DNSNA: DNS Name Autoconfiguration for Internet of Things Devices
(draft-jeong-6man-iot-dns-autoconf-00)

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Jaehoon (Paul) Jeong and Sejun Lee
Sungkyunkwan University

Jung-Soo Park
ETRI
Motivation: IoT Location-Based Service

Text-based Display of Devices by AllSeen Alliance

<table>
<thead>
<tr>
<th>Home IoT Device List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart TV</td>
</tr>
<tr>
<td>Refrigerator</td>
</tr>
<tr>
<td>Airconditioner-1</td>
</tr>
<tr>
<td>Airconditioner-2</td>
</tr>
<tr>
<td>Airconditioner-3</td>
</tr>
<tr>
<td>Robot Cleaner</td>
</tr>
</tbody>
</table>

Image-based Display of Devices by DNSNA and Localization

Goal

- **Global (or Local) DNS Name Configuration for IoT Device DNS Name**
  - Can be automated without the intervention of a network administrator (or home users).

Applicability Domains

- Home, Office, Smart grid, Road network, Mall (e.g., Wal-Mart and Best Buy), and Factory (e.g., GM and Hyundai)
DNS Name Format

**DNS Name Format 1:**

unique_id.device_model.device_category.location.domain_name

- **unique_id:** Unique identifier to guarantee the uniqueness
- **device_model:** Product model of manufacturer name
- **device_category:** Device category name
- **location:** Physical location of the device (e.g., kitchen)
- **domain_name:** Representation and use of domain name (e.g., home, skku.edu)

**DNS Name Format 2:**

unique_id.object_identifier.location.domain_name

- **unique_id:** Unique identifier to guarantee the uniqueness
- **object_identifier:** Object identifier standardized by ITU-T and ISO/IEC
  - Node Indication ID + Manufacturer ID + Model ID + Serial Number ID
- **location:** Physical location of the device (e.g., kitchen)
- **domain_name:** Representation and use of domain name (e.g., home, skku.edu)
Protocol of DNS Name Autoconfiguration

- **Generation and Registration of IoT Device’s DNS Name**

1. **DNS Name Generation**

   - Refrigerator generates its DNS name as `refrigerator1.samsung_RH269LP.refrigerator.kitchen.home`

2. **DNS Name Registration**

   - My DNS name is `refrigerator1.samsung_RH269LP.refrigerator.kitchen.home`

   - **Get DNS Name List for Devices**
     - Smartphone
     - Access Point
     - IPv6 Host

   - **Remote Control by Device Icon**
     - Router
     - Refrigerator

   - **NI Query (DNS Name Collection)**
     - Smartphone
     - Access Point
     - Router
     - IPv6 Host

   - **Dynamic Update (DNS Name)**
     - Refrigerator
     - DNS Server

   - **What is your DNS Name?**
Appendix Slides
Time Sequence Diagram of DNSNA

1. DNS Name Generation
   - RA (DNSSL Option)
   - DAD
   - NI Query (DNS Name?)
   - NI Reply (DNS Name & IPv6 Address)

2. DNS Name Collection
   - DNS Query (DNS Name & IPv6 Address)
   - DNS Response (No Such DNS Name)

3. DNS Name Registration
   - DNS Dynamic Update (DNS Name & IPv6 Address)

4. IoT Device List Retrieval
   - Get Device List
   - Put Device List
   - Remote Control by Device Icon
Network Topology

- Comparison between mDNS & DNSNA in terms of DNS Traffic for DNS Name Resolution in a Multi-link Network
## DNSNA vs. mDNS (RFC6762)

<table>
<thead>
<tr>
<th>Approaches</th>
<th>DNSNA</th>
<th>mDNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet Forwarding</td>
<td>Unicasting</td>
<td>Multicasting</td>
</tr>
<tr>
<td>Authoritative DNS Server</td>
<td>Yes</td>
<td>No (host itself is server)</td>
</tr>
<tr>
<td>Naming Scope</td>
<td>Global, Local</td>
<td>Local</td>
</tr>
<tr>
<td>Target Networks</td>
<td>Small, Large</td>
<td>Small</td>
</tr>
<tr>
<td>Socket</td>
<td>RAW/IPv6</td>
<td>UDP/IPv6</td>
</tr>
<tr>
<td>Host Implementation</td>
<td>A little extension of ND</td>
<td>mDNS implementation</td>
</tr>
<tr>
<td>Code Size</td>
<td>Hundreds lines</td>
<td>Thousands lines</td>
</tr>
<tr>
<td>Target Devices</td>
<td>Constrained Devices</td>
<td>Apple Equipment</td>
</tr>
<tr>
<td>Message Number</td>
<td>2 x #hops of the path from client to DNS server</td>
<td>#links in the network + #hops from target to client</td>
</tr>
</tbody>
</table>
Applicability Domain: Smart Grid in Korea Electric Power Corporation (KEPCO) for Pilot Service

