist in Neighbor Cache at a time
Handling ND-DOS Attacks

• Only in efficiency-Aware mode

• Tentative NCE entries are discarded if registration fails

• Duplicate entries must be checked before creating a valid NCE entry by checking EUI-64, MAC-address and IP-address

• All RS requests MUST contain SLLA option and avoids Neighbor Solicitation for the requestor’s address resolution
Handling Sleepy Nodes

- Sleepy nodes must support efficiency-aware mode only behavior
- No Multicast periodic RA
- No Address resolution Required
- Address Registration ensures duplicate checks
- Uses Default-router for packet forwarding
- Sleep and Registration interval should be synchronized for maximum energy savings