IPv6 in a scalable and easy way

torbjorn.eklov@interlan.se
https://interlan.se
https://dnssecandipv6.se
@tobbe_interlan
https://www.linkedin.com/in/tobbe1/
Me

• Co founder and 25% owner of Interlan

• Interlan celebrating 20 years in some weeks!

• Used IPv6 since 2000/2001

• Have much IPv6 and DNSSEC stuff at [https://dnsecandipv6.se](https://dnsecandipv6.se)
kommunermedipv6.se

~municipalitieswithipv6.se

Green if working -

www
DNS
smtp
The Christmas Goat and IPv6 (Year 7)

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By Torbjörn Eklov

It was a great year for the goat! 2016 marked the 60th anniversary for the Christmas Goat and there was a grand opening ceremony along with music and fireworks. But only a few hours after the opening, a pyromaniac set the goat on fire.

The only track the police have is a cap below that they hope to find DNA in and a crappy picture of the pyromaniac's back.

Municipality of Gavle decided not to rebuild the Goat but there have been a little brother of it nearly in the same spot for many years. They moved that goat to the original place. But after a few days a car ran into the smaller Goat and overturned it. But shame on those who give up — so today the smaller goat is in place and upright!

This year it was 27% native IPv6 unique visitors! But as usual there are very little action from Sweden.

Values from previous measurements:

- 2010 – 0.1% Native IPv6
- 2011 – 1 %
- 2012 – 1.4 %
- 2013 – 3.4 %
- 2014 – 11.1 % (!!!)
- 2015 – 14 %
- 2016 – 27%

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GavleNet - AS16117

• Gävle + Ockelbo municipality ~110’ inhabitants

• City network owned by the municipality’s energy company

• They can’t be outside these two municipalities

• Many small villages and long distances

• ~20’ customers in a few years

• GavleNet also celebrates 20 years!
Gävle kommun

Our POC
Harkskär - 200 customers

~80% lives here

~100 km
GavleNet FTTH

Max 400 FTTH / 4500

Cisco 4500

OSPFv3

Gavlenet ->
Internet

interlan
Cisco 4500

- 400 FTTH / switch - but we want to be able to easy scale up

- Maybe a BNG and MPLS in the future?
GavleNet

GavleNet was allocated 2001:b48::/29 by RIPE NCC way back in early 2003. This allocation gives them up to $2^{35}$ -- that's over 34 billion -- /64 networks to assign. They divide their space as described in this table:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001:b48::/32</td>
<td>Enterprise with static addresses</td>
</tr>
<tr>
<td>2001:b49::/32</td>
<td>DHCPv6 PD for FTTH</td>
</tr>
<tr>
<td>2001:b4a::/32</td>
<td>Free</td>
</tr>
<tr>
<td>2001:b4b::/32</td>
<td>Free</td>
</tr>
<tr>
<td>2001:b4c::/32</td>
<td>Part of 2001:b4c::/30 for 6RD</td>
</tr>
<tr>
<td>2001:b4d::/32</td>
<td>Part of 2001:b4c::/30 for 6RD</td>
</tr>
<tr>
<td>2001:b4e::/32</td>
<td>Part of 2001:b4c::/30 for 6RD</td>
</tr>
<tr>
<td>2001:b4f::/32</td>
<td>Part of 2001:b4c::/30 for 6RD</td>
</tr>
</tbody>
</table>

- Active since 2007/2008
- ~200 customers activated
- 6RD with option 212 since 2013
/16  -  /32  -  /48

- 2001::/16
- 2001:0b49::/32
- 2001:0b49:0000::/48

- Remember that it’s often easier to skip :: and use :0000:0000: in documentation and like now.
Address plan - /32

- 2001:b49:0000::/32 = 65536 /48’s
- /48 => 65536 /64 per subscriber
  2001:b49:0000:0000:
- 256 is enough so let's use /56 instead
  2001:b49:0000:0000:
Adress plan - /44

- Always use prefix even divisible with 4
- /64, /56, /44 etc
- You don’t want split a number
  2001:b49:4567:8000/50
- We chose to allocate a /44 per Cisco 4500 =>
  56 - 44 = 12 bits => we can expand to 4096 /56 per switch
  2001:b49:000|0:00|00/56
- => 4096 Cisco 4500
  2001:b49:000|0:00|0:0000
- 2001:b49:000|0:00|00/56
Adress plan - part 2 - /44