<table>
<thead>
<tr>
<th>Smart Grid Constrained Device List</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gateway</strong></td>
</tr>
<tr>
<td>gateway.smart_grid1.grid</td>
</tr>
<tr>
<td><strong>Standard meter1</strong></td>
</tr>
<tr>
<td>standard_meter1.smart_grid2.grid</td>
</tr>
<tr>
<td><strong>Standard meter2</strong></td>
</tr>
<tr>
<td>standard_meter2.smart_grid2.grid</td>
</tr>
<tr>
<td><strong>External meter1</strong></td>
</tr>
<tr>
<td>external_meter1.smart_grid3.grid</td>
</tr>
<tr>
<td><strong>External meter2</strong></td>
</tr>
<tr>
<td>external_meter2.smart_grid3.grid</td>
</tr>
<tr>
<td><strong>G_type meter1</strong></td>
</tr>
<tr>
<td>g_type_meter1.smart_grid4.grid</td>
</tr>
</tbody>
</table>
Demonstration Devices (1/2)

- System Environment
Demonstration Devices (2/2)

- **Gateway**

- **Meter (Constrained Device)**
DNSNA Configuration

- **Features**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gateway</th>
<th>Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>Linux</td>
<td>FreeRTOS</td>
</tr>
<tr>
<td>CPU</td>
<td>ARM Cortex-A5</td>
<td>ARM Cortex-M4</td>
</tr>
<tr>
<td>RAM</td>
<td>DDR2 256 Mbyte</td>
<td>64K-byte embedded SRAM</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>256 Mbyte</td>
<td>256/512 Kbytes</td>
</tr>
</tbody>
</table>

- **The Configuration of Router Advertisement Daemon (radvd)**

```c
Interface wisun0
{
    AdvSendAdvert on;
    MinRtrAdvInterval 600;
    MaxRtrAdvInterval 1800;
    Prefix 2001:2c8:ee:100::/64
    {
        AdvOnLink on;
        AdvAutonomous on;
        AdvRouterAddr off;
    };

    RDNSS 2001:2c8::1
    {
        AdvRDNSSLLifetime 3600;
    };

    DNSSL secter1.grid
    {
        AdvDNSSLLifetime 3600;
    };
```
Demonstration of DNSNA (1/5)

- **Router Advertisement (One Gateway and Two Meters)**

Gateway

| # tcpdump_dlb -i wisun0 icmp6  
| tcpdump_dlb: WARNING: wisun0: no IPv4 address assigned  
| tcpdump_dlb: verbose output suppressed, use -v or -vv for full protocol decode  
| listening on wisun0, link-type EN10MB (Ethernet), capture size 65535 bytes  
| 03:1b:23.6070506 IP6 fe80::e05b:85ff:fe74:cc02 > ff02::2: ICMP6, router solicitation, length 16  
| 03:1b:23.674062 IP6 fe80::e25b:85ff:fe74:0 > ff02::1: ICMP6, router advertisement, length 00  
| 03:1b:24.685071 IP6 :: > ff02::1:ffbe:5le: ICMP6, neighbor solicitation, who has fe80::107d:97f9:43ba:51ef, length 24  
| 03:1b:24.935066 IP6 :: > ff02::1:ff25:ebc5: ICMP6, neighbor solicitation, who has fe80::9350:bced:5b25:ebc5, length 24

**Meter 1**

```
[ICMP] Recv RA : L=80
Router Addr : fe 80 00 00 00 00 00 00 e2 5b 85 ff fe 74 00 00
option dnssl L=16, 07 73 65 63 74 65 72 31 04 67 72 69 64 00 00
DNS Search List : L=12, sector1.grid

Make DNS Name AutoConf : L=53, gtype_meter_cc14.jubix_wagmcc.powermeter.sector1.grid
[16] gtype_meter_cc14
[12] jubix_wagmcc
[10] powermeter
[ 7] sector1
[ 4] grid
```

**Meter 2**

```
[ICMP] Recv RA : L=80
Router Addr : fe 80 00 00 00 00 00 00 e2 5b 85 ff fe 74 00 00
option dnsssl L=16, 07 73 65 63 74 65 72 31 04 67 72 69 64 00 00 00
DNS Search List : L=12, sector1.grid

Make DNS Name AutoConf : L=53, etype_meter_cc02.jubix_waemcc.powermeter.sector1.grid
[16] etype_meter_cc02
[12] jubix_waemcc
[10] powermeter
[ 7] sector1
[ 4] grid
```
**Demonstration of DNSNA (2/5)**

- Duplicate Address Detection (DAD) for DNS Names

<table>
<thead>
<tr>
<th>Meter 1</th>
<th>Meter 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Network Traffic Logs" /></td>
<td><img src="image2.png" alt="Network Traffic Logs" /></td>
</tr>
</tbody>
</table>

| Make DNS Name MDS Addr : fe 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
| Check DAD for DNS Name |
| [NDP] Send NS : L=24 |
| option target L=16, fe 00 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
| [6Low] tx next hop is broadcast |
| [CC02->FFFF] Tx 6LowPAN : L=00 |
| [HMI] Tx MCPS-DATA.Req : P=0101, PL=120 |
| [HMI] Rx MCPS-DATA.Cnf : P=0102, PL=12 |

| Make DNS Name MDS Addr : fe 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
| Check DAD for DNS Name |
| [NDP] Send NS : L=24 |
| option target L=16, fe 00 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
| [6Low] tx next hop is broadcast |
| [CC14->FFFF] Tx 6LowPAN : L=80 |
| [HMI] Tx MCPS-DATA.Req : P=0101, PL=120 |
| [HMI] Rx MCPS-DATA.Cnf : P=0102, PL=12 |

| Make DNS Name MDS Addr : fe 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
| Check DAD for DNS Name |
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| option target L=16, fe 00 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
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| [HMI] Rx MCPS-DATA.Cnf : P=0102, PL=12 |

| Check DAD for DNS Name |
| [NDP] Send NS : L=24 |
| option target L=16, fe 00 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
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| [HMI] Tx MCPS-DATA.Req : P=0101, PL=120 |
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| Check DAD for DNS Name |
| [NDP] Send NS : L=24 |
| option target L=16, fe 00 00 00 00 00 00 00 00 00 00 00 00 10 7d 97 f9 43 ba 51 ef |
| [6Low] tx next hop is broadcast |
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| [HMI] Tx MCPS-DATA.Req : P=0101, PL=120 |
| [HMI] Rx MCPS-DATA.Cnf : P=0102, PL=12 |
Demonstration of DNSNA (3/5)

- Node Information Query for DNS Name Collection

<table>
<thead>
<tr>
<th>Gateway</th>
<th>Meter 1</th>
<th>Meter 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Gateway" /></td>
<td><img src="image2.png" alt="Meter 1" /></td>
<td><img src="image3.png" alt="Meter 2" /></td>
</tr>
</tbody>
</table>

**Gateway**

```
Timestamp: 2015/07/16 03:31:20

* Send NI Query  Len=32
  To  ff02::1

* Type   : 139, Node Information Query
* Code   : 0, Query Subject is IPv6 Address
* Checksum: 0x0000
* Qtype  : 2, Node Name
* Flags  : 0x0000
* Nonce  : 0x3483698389323283
* IPv6 Addr: ff02::1

8b 00 00 00 00 02 00 00 34 83 69 83 89 32 32 83 ff 02 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01
```

**Meter 1**

```
[ICMP] Recv NI Query : L=32
Code 0...ipv6
Qtype 2...node name
Data : L=16, ff 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01
```

**Meter 2**

```
[ICMP] Recv NI Query : L=32
Code 0...ipv6
Qtype 2...node name
Data : L=16, ff 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01
```
Demonstration of DNSNA (4/5)

- Node Information Reply for DNS Name Collection

<table>
<thead>
<tr>
<th>Gateway</th>
<th>Meter 1</th>
<th>Meter 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Gateway" /></td>
<td><img src="image2" alt="Meter 1" /></td>
<td><img src="image3" alt="Meter 2" /></td>
</tr>
</tbody>
</table>

```plaintext
[ICMP] Send NI Reply : L=76
Code 0...Success
Qtype 2...node name
Data : L=56
[16] gtype_meter_cc14
[12] jubix_waemcc
[10] powermeter
  [7] sector1
  [4] grid
```

```plaintext
[ICMP] Send NI Reply : L=76
Code 0...Success
Qtype 2...node name
Data : L=56
[16] etype_meter_cc02
[12] jubix_waemcc
[10] powermeter
  [7] sector1
  [4] grid
```
Demonstration of DNSNA (5/5)

- DNS Dynamic Update

Gateway

```
Found zone name: cpsdns.com
The master is: ns.cpsdns.com
Sending update to 115.145.178.190#53
Outgoing update query:
;; ->>HEADER<<- opcode: UPDATE, status: NOERROR, id: 65476
;; flags:; ZONE: 1, PREREQ: 0, UPDATE: 1, ADDITIONAL: 1
;; UPDATE SECTION:
etype-meter-cc02.jubix-waemcc.powermeter.secter1.grld.cpsdns.com. 300 IN AAAA 2001:be7f:0:190::11
```

```
Found zone name: cpsdns.com
The master is: ns.cpsdns.com
Sending update to 115.145.178.190#53
Outgoing update query:
;; ->>HEADER<<- opcode: UPDATE, status: NOERROR, id: 61610
;; flags:; ZONE: 1, PREREQ: 0, UPDATE: 1, ADDITIONAL: 1
;; UPDATE SECTION:
gtype-meter-cc14.jubix-wagoncc.powermeter.secter1.grld.cpsdns.com. 300 IN AAAA 2001:be7f:0:190::12
```

- DNS Name Lookup

Client PC

```
> etype-meter-cc02.jubix-waemcc.powermeter.secter1.grld.cpsdns.com
Server: 115.145.178.190
Address: 115.145.178.190#53
etype-meter-cc02.jubix-waemcc.powermeter.secter1.grld.cpsdns.com has AAAA address 2001:be7f:0:190::11
```

```
> gtype-meter-cc14.jubix-wagoncc.powermeter.secter1.grld.cpsdns.com
Server: 115.145.178.190
Address: 115.145.178.190#53
gtype-meter-cc14.jubix-wagoncc.powermeter.secter1.grld.cpsdns.com has AAAA address 2001:be7f:0:190::12
```