2001:b49::/32 provides 4,096 /44s in total. That's a lot. GavleNet's FTTH network is built almost exclusively with Cisco 4500 switches. We choose to assign a /44 to each Cisco 4500 as shown in this table:

<table>
<thead>
<tr>
<th>The 1st Cisco 4500</th>
<th>2001:b49:0010::/44</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 2nd Cisco 4500</td>
<td>2001:b49:0020::/44</td>
</tr>
<tr>
<td>The 3rd Cisco 4500</td>
<td>2001:b49:0030::/44</td>
</tr>
<tr>
<td>The 4th Cisco 4500</td>
<td>2001:b49:0040::/44</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
</tr>
</tbody>
</table>
Adress plan - part 3

- With /44 per FTTH POP we can chose other products who connects more FTTH / unit.

- We can "easy" move one /44 to a BNG.

- Or take a /4? from the /32 to the BNG for more then 4096

- Or 2001:b4a::/32?

- etc
DHCPv6 PD

- "static" /56 per customer port through option 37 - remote-id
- Tried ISC’s normal dhcpd.conf but we couldn’t get it work with option 37
- KEA 1.20 in April 2017 looks good with ”using hardware address or DUID in DHCPv6.”

- `apt-get install libtool autoconf g++ libssl-dev liblog4cplus-dev libboost-dev`
  `git clone https://github.com/isc-projects/kea.git`
  `autoreconf --install`
  `./configure --enable-logger-check --with-openssl --with-dhcp-mysql --enable-debug && make`
  `&& make install`
  `Time for coffee! :)`

- Cisco 4500 with dhcpv6 relay inserts remote-id default
3. The Relay Agent Remote-ID Option

This option may be added by DSCPv6 relay agents that terminate switched or permanent circuits and have mechanisms to identify the remote host end of the circuit.

The format of the DSCPv6 Relay Agent Remote-ID option is shown below:

```
0 1
1 1
0 1 2 3 4 5 6 7 8 9 0 1
+---------------+---------------+
| OPTION_REMOTE_ID | option-len |
+---------------+---------------+
| enterprise-number |               |
| remote-id       |               |
+---------------+---------------+
```

- **option-code**: OPTION_REMOTE_ID (37)
- **option-len**: 4 + the length, in octets, of the remote-id field. The minimum option-len is 5 octets.

**enterprise-number**  The vendor’s registered Enterprise Number as registered with IANA [13].

**remote-id**  The opaque value for the remote-id.

The definition of the remote-id carried in this option is vendor specific. The vendor is indicated in the enterprise-number field. The remote-id field may be used to encode, for instance:

- a "caller ID" telephone number for dial-up connection
- a "user name" prompted for by a Remote Access Server
- a remote caller ATM address
- a "nodes ID" of a cable data modem
- the remote IP address of a point-to-point link
- a remote X.25 address for X.25 connections
- an interface or port identifier

Each vendor must ensure that the remote-id is unique for its enterprise-number, as the octet sequence of enterprise-number followed by remote-id must be globally unique. One way to achieve uniqueness might be to include the relay agent’s DHC or Unique Identifier (UDID) [1] in the remote-id.
KEA testing!

- We only use PD, no IA_NA

- JSON format was something new! :)

- Logging isn’t 100% yet - must debug dhcpv6 packets for proper logging

```json
{
   "name": "kea-dhcp6.packets",
   "output_options": [
      {
         "output": "syslog"
      },
      {
         "output": "syslog"
      }
   ],
   "debuglevel": 55, ← 55 is needed
}
```
KEA

```
"Dhcp6": {
    "mac-sources": [ "remote-id" ],
    "output_options": [ {
        "output": "syslog"
    } ],
    "debuglevel": 55,
    "severity": "DEBUG"
},
```

Option 37 - remote ID
This is the magic option 37. Unique for every switch and port => we can identify and provide static and unique /56

020021000DBC00A00030001001F6CD1DB80 =>

01:00: 21:00 : 0D:BC : 00:0A:00 : 03:00:01:00:1F:6C:D1:DB:80

21:00 = slot 2 port 1 – 22:00 = slot 2 port 2 – 20:01 = slot 2 port 8. :) 
0D:BC = vlan 3516
03:00:01:00:1F:6C:D1:DB:80 = show ipv6 dhcp in the switch
KEA

"subnet6": [ {
    "subnet": "2001:b49:0080::/48",
    "pd-pools": [ { "prefix": "2001:b49:0080::", "prefix-len": 48,"delegated-len": 56 } ],
    "reservations": [ { "hw-address": "02:00:21:00:0D:BC:00:0A:00:03:00:01:00:1F:6C:D1:DB:80", "prefixes": [ "2001:b49:0080:0100::/56" ] } ],

21:00 = slot 2 port 1 - 22:00 = slot 2 port 2 - 20:01 = slot 2 port 8. :)
0D:BC = vlan 3516
03:00:01:00:1F:6C:D1:DB:80 = show ipv6 dhcp in switch

In this way we can provide "static" /56 per customer
OBS!! You must fill all /48 with dummy /56 if they not are in use!

Same provisioning system for IPv4 and IPv6 – Netadmin
Interface config

interface Vlan3516
    description FTTH_ro-harkskar01
    ipv6 address 2001:B49:80::1/64
    ipv6 enable
    ipv6 nd prefix default no-advertise
    ipv6 nd prefix 2001:B49:80::/64 no-advertise
    ipv6 nd managed-config-flag
    ipv6 nd other-config-flag
    ipv6 nd router-preference High
    ipv6 nd ra interval 10
    ipv6 verify unicast source reachable-via rx allow-default
    ipv6 dhcp relay destination 2001:B48:0:AAAA::BBBB
    ipv6 dhcp relay source-interface Vlan3516
    ipv6 dhcp relay trust
end

M and O flag for DHCPv6

BCP 38 - SAVI

Keepalived address

interlan
KEA

Virtual Ubuntu 16.04 active

Bare metal Ubuntu 16.04 Standby

Keepalived shared v6 address

Same DUID on both server failover not tested - yet :)
show ipv6 route static
IPv6 Routing Table - default - 98 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
R - RIP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
IS - ISIS summary, D - EIGRP, EX - EIGRP external, ND - ND Default
NDp - ND Prefix, DCE - Destination, NDr - Redirect, O - OSPF Intra
OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1
ON2 - OSPF NSSA ext 2, la - LISP alt, lr - LISP site-registrations
Id - LISP dyn-eid, IA - LISP away, a - Application
S 2001:B49:80::/44 [1/0]
   via Loopback10, directly connected
S 2001:B49:81:8C00::/56 [1/0]
   via FE80::3AD5:47FF:FEBB:78F0, Vlan3516
   via FE80::8226:89FF:FEEA:1FA8, Vlan3516
S 2001:B49:81:CC00::/56 [1/0]
   via FE80::1262:EBFF:FEF9:152D, Vlan3516

/44 routed to loopback
OSPFv3 only announces that prefix
A messy router can only disturb local vlan

show ipv6 dhcp relay binding
Relay Bindings associated with default vrf:
Prefix: 2001:B49:81:6000::/56 (Vlan3516)
   DUID: 000100012184B8A618D6C771E4FD
   IAID: 16345
   lifetime: 3600
   expiration: 17:15:52 SST Oct 26 2017
Prefix: 2001:B49:81:8C00::/56 (Vlan3516)
   DUID: 0003000138D547BB78F0
   IAID: 751856
   lifetime: 3600
   expiration: 17:07:51 SST Oct 26 2017
Prefix: 2001:B49:81:B600::/56 (Vlan3516)
   DUID: 00030001802689EA1FA8
   IAID: 151953439
   lifetime: 3600
   expiration: 17:14:25 SST Oct 26 2017
Prefix: 2001:B49:81:CC00::/56 (Vlan3516)
   DUID: 00030001106289EA1FA8
   IAID: 185569301
   lifetime: 3600
   expiration: 17:14:01 SST Oct 26 2017
Summary:
Total number of Relay bindings = 4
Total number of IAPD bindings = 4
Total number of IANA bindings = 0
Total number of Relay bindings added by Bulk lease = 0
Lessons learned

- IGMP snooping in customer’s CPE block ICMPv6
- Disabled IGMP snooping on ”wan” port in CPE => ICMPv6 works ok
Lessons learned

• Cisco 4500 reused port number from port 60 to 80 =>

• port 60 had same option 37 as port 1
  port 61 = port 2 etc.

• Solved by an upgrade but nothing about it in release notes
Problem!

- In Sweden we almost always buy our own homerouter
- IPv6 isn’t supported or don’t enabled default
- 200 customer => 6 active with IPv6
Thanks!

- A home without IPv6 is just a house
- I love the smell of IPv6 in the morning!